ALAM CIPTA
International Journal on Sustainable Tropical Design Research and Practice

IDENTIFYING EVACUATION CENTRE FOR FLOOD DISASTER IN HULU TERENGGANU BY USING AHP AND GIS

Nurul Hafizah Azmi[1], Nurhanisah Hashim[1*], Nabilah Naharudin[1] and Ainon Nisa Othman[1]

[1]School of Geomatics Science and Natural Resources, College of Built Environment, Universiti Teknologi MARA, 40540, Shah Alam, Selangor, Malaysia.

ARTICLE INFO

***Keywords**:*
AHP,
Flood Disaster Management,
GIS,
site suitability

ABSTRACT

This study aims to locate potential locations for a new evacuation area in Hulu Terengganu, Terengganu, using GIS and the AHP approach. The study was conducted based on the objectives where criteria for flood evacuation area were identified through background research and experts' opinions. The weights for each of the parameters were calculated using the pair-wise comparison matrix approach by considering opinions from experts in the related field. For this study, five (5) main criteria were considered: namely slope percentage, land use category, accessibility to the shelter, location to the shelter and occupancy, and the scope is limited to physical characteristics. The criteria were then weighted according to importance and those weighted criteria were combined to produce a suitability map. Based on the result obtained, highly suitable area is only 0.05% where it is far from flood prone and hazardous facilities, near to the road network, has suitable land use and also high in population. Next the area for moderate suitable is 4.88% while less suitable with 9.59% of total area in Hulu Terengganu. While most of the area in Hulu Terengganu is not suitable to establish a new evacuation centre, 85.48% of it is because of unsuitable land use, slope percentage and accessibility to the area.

1. INTRODUCTION

One of the most devastating natural catastrophes in Malaysia are floods, which annually affect 4.9 million people and cause millions of dollars' worth of damage [1]. A total of 29,720 square kilometres, or 9% of the country's land area, are at risk of flooding [2]. During the monsoon season, flooding affects all four of the country's regions, including the north, central, east, and south. Additionally, Malaysia's climate is experiencing rainfall, with an average of 2,500 millimetres per year in Peninsular Malaysia, 3,000 millimetres per year in Sabah, and 3,500 millimetres per year in Sarawak [3]. Due to increased rainfall frequency and the level of the sea in some areas of Malaysia, floods are a common phenomenon [3]. This makes natural disasters common in Malaysia. Nevertheless, it is expected to get worse as a result of the continuous growth in rural to urban migration, changes in the soil's structure due to development, poverty, and other factors that endanger floodplain areas [4]. Similarly, another study states that an increase in impervious surfaces, such as roads, buildings, and parking lots, has recently increased the risk and exposure of urban residents to flooding [5].

From December 2021 to January 2022, Malaysia experienced some of the worst flooding the country has ever experienced. Over 125,000 people were evacuated from their homes, and about 50 individuals lost their lives. Focusing on the east coast part of Malaysia where flood frequently occur during the year end monsoon, it had been recorded that, in 2022, the number of evacuated residents has already surpassed that of previous years. The area most severely impacted by the flooding is Hulu Terengganu, where some previously unflooded areas were this time completely submerged by floodwater, resulting in significant property destruction. Furthermore, Jalan Sekayu, which has never been flooded, is now flooded and closed to all vehicles. Due to the area flooded spread so quickly, many of the locals panicked and fled to the nearby forest because Temporary

*Corresponding Author: nurhanisahhashim@uitm.edu.my

Relief Shelter (PPS) was also hit by the flood (Bernama, 2022). This can be seen when two temporary evacuation centers (PPS) in Kampung Lubuk Periuk and Kampung Peneh were hit by floods causing the residents who took shelter in the supposed 'safe' places to be anxious and worried. In fact, the situation is quite serious because the water level can reach up to the roofs of the villagers' houses as well as the existing PPS. Due to a limitation of space in evacuation shelters, some people might need to drive far from their homes to find lodging, or they may decide not to go at all.

Because of the higher numbers of flood victims and evacuees in Malaysia, securing flood shelters or areas to be evacuated around the nation is one of the most crucial duties of Malaysia's flood risk management. However, providing evacuation area alone is insufficient; there are other crucial aspects to take into account, such as the suitability of the evacuation area. Previous research has shown how important it is to improve disaster readiness by identifying and setting aside sufficient space for emergency shelters before disasters strike. In the planning of an evacuation area, choosing a proper flood evacuation location is essential since potential shelters may be dangerous and cause more damage than expected. For instance, a survey of shelters in Southern Florida revealed that 48% of those that were already established and 57% of those that were candidates were situated in physically inappropriate areas [6].

