A Study of Flood Evacuation Center Using GIS and Remote Sensing Technique

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Abstract. This research demonstrated the use of Remote Sensing technique and GIS to determine the suitability of an evacuation center. This study was conducted in Batu Pahat areas that always hit by a series of flood. The data of Digital Elevation Model (DEM) was obtained by ASTER database that has been used to delineate extract contour line and elevation. Landsat 8 image was used for classification purposes such as land use map. Remote Sensing incorporate with GIS techniques was used to determined the suitability location of the evacuation center from contour map of flood affected areas in Batu Pahat. GIS will calculate the elevation of the area and information about the country of the area, the road access and percentage of the affected area. The flood affected area map may provide the suitability of the flood evacuation center during the several levels of flood. The suitability of evacuation centers can be determined based on several criteria and the existing data of the evacuation center will be analysed. From the analysis among 16 evacuation center listed, there are only 8 evacuation center suitable for the usage during emergency situation. The suitability analysis was based on the location and the road access of the evacuation center toward the flood affected area. There are 10 new locations with suitable criteria of evacuation center proposed on the study area to facilitate the process of rescue and evacuating flood victims to much safer and suitable locations. The results of this study will help in decision making processes and indirectly will help organization such as fire-fighter and the Department of Social Welfare in their work. Thus, this study can contribute more towards the society.

Keywords: Remote sensing, evacuation center, GIS, flood affected area.

1. Introduction

Flood is a natural disaster that could bring damage to the properties, infrastructures, animals, plants and even human lives. Flood is the most significant natural hazard in Malaysia in terms of the affects towards the population, frequency of the occurrences, areas damaged, the flood duration itself and its social and economic damage. Having 189 river basins throughout Malaysia, including Sabah and Sarawak, the rivers and their corridors of flood plains fulfill a variety of functions both for human use and for the natural ecosystem. These are fundamental parts of the natural, economic, and social system. In another perspectives, despite their numerous contribution for our daily lives, rivers itself might be the largest threat to its entire corridor areas [1].

The issue of flood especially involving the emergency response solution can be approached from the aspect of the evacuation center itself by the determinations of the effectiveness of every evacuation centers and this requires multiple solutions especially in using GIS and Remote Sensing technique. GIS was the technological developments which began to develop and start to be used in Malaysia in recent years. It was widely used in many sectors, especially those who required a lot of data management. There are various definitions and purposes of GIS applications, but based on the field this study, GIS is defined as a database system that is based on computer which were designed to support the acquisition, storage, analysis and display of data or information depending on the selected location [2]. Through GIS, the information needed can be obtained quickly and accurately as well having the benefits of the ability to connect spatial data and attribute data in order to make a more effective GIS data for analysis purposes [3]. Remote Sensing are defined as the process of sensing the Earth's surface from space by using the characteristics of electromagnetic waves emitted, reflected or disclosed by the detected objects, for the purpose of improving natural resource management, land use and environmental protection [4].

Flood is a natural phenomenon where the land is covered by water that overflow by the inland water bodies or the tidal waters. There are several definitions of floods that we can take into accounts so that it can help us to see the overall picture of how flood occurs. Flooding is a natural disaster caused by factors applicable climatology or climatic factors such as temperature state, a sprinkling of rain, evaporation, wind movement and the state of the natural earth [5]. Meanwhile, another theoretical explanation that commonly used to highlight the flood situation usually caused either by the continuous rain that causes greater quantity than usual or overflow of river water to the river bank or both happen at once [6].

2. Evacuation Center

Evacuation is a risk management strategy that may be used to mitigate the effects of an emergency on a community. It involves the movement of people to a safer location and their return. For an evacuation to be effective it must be appropriately planned and implemented [7]. Evacuation Centers will be defined by the relevant jurisdictional emergency management plan, and established (activated) by responsible authority on advice of the agency controlling or coordinating the emergency. It is acknowledged that terminology is different in each state and territory [8].

