DEVELOPMENT OF THE FLOOD RISK MAP FOR SUNGAI ISAP AREA

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DEVELOPMENT OF THE FLOOD RISK MAP FOR SUNGAI ISAP AREA

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for the award of the
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ABSTRACT

Flood is the most severe natural disaster that will cause huge economic loses. Sungai Isap has experienced a disastrous flood event in 2013. Flood risk map for Sungai Isap area have been developed to reduce the impact of the monsoon flood which frequently occurred at the end of year. This flood risk map also will provide an information for the communities for rescuing and preparation on facing the flood problem during the monsoon season. The main aim of this study are to develop the flood risk map based on the flood event in year 2013 at Sungai Isap area and determine flood potential area at Sungai Isap. The selected estimation of flood risk map for this study based on elevation, likelihood and vulnerability factor which contribute most of the factor of flood event in Sungai Isap area. In this study, the flood risk map produced by using ArcGIS and Google Earth software. Google Earth software is utilized for population intensity analysis and river distance calculation while ArcGIS software is used for mapping the flood risk. Classification techniques by colour such as red, orange, yellow, light green and dark green are applied in the flood risk map to make better understanding for all the communities. The risk of flood in the study area can be identified based on the development of the flood risk map by using ArcGIS software. From the result analysis, flood potential area has been identified which is the very high risk area is located at Taman Bukit Rangin (Zone 11) and low risk area is located at Sungai Isap Satu (Zone 15).

ABSTRAK

Banjir merupakan bencana alam yang paling dahsyat yang akan menyebabkan kerugian ekonomi yang besar. Sungai Isap telah mengalami peristiwa banjir yang teruk pada tahun 2013. Peta risiko banjir bagi kawasan Sungai Isap telah dihasilkan untuk mengurangkan kesan banjir monsun yang sering berlaku pada akhir tahun. Peta risiko banjir ini juga akan memberi maklumat kepada masyarkat untuk keselamatan dan persediaan bagi menghadapi masalah banjir pada musim tengkujuh. Tujuan utama kajian ini adalah untuk menghasilkan peta risiko banjir berdasarkan peristiwa banjir pada tahun 2013 di kawasan Sungai Isap dan menentukan kawasan yang berpotensi banjir di Sungai Isap. Anggaran yang dipilih untuk kajian ini adalah berdasarkan faktor ketinggian, kemungkinan dan kelemahan yang menyumbang sebahagian besar faktor peristiwa banjir di Sungai Isap. Dalam kajian ini, peta risiko banjir dihasilkan dengan menggunakan perisian ArcGIS dan Google Earth. Perisian Google Earth digunakan untuk menganalisa kepadatan penduduk dan pengiraan jarak sungai manakala perisian ArcGIS digunakan untuk pemetaan risiko banjir. Teknik pengelasan warna seperti warna merah, oren, kuning, hijau muda dan hijau gelap digunakan dalam peta risiko banjir untuk memudahkan pemahaman penduduk. Risiko banjir di kawasan kajian boleh dikenal pasti berdasarkan penghasilan peta risiko banjir dengan menggunakan perisian ArcGIS. Daripada analisis keputusan, kawasan yang berpotensi banjir telah dikenal pasti yang merupakan kawasan yang berisiko sangat tinggi terletak di Taman Bukit Rangin (Zon 11) dan kawasan berisiko rendah terletak di Sungai Isap Satu (Zon 15).

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

m	metre
km	kilometre
%	Percentage

LIST OF ABBREVIATIONS

R	Risk
H	Hazard
V	Vulnerability
SRTM	Shuttle Radar Topography Model
DEM	Digital Elevation Model
GIS	Geographical Information System
Sg.	Sungai
Tmn.	Taman
Kg.	Kampung

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Flood is a regular natural disaster that can be defined as the overflow water of its normal limit of water resources like river, lake, ocean and wetland that submerged the ground or land which is usually dry. Flood will risk the safety of the residence and property. Furthermore, it will interrupt human activities and economics in the surrounding.