The Analytic Hierarchy Process (AHP) method and the Geographic Information System (GIS) were combined to choose potential sites for a flood evacuation area in order to address the issue of evacuation area. The first objective of this study is to determine suitable criteria. Site suitability analysis helps in identifying suitable sites that match specific criteria or limitations to solve problems in decision making. Through the creation of a matrix of pairwise comparisons, AHP was utilised in this study to assess the consistency of weighting for the chosen criteria, with GIS playing a key role in the analysis of land use suitability. Analysis of suitable sites helps in locating sites that satisfy particular requirements or constraints. A procedure that integrates and combines geographic data and value judgments (the decision-preferences) can be used in conjunction with GIS to acquire information for decision-making [7]. Then, all the suitable evacuation area that match the criteria will be turned into map in order to produce a better understanding for the readers.

1.1 Site Suitability Criteria for Evacuation Area

Table 1 lists a few criteria that were employed by different studies. The authors utilised various criteria, and the study was conducted in various locations, with three of the authors conducting their study in Malaysia while the other authors in Bangladesh, Greece, Indonesia [8] and China [9].

The occupancy is important to give maximum protection to planning units and minimise the risk to vulnerable communities [10]. The new evacuation area should be placed within the current residential area or within a 1 km radius of each residential area, where the majority of people prefer evacuating within one kilometre of their residences and do not prefer flood shelters outside of their residences [11]. Thus, it is important to analyse flood shelters in every residential area to ensure maximum coverage and sufficient flood shelters for the affected populations.

Moreover, it is advisable to construct new flood shelters area in highly flood-prone settlement areas as well as in non-inundated areas. Based on previous studies as well as guidelines from international emergency shelter organizations, safe flood shelter areas must not be located in flood-prone areas or within the 100-year floodplain. This is due to the possibility that shelters in flood-prone locations could experience damage from the hydrostatic and hydrodynamic forces brought along by increasing flood waters, which could increase the risk to residents (FEMA, 2015). Additionally, there shouldn't be any possibility of river flooding in the area of a shelter that could flood roads and obstruct access to shelters.

The slope criteria for establishing evacuation area need to be defined clearly. The importance of slope in the placement of emergency shelters has been extensively covered in the literature by past researchers. Taking a closer look at the findings of the literature, the following criteria of the slope are highlighted: flood shelters should avoid slopes of 30% or higher in order to prevent landslides during heavy rainfall; slopes should exceed 7% and be preferably between 2% and 4% [10]. However, other study considering a suitable area of emergency shelter should be on a slope not exceeding 5% if extensive drainage and erosion measures are taken to provide enough drainage to limit flooding and ponding [11]. Other study analysed the contour data according to the 2-meter, 4-meter, and 6-meter highs to determine the flood water level [12].

Table 1: *List of criteria from previous study*

Author(s), Year	Location	Method	Criteria
Mustaffa et al., (2016)	Batu Pahat, Johor	AHP	Accessibility, suitable slope percentage
Mior Termizi (2016)	Kuala Krai, Kelantan	MCE, WLC and AHP	Accessibility, occupancy
Mabahwi et al., (2021)	Kuantan, Pahang	WOA and AHP	Location of the shelter, suitable slope percentage, occupancy, land use
Uddin & Matin (2021)	Bangladesh	AHP	Settlement area, safety and accessibility
Aidinidou et al., (2022)	Thessaloniki, Greece	MCDA and AHP	Environmental (potential flood risk, land use changes), Social (impact on population safety, impact on healthcare facilities), Economic (impact on population density, impact on road)
Muhammad et al., (2023) [8]	Palembang, Indonesia	AHP	Slope, elevation, drainage density, distance to river, land use, population, distance to road
Wang et al., (2024) [9]	Beijing, China	VGAE-RF	Population density, DEM, road network, building outline and height

Accessibility to shelter plays an important role in establishing a new evacuation area. Accessibility played a vital role as it involved the movement of people from their homes to a safer location as well as their return [12]. It is not only vital to the evacuees but also to the emergency team's response. They need to come fast in order to save the evacuees by using an accessible road at that time. If the road is fully blocked, other alternatives should be considered, such as using a boat or helicopter. Other than that, accessibility to health care or distance to the shelter need to be considered when establishing a new evacuation shelter, as it is important for evacuees to seek medical attention [13]. Numerous public health issues must be taken into consideration while planning an evacuation centre.

Accessibility to the evacuation facility is constrained by cost. It is also crucial since it will use a shortcut path to quickly direct the evacuees to the centre. Additionally, it is important for the response team to get to the evacuees' homes and the centre throughout the evacuation process. In order to ease the transition of the living community that will be rescued to the centre, site selection must take into account the distance and visibility of these types of roads. Evacuation areas that are close to residences or main roads are easy to reach. The distance constraint for accessibility to the shelter area must be less than 1km [14].