Planning for an evacuation center needs to address many public health concerns. These include the physical amenities and space required for well-being, minimizing of the risk of communicable disease outbreaks, and the need to promote the health of evacuees to prevent the acute exacerbation of chronic diseases [9]. An Evacuation Center is established to provide shelter to people who are directly affected by an emergency situation and for a people that do not have anywhere else to go to. For example they have been evacuated from their homes or cannot access their homes because of the incident. Evacuation Centers are usually established in halls or school gymnasiums to provide basic shelter. As the accommodation is fairly basic, it is recommended that people seek shelter with family or friends or private accommodation if they are able to [10]

3. Methodology

Data collection is one of the important phases in designing a GIS system. Primary data consist of the data from the remote sensing images. The data was obtained from the satellite image and composed into the form of value image data. The primary data of digital elevation model (DEM) is a data which is a type of elevation representation of the terrain surface. The data is in form of raster that contain value that represent each elevation point on the earth surface. Secondary data is the data that consist on the study area data such as placement location, the land used and the population data to support the primary data. The secondary data will provide support to any limitation in the primary data. Then, interview data will be provide consist of the data that from the conversation or interview with the department of welfare. The purpose of this interview was to determine the worst area levels of flood in Batu Pahat.

In the process of mapping, DEM data that obtained from the ASTER database is used in the process of contour extraction. Contour extraction process is a process that extracts the elevation value in DEM data to create elevation value or generate the contour of the study area and this process is conducted by using ArcGIS software. From ArcGIS the contour interval is set to 2 meter high according to the flood occurrences in the study area. The contour data is then analyse for each of it elevation value to contour map of the study area. For 2 meter, 4 meter and 6 meter high to determine the flood water level area. DEM data also had been used to determine the watershed of the study area. To produce a watershed of the study area, stream network of the area is needed for generate multiple basin in Batu Pahat area. From the basin and watershed delineated, the process of incorporating the value of curve number based on different types of land use can be done. After the watershed is produced the slope generation is processed from the DEM data to determining the peak discharge of the study area.

To determine the road access of each place in Batu Pahat the topographic map was used in the process of digitization to produce a road vector. Batu Pahat map act as a base map to digitize the road vector by using ArcGIS software. The road map is needed to be positioned in the process of geocoding that is the process that placed the map into the correct position and scale for the use of the next process. All the geocoding process will use the topographic map as the reference to get the exact position.

The satellite data used in this study is the Landsat 8 image. Landsat 8 image is used in making the land use image of classification. Before the process take place, the Landsat 8 image is needed to be placed into the correct position in the process of geocoding. The process of classification is to register the difference land use type into specific classes such as urban, forestry, vegetation, water body and open area. The land use map produce in the process of classification will help in differentiate the land use type for the study area.

All maps from different sources undergone different analysis. Flood map analysis is used to determine the level of flood of the study area. Flood map is produce by the process of contour selection of the contour and elevation value of the study area. Flood affected area analysis is the analysis of area that affected with the certain level of flood. Flood evacuation center analysis is the analysis of the suitability regarding the location of the evacuation. The effectiveness analysis is to determine the effectiveness of the evacuation center itself to support the flood victims according to the population of the area. The new location of evacuation center analysis is to determine the new location of evacuation center that can be used for the time of emergency. Figure-1. Show the flowchart of methodology.