In 15 back years, Kuantan was hit by a flood. According to Utusan Online as shown in Figure 1.1, Kuantan recorded 2672 people as of 34 villages affected by flood to a depth of 0.5 to 5.9 meters moved to the safest place (‘*Banjir di Pantai Timur Makin Buruk*’ 2001). The worst flood event in Kuantan was in year 2013. As stated in Utusan Online in Figure 1.2, flood in Kuantan is getting worst when a few main road to Kuantan submerged due to huge tide. This caused a few of electrical substation submerged and Tenaga Nasional Berhad decide to cut down the electricity for safety factor (‘*Banjir Kuantan Lumpuh, Talian Elektrik Diputuskan*’ 2013).

ARKIB : 24/12/2001

Banjir di Pantai Timur makin buruk

PEKAN Sungai Lembing di Pahang yang pernah terkenal dengan lombong bijih besi terdalam di dunia, kini ditenggelami air sejak banjir melanda negeri-negeri Pantai Timur Semenanjung kelmarin. - Gambar SIN CHEW.

KUANTAN 23 Dis. - Keadaan banjir di Pantai Timur Semenanjung semakin buruk apabila lebih banyak kawasan dinaiki air serta jumlah mangsa yang dipindahkan bertambah kepada 4,000 orang.

Beberapa batang jalan raya utama di Pahang dan di Kelantan masih ditutup, menyebabkan ramai pengguna jalan raya terkandas atau terpaksa mencari jalan-jalan alternatif.

Perkhidmatan kereta api antara Tumpat dan Kuala Lumpur dihentikan sementara kerana landasan di Gua Musang ditenggelami air.

Penduduk di sepanjang Sungai Kelantan pula diletakkan dalam keadaan berjaga-jaga berikutan paras air yang semakin naik.

Di **Pahang**, jumlah keseluruhan mangsa yang dipindahkan meningkat kepada 3,461 orang berbanding 1,088 orang semalam.

Figure 1.1: Online Newspaper About Flood in 2001

Source: Utusan Online

ARKIB : 04/12/2013

Bandar Kuantan lumpuh, talian elektrik diputuskan

JALAN Gambang-Kuantan di Tanah Putih menjadi sungai selepas air pasang besar yang berlarutan dari malam semalam sehingga pagi ini. - UTUSAN

KUANTAN 4 Nov. - Situasi banjir di negeri ini terutama di Kuantan bertambah buruk apabila beberapa laluan utama memasuki bandar ini terputus hubungan akibat air pasang besar yang berlaku kira-kira pukul 10 malam tadi.

Figure 1.2: Online Newspaper About Flood in 2013

Source: Utusan Online

Sungai Isap is selected for this case study in order to develop the flood risk map. It is in flood prone zone and surrounded by Sungai Kuantan. The location of Sungai Isap is shown in Figure 1.3 and 1.4 below. For information, Sungai Isap was a residential area and economic area with high populated region which is 427 515 people lives in Kuantan (Department of Statistics Malaysia 2010). Flood within this area will risk community life and losses of property. With the existing of flood risk map for Sungai Isap area, it will help all of the community to be aware which location will be in high and low risk of flood event. It also will reduce the community's losses in term of life and property.