Since it is closely linked to human life, the social aspect is equally significant when deciding the criteria to establish a new evacuation area. Research on project prioritisation and strategic planning for flood mitigation, the social parameters taken into account have an impact on flood incidents, population safety, healthcare, social, and civil protection facilities, as well as facilities for protecting against natural disasters. Thus, it is vital to know how many livings community can get in that evacuation area during the disaster [15].

In determining the suitable locations for evacuation centers in Hulu Terengganu using GIS and AHP techniques, the decision was made to exclude existing flood shelters as a criterion. This exclusion was intentional to ensure a comprehensive and forward-looking analysis. Existing shelters, which may have been established based on outdated or suboptimal criteria, could limit the study's potential to identify new, more suitable locations. By not considering these shelters, the study maintained flexibility and allowed for the unbiased evaluation of potential new sites that better align with current and future needs.

2. METHODOLOGY

To achieve good results and complete all the goals and objectives for the study, it is crucial to develop proper methodology planning. The workflow methodology used to carry out this study is represented in Figure 1.

2.1 Study Area

The selected study area for this study is Hulu Terengganu that is an interior district which located at Terengganu, Malaysia. Hulu Terengganu situated at geographical coordinates of 5.0730° N, 103.0089° E. Kuala Berang, the district's administrative centre, lies about 40 kilometres (25 miles) from Kuala Terengganu, the state capital. The Terengganu Inscription Stone and Tasik Kenyir, often known as Kenyir Lake, are two of the area's most well-known landmarks.

A study of flood disaster management is comprehensive because it takes into consideration both regional and local contexts with respect to the rivers and the drainage system. The selected area of study is Hulu Terengganu, Terengganu, Malaysia, which is listed as having a high risk of flooding under the National Physical Plan 3 (NPP3) [14]. Furthermore, the study area, Hulu Terengganu, was picked because the Kenyir Dam, an electric power dam, is located here. Tenaga Nasional Berhad (TNB) will gradually discharge water into the river if there is continuous rain and the dam reservoir is at or over capacity.

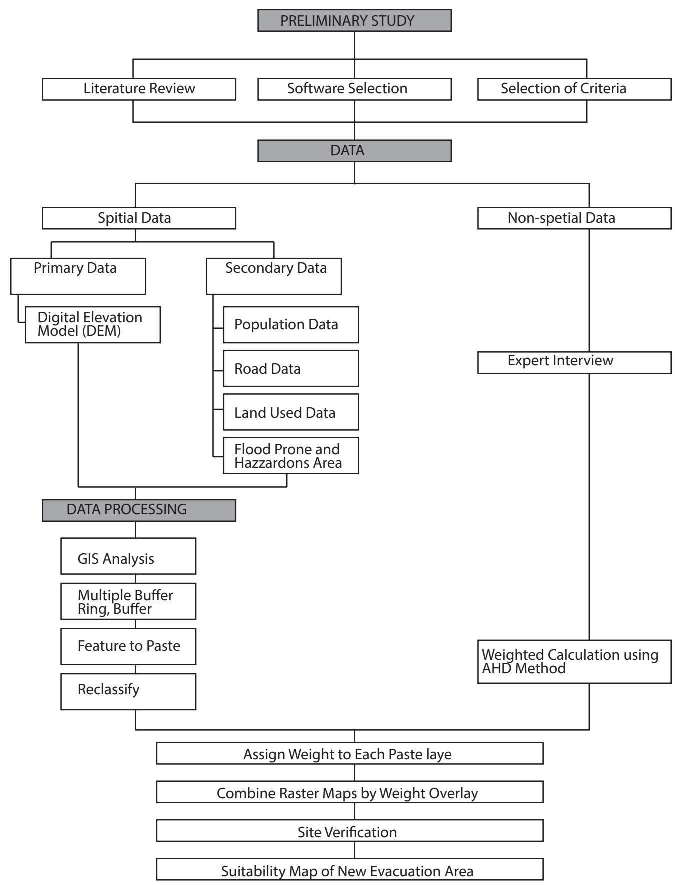

***Figure 1**: General Research Methodology Flowchart*

The main river that will receive this overflow of water is in the Hulu Terengganu area and will probably flood in a short time. The main river in this basin is the Terengganu River, which flows from the upper watershed of Kenyir Lake to the South China Sea. The main tributaries feeding the Terengganu River are the Nerus, Tersat, Berang, and Telemung Rivers, with a total catchment area of about 5000 km2. Three out of the four main rivers in Terengganu lie in Hulu Terengganu district.