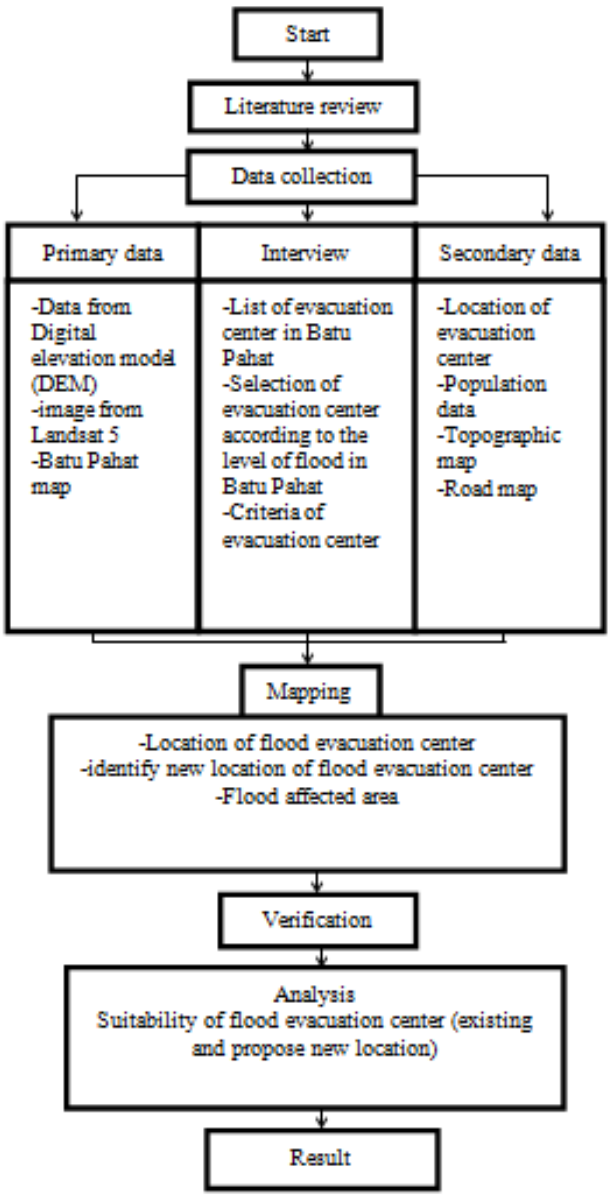

Figure 1. Flow chart of methodology.

4. Result and Discussion

Flood map is used to determine the level of flood of the study area. Flood map is produce by the process of contour selection of the contour and elevation value of the study area. The contour consists of the value of each elevation in the study area. Figure-2 show the flood map of Batu Pahat.

4.1 Flood Affected Area Analysis

Flood affected area analysis is the analysis of area that affected with the certain level of flood. This analysis consist the use of overlaid land use map with contour and elevation value. Both data need to be overlaid to show the relationship that can be produce by it. The land use map shows the characteristic of the land use classes and the contour will develop the flood level. Table-1 shows that the area coverage for the area affected by 2 metre flood from the mean sea level is 2.79% from the total area of Batu Pahat. This shows that 52.243km^2 area from 1872.56 km^2 area of Batu Pahat had been submerged by 2 metre flood.The area coverage for the area affected by 4 metre flood from the mean sea level is 5.56% from the total area of Batu Pahat. This shows that 104.114 km^2 areas from

1872.56 km^2 area of Batu Pahat had been submerge by 4 metre flood. The area coverage for the area affected by 6 metre flood from the mean sea level is 11.18% from the total area of Batu Pahat.

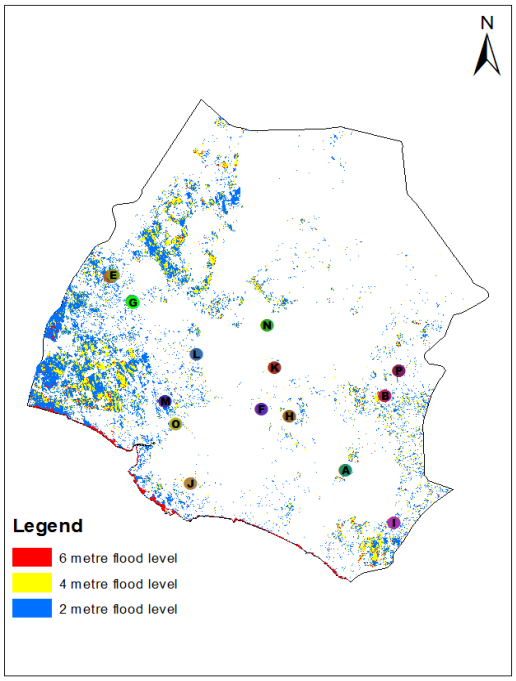

Figure 2. Flood affected area of Batu Pahat.

Table 1. Flood affected area analysis.

Flood affected area level (m)	Percentage(%)	Area affected (km^2)
2	2.79	52.243
4	5.56	104.114
6	11.18	209.49

This shows that 209.49km^2 area from 1872.56km^2 area of Batu Pahat had been submerge by 6 metre flood.

