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FLOOD LOSS ASSESSMENT IN THE KOTA TINGGI

T H Tam[1], A L Ibrahim[1*], M Z A Rahman[2] and Z Mazura[3]
[1]Institute of Geospatial Science and Technology,
Universiti Teknologi Malaysia, 81310 UTM, Skudai, Johor, MALAYSIA
[2]TropicalMap,
Universiti Teknologi Malaysia, 81310 UTM, Skudai, Johor, MALAYSIA
[3]Dr. Nik & Associate Sdn Bhd, Kuala Lumpur, MALAYSIA

[*]E-mail: ablatif@utm.my

Abstract. Malaysia is free from several destructive and widespread natural disasters but frequently affected by floods, which caused massive flood damage. In 2006 and 2007, an extreme rainfall occured in many parts of Peninsular Malaysia, which caused severe flooding in several major cities. Kota Tinggi was chosen as study area as it is one the seriously affected area in Johor state. The aim of this study is to estimate potential flood damage to physical elements in Kota Tinggi. The flood damage map contains both qualitative and quantitative information which corresponds to the consequences of flooding. This study only focuses on physical elements. Three different damage functions were adopted to calculate the potential flood damage and flood depth is considered as the main parameter. The adopted functions are United States, the Netherlands and Malaysia. The estimated flood damage for housing using United States, the Netherlands and Malaysia was RM 350/m^2, RM 200/m^2 and RM 100/m^2 respectively. These results successfully showed the average flood damage of physical element. Such important information needed by local authority and government for urban spatial planning and aiming to reduce flood risk.

1. Introduction

Natural disasters are occurred at every part of the world. Among the natural disasters, floods are causing enormous economic losses of US $ 18 billion and about 6,000 people death annually for last 30 years. All this numbers are registered into The OFDA/CRED International Disaster Database. Similar problem occurs in Malaysia annually and also cause huge economic losses in which the average annual flood damage is as high as RM 100 million (US $ 33 million). This flood damage cost is acquired from The OFDA/CRED International Disaster Database. These flooding have caused considerable damage to highways, settlement, agriculture and livelihood. Generally, flood management approaches are used to reduce flood damage or prevent damage can be divided into structural and non-structural measures [1].

Experience shows that absolute protection against flood is impossible as flooding still continuously occur especially those protections relying on structural measures [2]. Moreover, largest floods can occur, which are larger than design floods due to failure of dikes [3]. [4] also stated that increased

[1] To whom any correspondence should be addressed.

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number of dikes do not reduce risk, in the contrast, it is increasing flood risk, especially increasing flood risk at downstream [5, 6]. In recent year, a shift has taken place from flood control approach or flood protection to flood risk management [3, 7]. This protection aims at preventing flood hazard with a certain magnitude. In contrast, flood risk management does not only consider the hazard but also the possible consequences. Therefore, flood risk management measures not only aim to control flood waters but also consider possibilities to reduce the vulnerability for flooding [8]. In other word, flood risk management is aimed at minimising adverse effects and at learning to live with floods [9]. Flood risk management can be divide into 2 steps, which is flood risk assessment and flood risk reduction. Risk assessment is to provide information on current or future flood risks in order to find out where these risks are unacceptable high, while risk reduction aims at finding measures to decrease flood risk [10].

In Malaysia, Department of Irrigation and Drainage (DID) is responsible for flood disaster mitigation. In the early of 21st century, DID have adopted a new approach for flood mitigation, which referred to “Integrated Flood Management”. This approach is lacking of development of flood risk assessment and flood risk reduction. There are also lack of study related to risk assessment have been carried out in Malaysia. Thus, an initiative to develop a framework and show preliminary results related to losses of physical elements at risks at Kota Tinggi city. The main objective of this paper is to determine the physical elements at flooding area with different magnitude flood event. Kota Tinggi situated in Johor state of Malaysia. This city was stroke twice extreme flood events at 2006/2007. This flood event was considered the most severe flood event in Malaysia history.