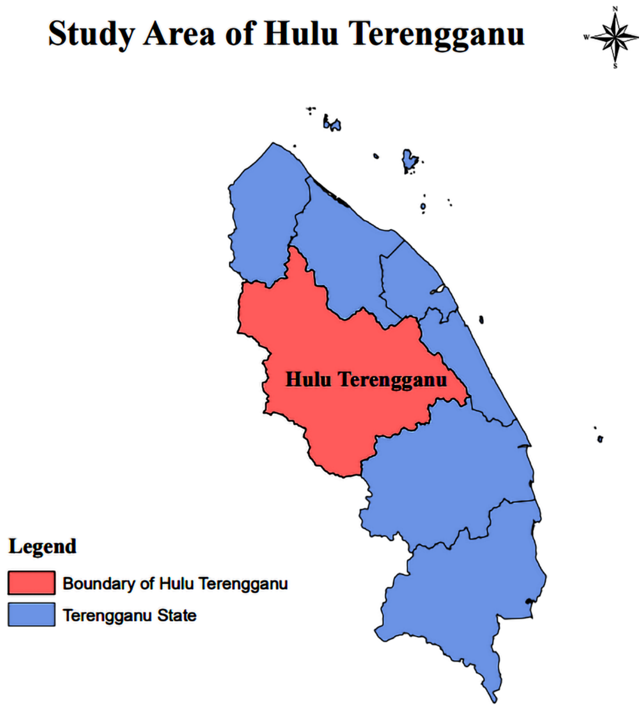

Figure 2: Study Area

2.2 Data Collection

This study used various spatial datasets to identify suitable site area for an evacuation centre in the study area. Data collection is very important in this study because it ensures that information-rich and reliable data is collected for analysis later. To guarantee that it can be completed in the time allocated, this study therefore incorporates both types of data, which are primary and secondary data. Primary data are those that have been gathered by questionnaires, and interviews. While secondary data is being gathered by an earlier source.

The slope extraction procedure uses DEM data that was acquired from the ASTER database. The slope map of the study area is created by first analyzing the contour data for each elevation value. The dataset that represents the road access of each place in Hulu Terengganu was provided by National Geospatial Centre (PGN). The road map is needed to be processed as it can determine the traffic pattern and the shortest path as well as the accessibility to the evacuation centre that will allow evacuees and the response team to reach the centre quickly.

The classification of the land use image was retrieved from the Department of PLAN Malaysia Terengganu. Different land use types are classified into different classes, such as built-up, vegetation, water bodies, forest, and bare-land, as part of the classification process. The land use map created during the classification process will aid in identifying the various land use types in the research region. To add more, it will also help to identify new areas that are far from hazardous facilities or dumpsites to avoid discomfort for the evacuees. Since people are the most significant flood-affected object, precise spatial distribution data based on population is crucial for disaster mitigation and prevention. Usually, the population affected by flooding is determined by combining flood information with demographic data sets. According to the local population, the effectiveness analysis will determine how well the evacuation area will help flood victims. The examination of the new evacuation area location is intended to identify the new evacuation area site that can be used in an emergency.

2.3 Data Processing

Generally, there are two main phases for the data processing in this study, which are the AHP and GIS analysis. The AHP part includes determining the criteria and constructing a hierarchy framework, weightage calculation through a pairwise comparison matrix, consistency inspection, and aggregate indicator weight [17]. While for the GIS part, the process includes standardising the dataset format by converting all the vector datasets to raster format, buffering, reclassify and weighted overlay analysis.

2.3.1 Analytical Hierarchical Process

In this study, occupancy, land use, slope percentage, accessibility, and location of the shelter have been selected as the most effective criteria to compare during the data analysis later. Figure 3 shows the main criteria for the new evacuation area in Hulu Terengganu. These criteria, which cover a wide range of factors, are thought to be relevant to this study. The main criteria used in this work are represented by Level 1, while Level 2 is the sub-criteria. Their dependencies were modelled in a hierarchical structure as shown in Figure 3.

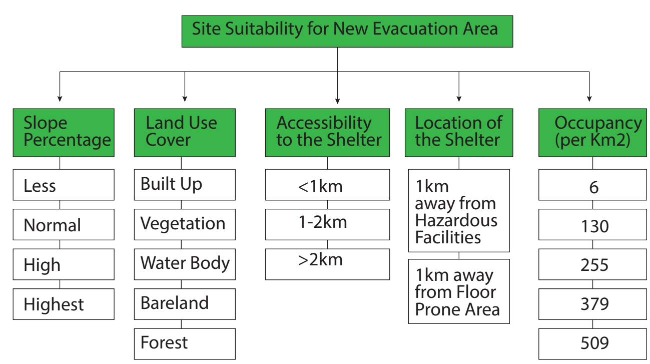

Figure 3: Hierarchical Structure

Four (4) respondents in total, including two (2) each from PLAN Malaysia Terengganu and Welfare Department (JKM), were chosen to provide the degree of importance for the criteria. Here, the experts need to rank the criterion on a scale of 1 to 9 before calculating the weightage through a pairwise comparison matrix using Equation 1 [18][19][20]. The weightage of main criteria and sub-criteria were calculated using the pairwise comparison method, and only two criteria are compared at a time rather than trying to compare many at once. Then, the Consistency Ratio was used to determine whether the judgements given are consistent or not.