4.2 Flood Evacuation Center Analysis

Based on Table-2, it shows the evacuation center is place at the suitable distance from the flood affected area. Based from the interview data obtained from the Department of Public Welfare, one of the criteria of evacuation center is the building itself should be in the location that are reachable and safe from the flood affected area. Some of the evacuation center pass the criteria but there are certain of it did not because of the position of the building itself was placed in the affected area of flood. In this analysis we have determine that S. A. Tiga Serangkai, S. K.Tiga Serangkai and S. K. Bukit Kuari is not suitable for selected evacuation center for 4 meter and 6 meter flood. Meanwhile S. K. Sri Merlong and S. K. Kota Dalam are not suitable for selected evacuation center for 6 meter flood. Meanwhile Balairaya Parit Lapis Laman, S. K. Parit Sulong, S. A. Sengkuang, S. K. Sri Laksana, S. K. Sri Gading, S. K. Sungai Suloh, S. K. Sri Bengkal, S. A. Sri Binjai, S. K. Parit Lapis, S. K. Seri Telok, and S. M. Tinggi is suitable for selected for evacuation center in term suitability of the location in the study area. From this analysis it has been shown that the entire evacuation center listed is suitable for 2 metre flood.

Table 2. List of flood evacuation center affected.

No.	Evacuation center	Condition
1 (A)	Balairaya Parit Lapis Laman	Not affected
2 (B)	S.K. Bukit Kuari	Affected > 4 m
3 (C)	S. K. Tiga Serangkai	Affected > 4 m
4 (D)	S. K. Parit Sulong	Not affected
5 (E)	S. A. Tiga Serangkai	Affected > 4 m
6 (F)	S. A. Sengkuang	Not affected
7 (G)	S. K. Sri Laksana	Not affected
8 (H)	S. K. Sri Gading	Not affected
9 (I)	S. K. Sri Merlong	Affected > 6 m m)
10 (K)	S. K. Sungai Suloh	Not affected
11 (L)	S. K. Sri Bengkal	Not affected
12 (M)	S. A. Sri Binjai	Not affected
13 (N)	S. K. Parit Lapis	Not affected
14 (O)	S. K. Seri Telok	Not affected
15 (P)	S. M. Tinggi	Not affected
16 (Q)	S. K. Kota Dalam	Affected > 6 m

4.3 Road Access For The Evacuation Center

While, Figure-3 shows that all the evacuation selected have a road connected to it but the access of the road depend on the flood level from mean sea level. Based on the figure when flood is on 2 meter from the mean sea level, all the roads are able to access to the evacuation center and placed in a safe from flood affected area. When the flood level rises for 4 meter there are certain roads that have been affected and submerge by flood. From the analysis we found that S. A. Tiga Serangkai, S.K. Tiga Serangkai, S. K. Sri Merlong, S. K. Sungai Suloh, and S. K. Bukit Kuari does not have a proper road access for the process of delivering helps and needs of the victims. Most of the road within 1 km radius area is submerge by 4 meter flood and there is no other road that can be access to the evacuation center. For the 6 meter flood, the road that connected to the evacuation center such as S. K. Parit Sulong, S. K. Sri Laksana, and S. K. Parit Lapis are unable to be access. Most of the road within 1 km radius area is submerge by 6 meter flood and there is no other road that can be access to the evacuation center. So the evacuation centers that have the suitability to be selected as the evacuation center in term of road access for the three flood level is Balairaya Parit Lapis Laman, S. A. Sengkuang, S. K. Sri Gading, S. K. Sri Bengkal, S. A. Sri Binjai, S. K Seri Telok, S. M. Tinggi, and S. K. Kota Dalam. From this analysis the suitability of the evacuation center in term of road access is determined. For the conclusion, there are nine evacuation centers that are not suitable to be evacuation center and another seven of them suitable for being selected to be evacuation center.

