

ANALYSIS OF SITE SUITABILITY OF EVACUATION AREA  
FOR FLOOD DISASTER

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ANALYSIS OF SITE SUITABILITY OF EVACUATION AREA  
FOR FLOOD DISASTER

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## ABSTRACT

The worst flood was in December 2014 in Kelantan has given a big impact in term of property damage to that area. The flood has caused many victim lost their homes and has to find a shelter that is safe from the flood. So by determining the suitable area or shelter for evacuation it can help local authorities in flood disaster management in order to help evacuees to live in the safest shelter. This study was conducted to analyze site suitability of evacuation Centre when flood disaster occur. Shelter for evacuation also identified in the study area and the existing shelter for evacuation also analyzed to see their suitability against the flood disaster. DEM and hydrological data were used to produce flood extent map, which were important to identify the extent of flood in an area. The criteria that effect the evacuation suitability were identified such as the evacuation site or shelter must near to road and healthcare centre. By using Multi-Criteria Evaluation (MCE) with Weight Linear Combination (WLC) and Analytic Hierarichy Process (AHP) technique, the criteria is weighted and combined with the flood extent. The result shows the suitability map for evacuation centre and the existing shelter is analyzed according to the suitable area map result. There is about 22 new propose evacuation centre based on the very high suitability from the suitability map of evacuation centre due to flood. Each existing and proposed evacuation centre is analyzed by factor, such as distance to health care, affected area by flood, and occupancy of the evacuation centre. These factors is weight overlay and the result shows that there are 4 from 22 existing evacuation centre are low suitability score, while 13 from 22 is in high and very high suitability, which were suitable for future flood event. The suitable site for establish temporary area also conducted where the result found 22 proposed empty land that is suitable for establish evacuation shelter or tents. This study can assist local authorities in planning, rescuing and relocating the flood victim to the safest evacuation centre.

## ABSTRAK

Banjir paling teruk telah berlaku pada Disember 2014 di Kelantan telah memberi kesan yang buruk seperti kerosakan harta benda. Banjir tersebut menyebabkan banyak mangsa kehilangan rumah mereka dan terpaksa mencari tempat perlindungan lain yang selamat dari banjir. Maka dengan menentukan kawasan atau tempat tinggal yang sesuai untuk pemindahan banjir boleh membantu pihak berkuasa dalam pengurusan bencana banjir dan membantu mangsa banjir tinggal di tempat perlindungan yang paling selamat. Kajian ini dijalankan untuk menganalisis kesesuaian pusat pemindahan apabila berlakunya bencana banjir. Tempat pemindahan mangsa banjir yang sedia ada untuk pemindahan dianalisis untuk melihat kesesuaiannya terhadap bencana banjir. Dalam kajian ini, data DEM dan hidrologi digunakan untuk menghasilkan peta limpahan banjir, ia penting untuk mengenal pasti sejauh mana limpahan banjir di sesuatu kawasan. Kriteria yang mempengaruhi kesesuaian pemindahan dikenalpasti seperti tempat pemindahan mangsa mesti berhampiran dengan jalan dan pusat penjagaan kesihatan. Dengan menggunakan Multi-Criteria Evaluation (MCE) dengan teknik Weighted Linear Combination (WLC) dan Analytic Hierarichy Process (AHP), kriteria diukur dan digabungkan dengan peta kawasan limpahan banjir. Hasil kajian menunjukkan peta kesesuaian untuk pusat pemindahan, dan tempat tinggal yang sedia ada dianalisis mengikut hasil peta kesesuaian tersebut. Terdapat 22 pusat pemindahan baru dicadangkan berdasarkan kesesuaian yang sangat tinggi dari peta kesesuaian pusat pemindahan akibat banjir. Setiap pusat pemindahan yang sedia ada dan yang dicadangkan dianalisis oleh faktor jarak kepada pusat penjagaan kesihatan, kawasan yang terjejas oleh banjir, dan jumlah penghuni pusat pemindahan. WLC digunakan untuk faktor-faktor ini dan hasilnya menunjukkan bahawa terdapat 4 daripada 22 pusat pemindahan yang sedia ada mempunyai skor kesesuaian rendah, manakala 13 daripada 22 dalam kesesuaian tinggi dan sangat tinggi, ia sesuai jika berlaku banjir pada masa hadapan. Tapak sesuai untuk membina tempat perlindungan sementara atau khemah juga dijalankan di mana hasilnya adalah 22 cadangan tanah kosong yang sesuai untuk diwujudkan tempat perlindungan.