$$V(A_t) = \sum_{k=1}^{n} W_1 W_{k(1)} V(\alpha_{ik})$$

Equation 1

Where;

n = the number of criteria

$W_1 W_{k(1)}$ = criterion weightage of sub-criteria

$V(\alpha_{ik})$ = value function

2.3.2 Weighted Overlay Analysis

Once the weightage for each criterion and their subcriteria had been derived, they will be used in Weighted Overlay Analysis to produce site suitability index for the flood evacuation centre. This analysis combines various raster inputs into one analysis and adds weightage value to them. To produce a suitability value for each site on the input map, each individual raster cell is classed into units of suitability, multiplied by a weight to give each a relative relevance, and then added together for the final weight.

3. RESULT AND ANALYSIS

In order to ensure the study's goals had been achieved, experts' opinions were considered, and calculation of pairwise comparison matrix to determine the weightage for each criterion based on the expert's choice were done. Based on the weightage calculation, the site suitability for new evacuation area in the research region were determined using the weighted overlay technique. Finally, a suitability map for new evacuation area in the research region was created, which will complete the study goal.

3.1 Weightage of the Criteria

Table 2 shows the results of the weightage calculation for each criterion. For the slope main criteria, it indicates that the most important sub-criteria are normal slope, followed by less, high, and highest. While for the land use, two sub-criteria, which are forest and water bodies, are labelled as restricted as it is undoubtedly unsuitable to place a new evacuation centre area there. Thus, the important sub-criteria are bare-land, followed by vegetation, and also built-up area. Furthermore, for accessibility, the most important sub-criteria within the criteria are within 1km, then 1 km–2 km, and last more than 2km. For the main criteria for the location of the shelter, it is important to construct the new evacuation area far from flood-prone areas, followed by hazardous facilities. Thus, it is restricted to construct the new evacuation centre area within this area because it can be harmful. Last but not least, the area with more population is more important than the location with less population.

Table 2: *Weightage Value including Priorities for Main and Sub-Criteria*

Main Criteria	Criteria Weight	Sub-Criteria	Sub-Criteria Weight	Priorities
Slope	0.3202	Less	0.2476	0.0793
		Normal	0.5531	0.1771
		High	0.1314	0.0421
		Highest	0.0679	0.0217
Land Used	0.0827	Vegetation	0.2082	0.0172
		Bareland	0.5136	0.0425
		Forest	0.0969	0.0080
		Built-Up	0.1312	0.0109
		Water Body	0.0501	0.0041
Accessibility	0.1974	< 1km	0.6705	0.1324
		1km - 2km	0.2255	0.0445
		> 2km	0.1041	0.0205
Location of Shelter	0.3583	Away from Hazardous	0.1563	0.0560
		Away from Flood Prone	0.8438	0.3023
Occupancy	0.0414	6 per km2	0.0472	0.0020
		130 per km2	0.0876	0.0036
		255 per km2	0.1460	0.0060
		379 per km2	0.2513	0.0104
		503 per km2	0.4679	0.0194

3.2 Weighted Overlay Site Suitability Analysis

The area according to the criteria classification framework and coverage percentage of the suitability map (Figure 4) were summarized in Table 3. Unsuitable areas are shown by the red colour on the map. It consists of a huge area from the Hulu-Terengganu boundary, with 85.48% of the study area. This is mostly seen in the West and Centre regions, where there is a huge amount of forest and water body area. As half of Hulu Terengganu's land use is designated as a forest reserve and water body area, these areas were classified as restricted. Industries were classified as restricted, as were flood shelters, which should not be built near industrial areas. Not only that, non-existing infrastructure, such as being far from roads and having a lower population, may also be a major component because unsuitable regions are more common than others.

Less suitable lands for the new evacuation area make up the second majority of land, with 9.59% of the study area. This is due to the large area of Hulu Terengganu in the East region, which is a built-up area. Built-up areas are categorized as less suitable due to limited space and environmental pollution. Furthermore, this area has a lower population density compared to the centre of the east region. This area in general is quite far from the road as it takes a 3km buffer, and hence, it could be difficult for the rescue team and evacuees to reach the centre in a short time. Finally, the slope factor can also be the reason why this area is less suitable because it consists of a high slope range of 7% and above. It is considered not suitable to locate the evacuation site there as it might be risky for other natural disasters, such as landslides, and it is hard for elderly and disabled people to get there.