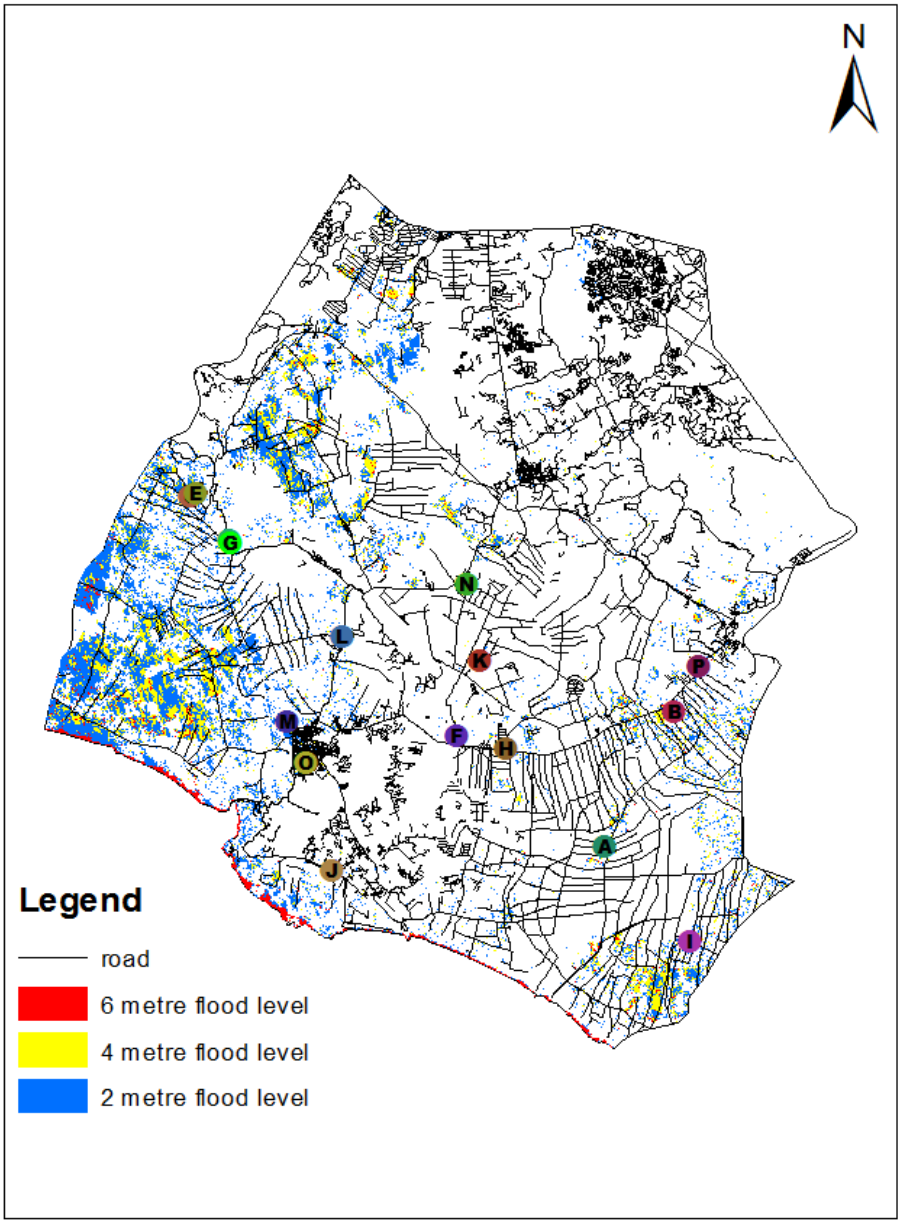

Figure 3. Road accesses for flood evacuation center on the flood map.

4.4 Evacuation Center Effectiveness Analysis

From the survey conducted by GEMA Terengganu the capacity that can be hold by the evacuation center such as Multipurpose Hall and other bigger building is 800 to 1000 capacities, School or High School is 300 to 500 capacities and for community center is 80 to 120 capacities. Multipurpose hall is the best building for being selected as an evacuation center. Based on the population data for Simpang Kiri, Lubok, Bagan, Perserai and Sungai Kluang, the total population of 64476 people are affected to the flood so it is 64 evacuation centers to hold the capacity of it. As for the Seri Medan that has average flood condition, 22501 populations of people should be hold by the evacuation center from the county of Seri Medan and the county that have low condition of flood. From the analysis at least 10 evacuation center should be open for emergency use in the county that have low flood condition such as Sri Gading, Linau, Minyak Beku, Kampung Bahru, Simpang Kanan, Chaah Baru, Tanjung Semberong and Sungai Punggor and Seri Medan should open 2 evacuation center of its own.