2. Study Area

Kota Tinggi is a town in Johor state (green box in Figure 1), Malaysia. It is located approximately 40 kilometres northeast of Johor Bahru, capital city of Johor state. The district of Kota Tinggi is located at the east of Johor state with 65% of its border is surrounded by the sea. Kota Tinggi district consists of an area of 3,500 km^2 (364,399 hectares) and divided into 11 sub-districts (Figure 1). Urbanization in this area is growing rapidly focus in agricultural activities and housing development with a population of more than 200,000 people. The administrative town of this district also was named Kota Tinggi. The average elevation of Kota Tinggi is 6 meters above mean sea level.

Figure 1. Location of study area (Green box shown the location of Kota Tinggi city).

3. Data used and Methodology

The primary data were used in this study included an optical Landsat TM 5 image, hydrological data (water level and discharge), LiDAR Digital Elevation Model (DEM), river networks and cross sections, cadastral data and real estate value information. U.S. Geological Survey (USGS) website provides free available Landsat satellite imagery covered around the world. A Landsat TM 5 image captured on 2005 at the study area was obtained at the website. Department of Irrigation and Drainage (DID), Malaysia is the main agency responsible for flood mitigation and management. Thus, data such as hydrological data (2, 25, 50, 100, and 200-yr), one meter resolution Digital Elevation Model (DEM) data, river networks, cross section were provided by DID. For Cadastral data and real estate value information were provided by Kota Tinggi District Council and Valuation and Property Services Department, Johor Bahru, respectively. The methodology of this study included 3 main parts, i.e. pre-processing part, main-processing part and lastly is analysis part.

Pre-processing part included radiometric correction of Landsat TM 5 image and resize of DEM resolution. In this study, FLAASH model was adopted to perform radiometric correction to Landsat TM 5 image. The downloaded Landsat TM 5 has been geometrically corrected. Total of 6 landuse/cover classes' map was produced using the corrected Landsat with the help of maximum likelihood technique. By referring the published Manning's roughness coefficient value, every landuse/cover class has one roughness value. The overall accuracy and kappa coefficient of the classified image are 67.52% and 66.16 respectively. Downgrade 1 m resolution DEM to 30 m that made same as Landsat image resolution. Thus, every DEM pixel contains one surface roughness value that an important parameter for flood simulation.

In this study, a hydrodynamic modelling, 1D2D Sobek was used to simulate different flood scenarios. For model setup of 1D2D SOBEK, the essential inputs included DEM, boundary conditions (discharge at upstream, water level at downstream), cross section and Manning's roughness coefficient. Calibration is an important step for any simulation in order to produce a simulation that closes to the observed data. The most important parameter for model calibration is roughness coefficient of the channel and land surface [11]. Thus, in this study, total of 2 set of Manning's n values were used in the calibration step.

Two important outputs that result from flood simulation included maximum flood extent and maximum flood depth. According to Japanese International Cooperation Agency (JICA), flood depth was used to determine the flood hazard of a particular area. Flood hazard is an input to produce flood vulnerability map with the aid of cadastral data. Depth-damage function is used to analyse the elements at risks vulnerable to flooding. This function can refer to damage factor is the range from 0 to 1. Generally, flood risk is a product of hazard (probability) and vulnerability (consequence). In this study, flood risk is defined as the potential damage associated with a flood event and expressed as monetary losses. Thus, flood damage of one unit property can be estimated as damage factor multiplied by building value. An average damage expressed as RM/m^2 is the standard unit show in flood risk map. The average damage is calculated by sum up of damage unit divide by total affected area.

4. Results and Analysis

4.1. Calibration of Flood Simulation

Among all the flood model calibration method, remote sensing has proved an indispensable tool for model calibration and validation [12, 13] because of its large coverage area and especially SAR is capable of captured data regardless day and at night time or in bad weather condition [14]. Unfortunately, calibration of flood simulation of this study can be done by visualization method.

4.2. Flood Maps

In this study, three different flood maps (flood hazard map, flood vulnerability map and flood risk map) have been produced for Kota Tinggi city. Figure 2 shows the flood map in 200-year.