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## LIST OF ABBREVIATIONS

AHP	Analytic Hierarchy Process
DEM	Digital Elevation Model
DID	Department of Irrigation and Drainage
GIS	Geographical Information System
JKR	Jabatan Kerja Raya
JPAM	Jabatan Pertahanan Awam Malaysia
LiDAR	Light Detection and Ranging
MCE	Multi-Criteria Evaluation
NaDMA	National Disaster Management Agencies
NDMRC	Natural Disaster Management and Relief Committee
NGO	Non-Government Organization
NSC	National Security Council
PBT	Pihak Berkuasa Tempatan
SMS	Short Messages System
WHO	World Health Organization
WLC	Weighted Linear Combination

**LIST OF SYMBOLS**

°	Degrees
%	Percent
ha	Hectare
m	Meter
km	Kilometer
m <sup>2</sup>	Meter square
m <sup>3</sup> /s	Cubic meter per second
n	Manning's value



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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background of the Problem**

Geographically, Malaysia is away from the Pacific Rim of fire and relatively free from some damaging natural disasters. However, Malaysia is still subjected to several other natural hazards for example monsoonal floods, landslides and air pollution. Among these, flood is the utmost destructive natural disaster in terms of frequency, flooded areas, people affected and economic loss.

Floods in Malaysia can be generally divided into two categories that are monsoonal flood and flash flood. Flash floods refer to a situation which happens suddenly due to prolonged heavy rain (National Weather Service, 2015). Basically, flash flood happen in a very fast and short time due to the failure of drainage system in an urban area, such as Kuala Lumpur. Monsoon floods can be defined as flooding that happens due to the result of wind that brings a lot of rain (Aziz, 2015). Generally, this monsoon flood will affect many areas in Malaysia and it happen in certain seasons. Normally, northeast monsoon floods occur from October to February and bring heavy

rainfall to Malaysia, especially Kelantan, Terengganu, Pahang, Sabah and Sarawak, while southwest monsoon floods happen from May to August and bring little rainfall to the west coast of the peninsula, including Kuala Lumpur, Selangor, Melaka, Johor, Perak, and Penang (JKR, 2015).

At the end of the year 2014, several states in Malaysia have been hit with floods, one of the country's worst incidents in history. More than 200,000 people were affected while 21 were killed in this flood disaster (AFP, 2014). As part of the northeast monsoon, heavy rains since 17 December forced 3,390 people in Kelantan and 4,209 people in Terengganu to flee their homes (The Nation, 2014).

## **1.2 Statement of the Problem**

Recent flood in Kelantan was the worst in the history of the state and superseded the flood occurred in 1967. The flood that is the worst in 30 years, with a recorded number of over 45,467 victims seeking shelter at evacuation centres (The Star Online, 2014). Two factors were believed to be the causes of this catastrophe which is the effect of weather (heavy rainfall) and uncontrolled land management in the upstream area (Azlee, 2015). The unprecedented damages were believed due to the debris flow and timber waste due to uncontrolled logging (Komoo, 2015).

During flood in Kelantan, the emergency response was handled by 3 different levels that is district, state and federal. However the scale or magnitude of the flood event was beyond expectation and control and further worsen by failed electricity supply and very limited communication. It was also reported that some of the evacuation centres and important agencies such as hospital, fire brigade, and Jabatan

Pertahanan Awam Malaysia (JPAM) were flooded and evacuees had to be transferred to another centre which already occupied beyond its designated capacity. Furthermore there were also some issues in reaching the evacuation centres as well as transporting the evacuees since the water flow is too fast and no suitable landing area for helicopter. This further complicates the process of flood aids distribution.

The limited space in evacuation shelters may cause evacuees to travel far from their home to lodging or may result in them not evacuating at all. Since evacuation shelters are almost always 'dual-use' facilities, their location in disaster situations may be less than ideal (Bandana and Michael, 2008). Dual-use facilities is the facility that turned into an evacuation shelter where the primary purpose of the facility is for some other public function such as school, hospital, and mosque. Thus, there is a need to identify suitable shelters for evacuation. Instead of constructing new shelters, the most cost effective solution is to identify existing facilities such as hospitals, recreation buildings, schools, community centres, and others that are structurally suitable for evacuees.

The evacuation area have to be away from the flood prone area and give a safer yet comfortable for the evacuees to stay on the selected evacuation area. Thus Geographic Information System (GIS) with site suitability analysis can be used to determine the suitable evacuation centre that match with criteria. A GIS provide a valuable tool in planning for, responding to and recovering from incidents that may require evacuation and shelter (UK Government, 2013). A GIS based site suitability approach is extensively used to evaluate and rank candidate facility locations (Bandana and Michael, 2008). Sites suitability analysis helps in identifying suitable sites that match specific criteria or limitation. GIS with Multi-criteria evaluation technique can be used as a process that transforms and combines geographical data and value judgments (the decision-maker's preferences) to obtain information for decision making (Ronald, 2011).

### **1.3 Aim**

The aim of this study is to analyse site suitability of the evacuation centre using the suitability criteria for evacuation centre due to flood disaster with Multi-Criteria Evaluation (MCE) technique.