Table 2. List of purpose of evacuation center.

County	Population	Evacuation Cen.		
		A	B	C
Sri Gading	63903	3	1	2
Linau	8325	3	0	3
Minyak Beku	16,634	1	1	0
Kampung Bahru	11,627	1	0	1
Sg. Kluang	15,844	1	1	0
Seri Medan	22,501	4	4	0
Simpang Kanan	135,911	3	1	2
Bagan	7,440	0	0	0
Lubok	6,594	0	0	0
Perserai	9,143	0	0	0
Simpang Kiri	25,455	0	0	0
Chaah Baru	5,426	0	0	0
Tg. Semberong	34,456	0	0	0
Sg. Punggor	10,132	0	0	0

A – Existing, B – Non-suitable, C – Ready to used.

4.5 Propose of the New Location of Evacuation Center

This analysis was carried out to determine the new location of evacuation center that can be used during emergency time. The new location was determined based on several criterias as evacuation center that related with the effectiveness. It also had been determined by the suitability of the location and the road access that connected to it. Table-3 shows the new location of the proposed evacuation center on the map.

Table 3. Location of proposed evacuation center.

County	Type of Evacuation Center
Chaah Bahru	Multipurpose hall
Tanjung Semberong	SMK Dato' Seth
Seri Medan	Multipurpose hall
Linau	Multipurpose hall
Sri Gading	UTHM
SimpangKanan	SMK Dato' Bentara Luar
SimpangKanan	SMK Tun Aminah
Minyak beku	Multipurpose hall
Kampung Baharu	SMK Tunku Mahmood
Sungai Punggor	Multipurpose hall

5.0 Conclusion

This research had managed to improved several aspect on the evacuation center selection issues. In order to find the best solution for the evacuation selection location issues, a method by using GIS and Remote Sensing software have been created which is important contribution to the process of rescue and selection of the location for evacuation center. The creation of the method in software has brought new approach and technique for evacuation center site selection especially for fire fighter and Department of Public Welfare and also can make the decision makers to speed up the decision making process.

The evacuation site selection begins with the analysis of the flood map process which could determine the level of flood from the contour and elevation value of the study area. From the flood map the process continue with the analysis of the flood affected area analysis. This analysis

determines the type of the land use affected by the flood with different level from the mean sea level. There are several classes of land use type such as urban, vegetation, open, area and forestry the flood affected the land use classes. All of this analysis is to determine the area of the flood effect and the level of flood from mean sea level.

The processes continue to the location analysis of the evacuation center. The analysis determined the suitability of the location and position of the evacuation center that exist in the study area. The flood map used to helps in determination of the suitable and non-suitable evacuation center from the map. The evacuation center that is expose to the flood will be classified a non-suitable evacuation center and the spared from flood will be classified as suitable evacuation center. The analysis continues to the road access analysis that is to determine the road access of the evacuation center. The analysis had showed that the not all suitable evacuation center could have the proper road access so the suitable evacuation center will be filter down and only the suitable evacuation center with the proper road access will be selected to be used in time of emergency. All the analyses is to determine the suitability of the existing evacuation center in the study area.

The process continues with the effectiveness of the evacuation center analysis. This analysis is to determine the effectiveness of the evacuation center in providing a enough capacity of the population in the area. The criteria are important to achieve the effective evacuation center for the comfort of the flood victims.

From all the process, the new selection of evacuation center can be propose to provide the suitable and effective type of evacuation center for the use of emergency time. It is needed that to propose 1 evacuation center on each suitable county in the study area which have a good location that a near to residential area, have high elevation, can hold enough capacity of people, and have a proper road access for the use of delivering help.

From this study all the objective of determine the flood affected area and analysing the existing and propose flood evacuation center are achieve. The result of the analysis shows the completion of each objective and provided a data that can be used in the future studies.

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