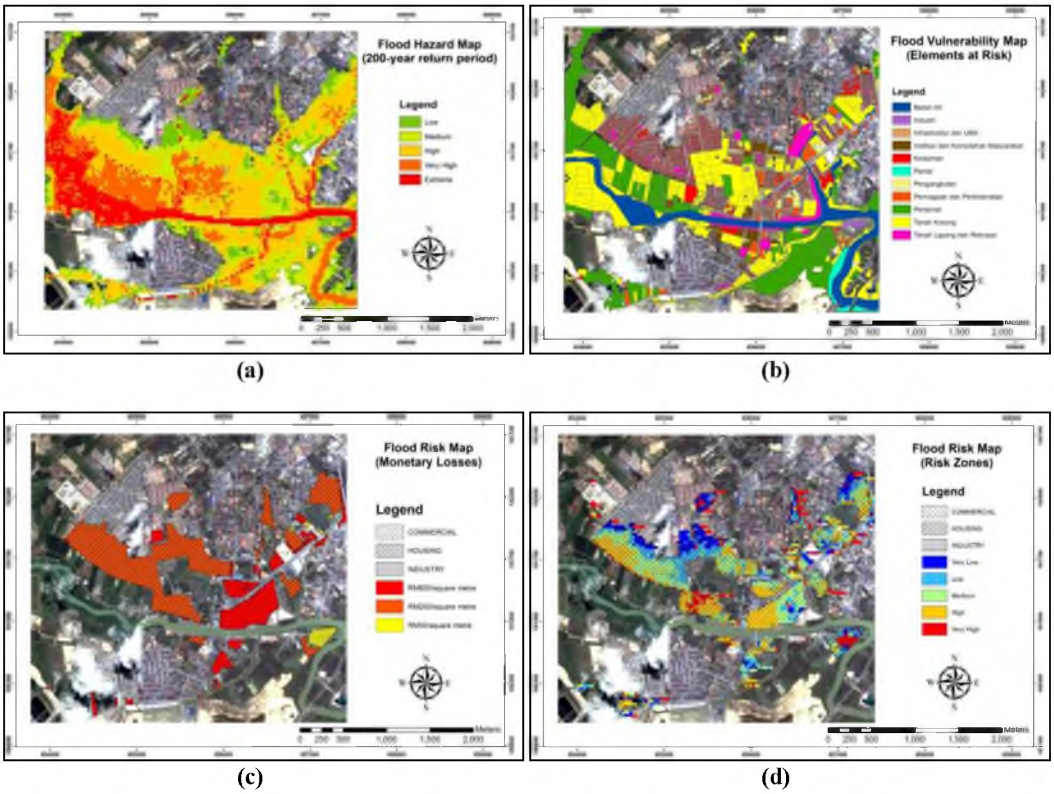

Figure 2. Flood maps show in 200-year (a) flood hazard map; (b) flood vulnerability map; (c) flood risk map (monetary losses); (d) flood risk map (risk zones).

Flood hazard map shown 5 hazard classes in term of flood depth. This map found that those areas are proximity to river is experiencing more hazards compared to those areas far from river. Areas with low topography also cause an area more hazard, which shown in the middle of Figure 2(a) where the hazard level is reached to very high category.

Flood vulnerability map displays the information of affected elements at risks, which produced by overlying of flood extent and cadastral data. This kind of map tells us the specific location of a place. So, when flooding happen, rescue works can priority on senior citizen and children at old folk home and kindergarten, respectively or patients at hospital.

Flood risk map can be delivered into qualitative and quantitative ways. Figure 2 (c) is a quantitative map which show the average flood damage of a particular area. For dwelling, commercial and industrial area, their average flood damage per meter square are RM 200/m^2, RM 800/m^2 and RM 30/m^2, respectively. These values are derived using depth-damage function from the Netherlands. Figure 2 (d) show which areas are unacceptable high risk.

5. Conclusion

The objective of this study was achieved where flood risk map has been produced for Kota Tinggi city. Production of flood risk map is very important as it provide valuable information for implementing flood risk management. Thus, every flood event happen, a preliminary flood loss in term of monetary can be obtained from flood risk map. Due to flood damage of this study is not very ideal because of lack of local-based depth-damage function. A local-based depth-damage function should be developed in order to enhance the flood risk map information. Thus, a further study should carry out.

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