### **1.4 Objectives of the Study**

Following are the objectives for this study: -

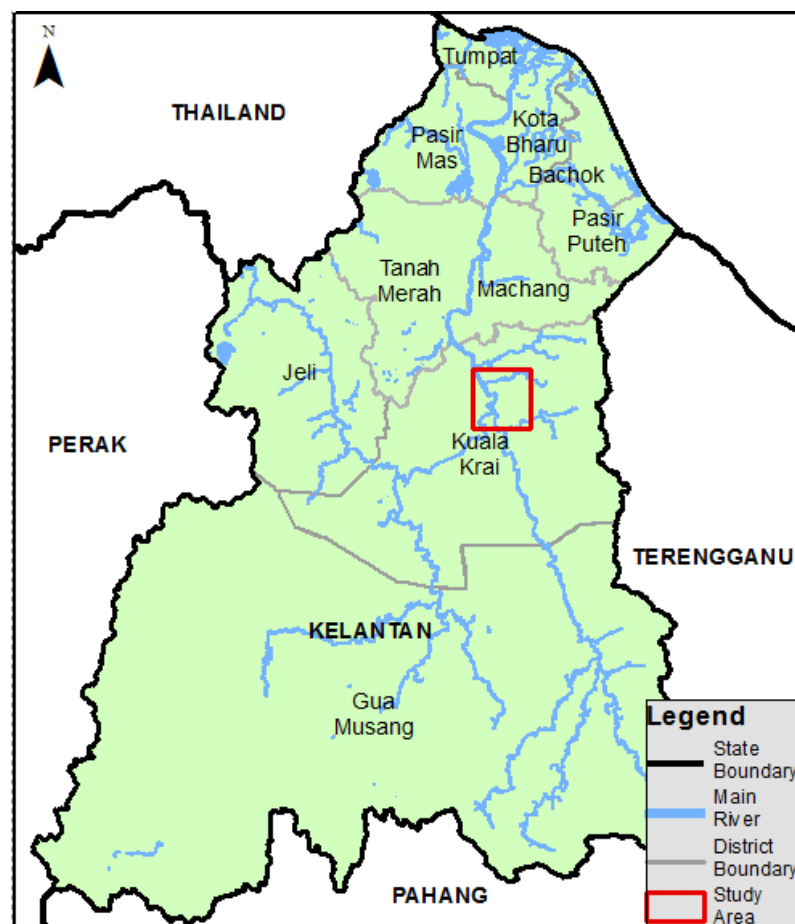
- 1) To produce a flood extent map of the study area.
- 2) To analyse site suitability for evacuation centre due to flood.
- 3) To proposed new evacuation centre due to flood.
- 4) To analyse the existing and the proposed evacuation centre suitability.

### **1.5 Scopes of the Study**

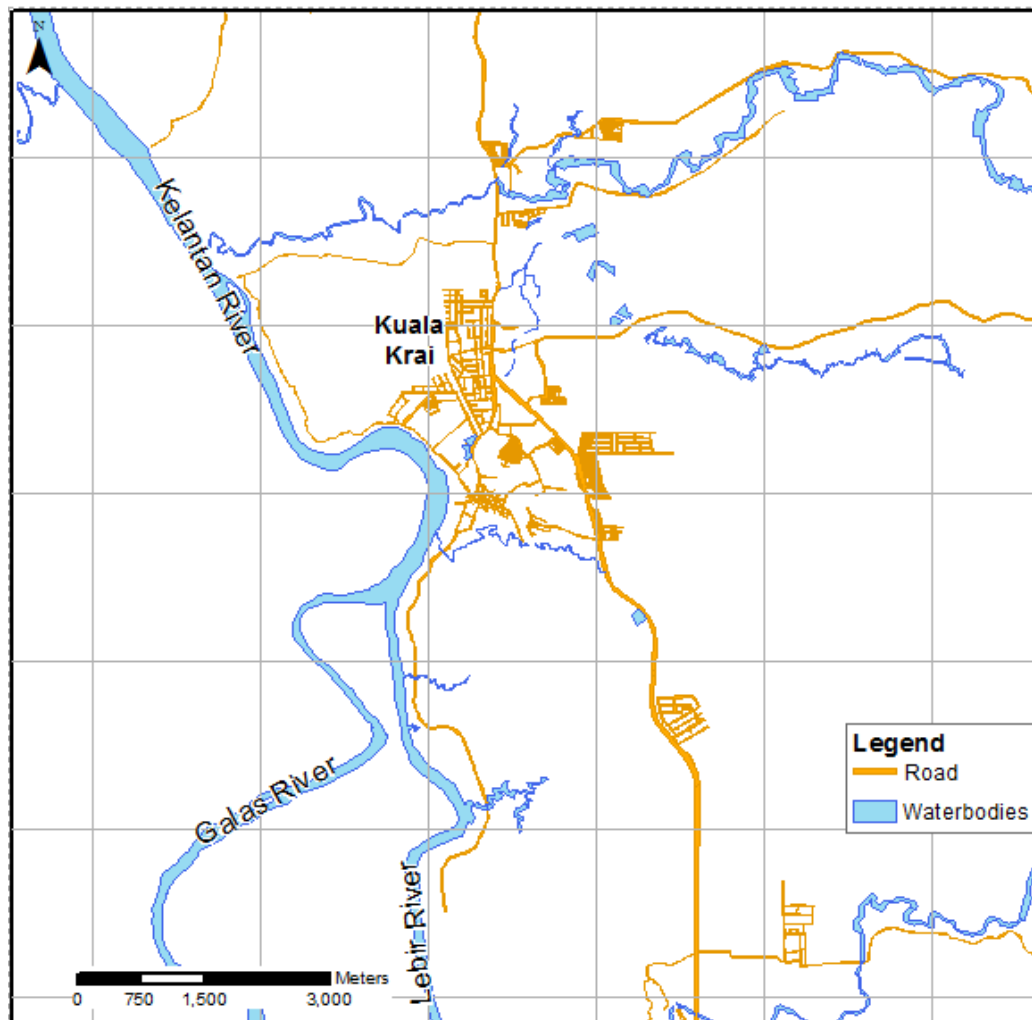
The scope of this study may include the study area, data source, and software used for completing this study.