Moderately suitable areas are covered in dark green with 4.88%. This is due to the large area of Hulu Terengganu in the East region being covered by built-up areas, vegetation, and bare-land, where the distance from the nearest roads is in the range of 1km to 2 km, which is suitable to ensure the response team and other evacuees reach the centre. This is also considered a buffer zone. The distance of buffer zones between flood-prone areas and hazardous facilities must be of sufficient distance and structure to avoid drift or runoff of forbidden substances. Next, with gentle slopes ranging from 2% and 3% to 5%, this helps in optimising the centre from the large-scale flood [10].

The area that was classified as highly suitable covered less area compared to the others. The lands classified into this class mostly consist of bare-land where there is enough space to build the centre and it is not a restricted area. Next, the slopes with ranges from 3%–5% are considered good to establish an evacuation area as they are reachable, far from flooding, and can prevent landslides. Moving on, the land is deemed suitable if it is within 1km of the road access. Roads are considered important when designing new evacuation areas, as it must take a short time for evacuees to reach the centre, and it is also important for other agencies to supply food or medical supplies. Moreover, it is highly suitable as it is away from the buffer zone for flood-prone areas and hazardous facilities, which is the most important factor that needs to be considered when planning the evacuation area.

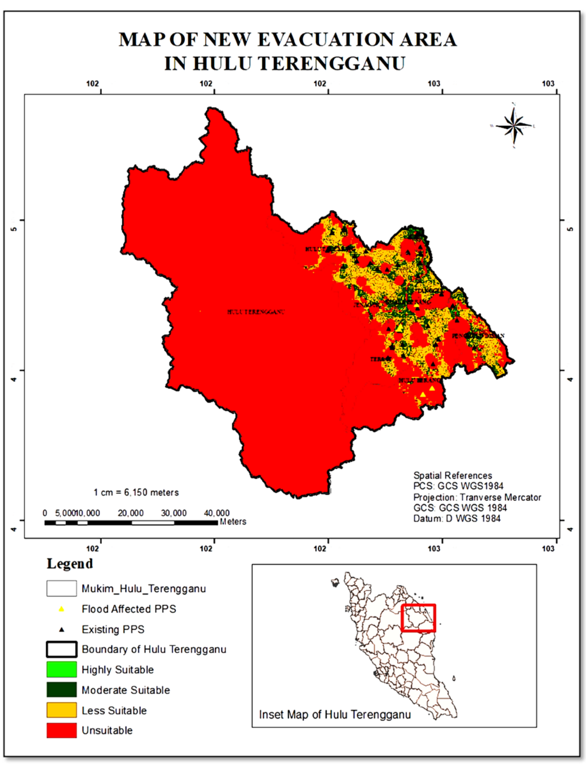

Figure 4: Suitability Map of New Flood Evacuation Area

Table 3: Summary of Area and Percentage

Suitability Classes	Area (meter square)	Area (ha)	Percent (%)
Unsuitable	3309255844.510	330925.585	85.48
Less Suitable	371332031.393	37133.203	9.59
Moderate Suitable	188968130.063	18896.813	4.88
Highly Suitable	1654011.499	165.401	0.05
Total	**3871210017**	**387121.002**	**100**

Based on Figure 4, it is evident that there are 50 existing shelters (Pusat Pemindahan Sementara, PPS) scattered throughout the Hulu Terengganu area. Of these 50 shelters, five were affected by the 2022 flood. The affected shelters were located in Kg Lubuk Pait, Kg Peneh, Kg Bukit Gemuruh (two shelters), and Kg Batu 24. This indicates a significant vulnerability of these locations to flooding events, highlighting the necessity for a reevaluation of their suitability as emergency shelters. Further analysis reveals that out of the 50 shelters, 19 are situated in unsuitable areas, while 31 are located in areas deemed suitable or moderately suitable for evacuation purposes. The distribution of shelters in unsuitable areas raises concerns about their effectiveness in providing safe havens during flood events. This assessment can serve as a foundation for future improvements in disaster management strategies, aiming to enhance the resilience and safety of the affected populations in Hulu Terengganu.

Five affected PPS can be attributed to the continuous rainfall for several days in Hulu Terengganu, which led to severe flooding in specific areas. This prolonged rainfall caused water levels to rise significantly, overwhelming the natural and man-made drainage systems. As a result, the shelters located in lower-lying regions or areas with inadequate drainage, such as Kg Lubuk Pait, Kg Peneh, Kg Bukit Gemuruh, and Kg Batu 24, were more susceptible to flooding. Conversely, shelters situated in higher elevations or regions with better drainage infrastructure remained unaffected. The intensity and duration of the rainfall were critical factors in determining which shelters were impacted, highlighting the need for improved flood management and strategic placement of evacuation centers to mitigate the risks posed by extreme weather events in the future.

3.3 Site Verification

Figure 5 below shows the map for highly suitable for a new evacuation area in Hulu Terengganu.

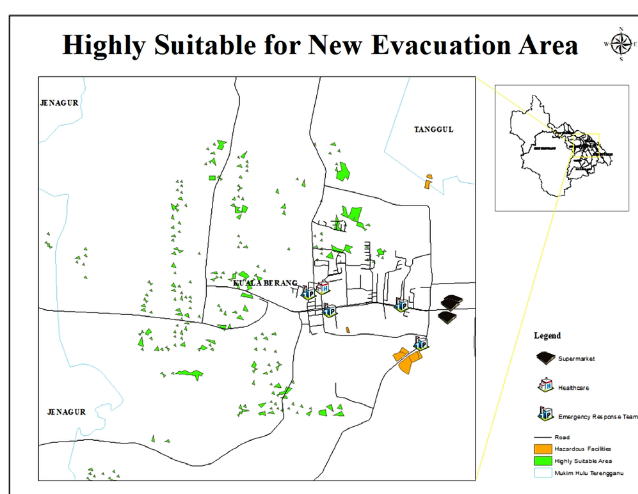

Figure 5. Highly suitable area

The results of the suitability analysis can be verified, improved, and, if necessary, changed by undertaking site verification. It enables an accurate understanding of the limitations and actual consequences related to each proposed site. This may entail assessing the site's physical features, such as terrain, soil composition, vegetation, and any existing infrastructure. The site's closeness and accessibility to utilities, transportation networks, and other essential services are also evaluated as part of the site verification process to ensure they meet the criteria needed. The findings from site verification are then compared and integrated with the results of the site suitability analysis.

Based on Figure 5, the areas designated as highly suitable are highlighted in green. A closer examination of these areas reveals that they are primarily located in Mukim Kuala Berang. A few villages was selected as a highly suitable such as Kg Telaga, Kg Butut, Kg Buluh and Kg Gaung after considering a various factor. This strategic placement is due to the proximity to essential facilities such as supermarkets, healthcare centers,and emergency response teams. The availability of these facilities ensures that necessary assistance can be provided promptly during a flood disaster, where timely intervention is crucial. In the context of flood preparedness, the swift mobilization of resources is paramount to effectively manage the crisis. Within Hulu Terengganu, the total area classified as highly suitable for establishing evacuation centers, taking into account the restricted forest reserves, is merely 0.05% of the overall area. This limited availability of suitable land underscores the necessity for meticulous planning and precise selection of locations for evacuation centers to optimize their accessibility and functionality during emergencies.

4. CONCLUSION

This study integrating the use of AHP and GIS to identify suitable site for new evacuation center for flood disaster in Hulu Terengganu. Firstly, five main criteria were considered: slope, landuse, accessibility, location of center and occupancy. The criteria were chosen based on the literature review and the scope is limited to physical characteristics. Based on experts' opinion within AHP environment, location of shelter indicates the most important criteria, followed by slope, accessibility, landuse and the least important is occupancy. Secondly, the suitability map was produced using weighted overlay analysis. From the suitability map, it was computed that the study area was divided into four categories: unsuitable (85.48%), less suitable (9.59%), moderately suitable (4.88%) and highly suitable (0.05%). Lastly, site verification has been done in a highly suitable area which involves physical assessment, field surveys, and evaluation of site-specific factors to ensure the practicality and suitability of potential sites. The areas designated as highly suitable area primarily located in mukim Kuala Berang, specifically at Kg Telaga, Kg Butut, Kg Buluh and Kg Gaung. Other than that, further analysis reveals that 62% of the PPS located in suitable and moderately suitable areas while 38% situated in unsuitable areas. This result shows that the integration of AHP and GIS for site suitability analysis can provides a thorough and organized method for assessing and ranking candidate sites based on a variety of factors. AHP gives decision-makers the ability to establish a clear decision hierarchy, consistently compare alternative sites, and gauge the relative importance of various factors. The major advantage of this method was the possibility to combine quantitative and qualitative criteria. However, for future studies, it is recommended to taking into account the social science parameters including social and economic aspect such as impact on population safety, impact on population density and others for better improvement.

REFERENCES

Mohit, M. A., & Sellu, G. M. (2013). Mitigation of Climate Change Effects through Non- Structural Flood Disaster Management in Pekan Town, Malaysia. Procedia - Social and Behavioral Sciences, 85, 564–573.

Department of Drainage and Irrigation. (2013). Flood Management - Programme and Activities.