### 1.5.1 Study Area

The study area covers the part of Kuala Krai district in Kelantan state. Kuala Krai is one of the worst district that hit with flood on year 2014 with about 5200 evacuees fled from their home to the relief centre (Bernama, 2014a). Figure 1.1 shows the study area in Kelantan state and Figure 1.2 shows the detailed study area. The area size of the study area is 14,600 ha. The main rivers in this area are Sungai Kelantan, Sungai Lebir, and Sungai Galas.



**Figure 1.1:** The location of the study area in Kelantan State.



**Figure 1.2:** The detailed location of the study area.

## 1.5.2 Data

Table 1.1 shows the data used in this studies and it also shows the description and the data specification.

**Table 1.1:** The data used in this study and its specification.

<b>Data</b>	<b>Data Format</b>	<b>Year</b>	<b>Source</b>
LiDAR 3 Meter	Raster	2007	DID Kelantan, data captured by RESGIS and AAMHatch
River water level	Textual	2014 - 2015	DID Kelantan
Stream Flow	Textual	2014 - 2015	DID Kelantan
Existing Shelter List	Textual	2014 - 2015	eBanjir
Land Use	Shapefile	2013	MaCGDI

### 1.5.3 Software

The software used in this study was mainly ArcGIS 10.3. In order to produce flood extent map, SOBEK 2.14 was used. Table 1.2 shows the software's used in this study.

**Table 1.2:** Software used in the study and with its description.

<b>Software</b>	<b>Description</b>
ArcGIS 10.3	ArcGIS used for processing multi-criteria analysis. Also used to analyses the suitability of evacuation centre and identifying suitable site for evacuation shelter/camp.
SOBEK 2.14	This software used in this research study to produce flood extent area of 200-years flood prediction



## **1.6 Significance of Study**

The results and methodology from this study can be used to determine the suitable emergency evacuation centre for flood. It may help in planning and disaster management when or after the disaster occur. Local authorities can have a better planning in rescuing and relocating the flood victims to the safest, comfortable, and establishing the evacuees live with a good health.

## **1.7 Thesis Structure**

### **Chapter 1: Introduction**

Describe the background of research which contributes on the problem statement, aim, and objectives.

### **Chapter 2: Literature Review**

Literature review that were related to this study. This chapter describe what the 2014 flood phenomena in Kelantan state and the emergency response due to the flood on that event. This chapter also review the method that will be used in this studies, and the recent studies that are related to evacuation suitability due to disaster using GIS.

### **Chapter 3: Methodology**

Consist of the research methodology that explains all the related method used in this research. This chapter describe about the methodology on producing flood extent map and to create the suitability for evacuation map using Multi-Criteria Evaluation (MCE) with Weighted Linear Combination (WLC) and Analytic Hierarchy Process (AHP).

**Chapter 4: Result and Analysis**

This chapter explains the result from methodology in the chapter three. Then the final result be analysed to answer the objectives of this research. Suitability map created in chapter three is used to analyses the existing evacuation shelter used in 2014 flood event, and also will be used to propose other evacuation shelters that are suitable when flood occurs again in the future.

**Chapter 5: Conclusion and Recommendation**

This chapter provides the conclusion with reference to the research objectives and several suggestions and recommendations for future research.

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