Mohamad Yusoff, I., Ramli, A., Mhd Alkasirah, N. A., & Mohd Nasir, N. (2018). Exploring The Managing of Flood Disaster: A Malaysian Perspective. Malaysian Journal of Society and Space, 14(3), 24–36. https://doi.org/10.17576/geo-2018-1403-03

Mustaffa, A. A., Rosli, M. F., Abustan, M. S., Adib, R., Rosli, M. I., Masiri, K., & Saifullizan, B. (2016). A Study of Flood Evacuation Center Using GIS and Remote Sensing Technique. IOP Conference Series: Materials Science and Engineering, 136(1). https://doi.org/10.1088/1757-899X/136/1/012078

Durumin Iya, S. G., Gasim, M. B., Toriman, M. E., & Abdullahi, M. G. (2014). Floods in Malaysia Historical Reviews, Causes, Effects and Mitigations Approach. International Journal of Interdisciplinary Research and Innovations, 2(4), 59–65.

Chen, W., Zhai, G., Ren, G., Shi, Y., & Zhang, J. (2018). Urban Resources Selection and Allocation for Emergency Shelters: In a Multi-Hazard Environment. Int. J. Environ. Res. Public Health, 15.

Ronald, C. E. (2011). GIS-based Multi-Criteria Decision Analysis (in Natural Resource Management).

Muhammad, R., Wan Mohd Razi, I., Sahibin, A, R., Hazem, G, A., Hussein, A., & Ahmed Abdullah, A, D. (2023). Flood Risk and Shelter Suitability Mapping Using Geospatial Technique For Sustainable Urban Flood Management: A Case Study In Palembang City, South Sumatera, Indonesia. https://doi.org/10.1080/24749508.2023.2205717

Wang, Y., Han, Y., Luo, A., Chen, J., & Liu, W. (2024). Site Selection and Prediction of Urban Emergency Shelter Based on VGAE-RF Model. doi: 10.1038/s41598-024-64031-6

Mabahwi, N. A., Bhattacharya, Y., & Nakamura, H. (2021). GIS-Based Multi-Criteria Analysis to Identify Site Suitability of Flood Shelters in Kuantan, Malaysia. IOP Conference Series: Earth and Environmental Science, 799(1). https://doi.org/10.1088/1755- 1315/799/1/012027

Kusumo, A. N. L., Reckien, D., & Verplanke, J. J. (2017). Utilising Volunteered Geographic Information to Assess Resident's Flood Evacuation Shelters. Case Study: Jakarta. Applied Geography, 88, 174–185.

Mustaffa, A. A., Rosli, M. F., Abustan, M. S., Adib, R., Rosli, M. I., Masiri, K., & Saifullizan, B. (2016). A Study of Flood Evacuation Center Using GIS and Remote Sensing Technique. *IOP Conference Series: Materials Science and Engineering*, *136*(1)

Mior Termizi, M. A. (2016). Analysis of Site Suitability of Evacuation Area for Flood Disaster Evacuation Area.

Plan Malaysia. (2016). Rancangan Fizikal Negara.

Aidinidou, M. T., Kaparis, K., & Georgiou, A. C. (2022). Analysis, Prioritization and Strategic Planning of Flood Mitigation Projects Based on Sustainability Dimensions and A Spatial/Value AHP-GIS System. Expert Systems with Applications, 211. https://doi.org/10.1016/j.eswa.2022.118566

Zhou, G., Huang, S., Wang, H., Zhang, R., Wang, Q., Sha, H., Liu, X., & Pan, Q. (2018). International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives, 42(3), 2487–2490. https://doi.org/10.5194/isprs-archives- XLII-3-2487-2018

Liu, S., Zhao, Q., Wen, M., Deng, L., Dong, S., & Wang, C. (2013). Assessing The Impact of Hydroelectric Project Construction on The Ecological Integrity of The Nuozhadu Nature Reserve, Southwest China. https://doi.org/10.1007/s00477-013-0708-z

Azizan, N. H., Naharudin, N., Hashim, N., & Rusli, M. U. (2023). Site Suitability Analysis for Sea Turtle Nesting Area by using AHP and GIS Site Suitability Analysis for Sea Turtle Nesting Area by using AHP and GIS. *IOP Conference Series: Earth and Environmental Science*. https://doi.org/10.1088/1755-1315/1217/1/012031

Malczewski, J., & Rinner, C. (2015). Multicriteria Decision Analysis in Geographic Information Science. In *Analysis methods* (Issue Massam 1993). http://www.amazon.com/Multicriteria-Decision-Analysis-Geographic-Information/dp/3540747567/ref=sr_1_1?ie=UTF8&qid=1430864854&sr=8-1&keywords=Multicriteria+decision+analysis+in+geographic+information+science

Saaty, T. L. (2006). Rank from comparisons and from ratings in the analytic hierarchy/network processes. *European Journal of Operational Research*, *168*(2 SPEC. ISS.), 557–570. https://doi.org/10.1016/j.ejor.2004.04.032