Figure 1.3: The Location of Sungai Isap

Source: Google Earth

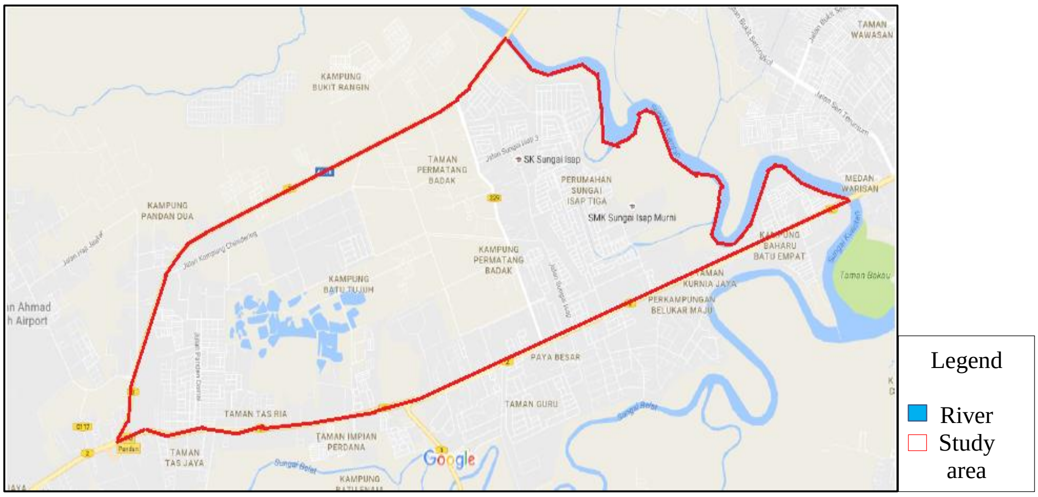

Figure 1.4: The Location of Sungai Isap

Source: Google Maps

1.2 PROBLEM STATEMENT

Pahang is located at the east coast of Peninsular Malaysia which will experience Northeast Monsoon season (November to February). The important issue to be discussed is flood problem which is always happen in most area around Kuantan as shown in Figure 1.5 below. Kuantan is a strategic place which now undergoing urbanization process. Due to this urbanization which is the conversion of land into commercial, residential and industrial properties, it caused flooding in Kuantan area.

Figure 1.5: Flood Event 2013 at Sungai Isap

Source: DID

Other than that, heavy rainfall and non-stop raining during monsoon season caused the quantity of the surface run off increase quickly and caused the low land area risk to flooding. Overflowed river water from the nearest river such as Sungai Kuantan, Sungai Pandan and Sungai Belat will caused flooding at the nearest area. Flood is a disaster that may risk surrounding such as plantation area, residential area, buildings, public facilities as well. Flood within residential area and economic area will risk community life and losses of property.

Therefore, this study is conducted to develop the flood risk map and determine the potential risk area of flooding.

1.3 OBJECTIVE

The main objective for this study of the development of the flood risk map for Sungai Isap area is stated as below:

i. to develop the risk map based on the flood event in year 2013 at Sungai Isap area.

ii. to determine flood potential area at Sungai Isap area.

1.4 SCOPE OF STUDY

Pahang which located at east coast of Peninsular Malaysia which lies in the latitude 3º45'N and longitude 102º30'E (Google). Kuantan is the capital of Pahang and its location is faces the South China Sea. Area of Kuantan is 2960 km^2 which consist of 427 515 population (Department of Statistics Malaysia 2010). Sungai Isap is selected for this case study on development of the flood risk map due to the worst affected area during flood event in 2013. Sungai Isap is located in Kuantan at latitude 3.7860ºN and longitude 103.2793ºE. Figure 1.6 and 1.7 show the location of study area.

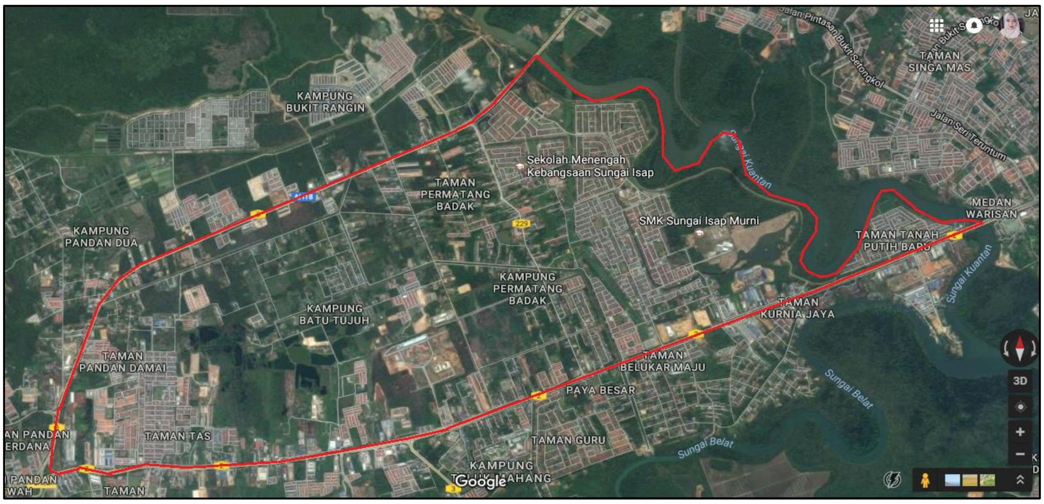

Figure 1.6: The Location of Study Area

Source: Google Earth

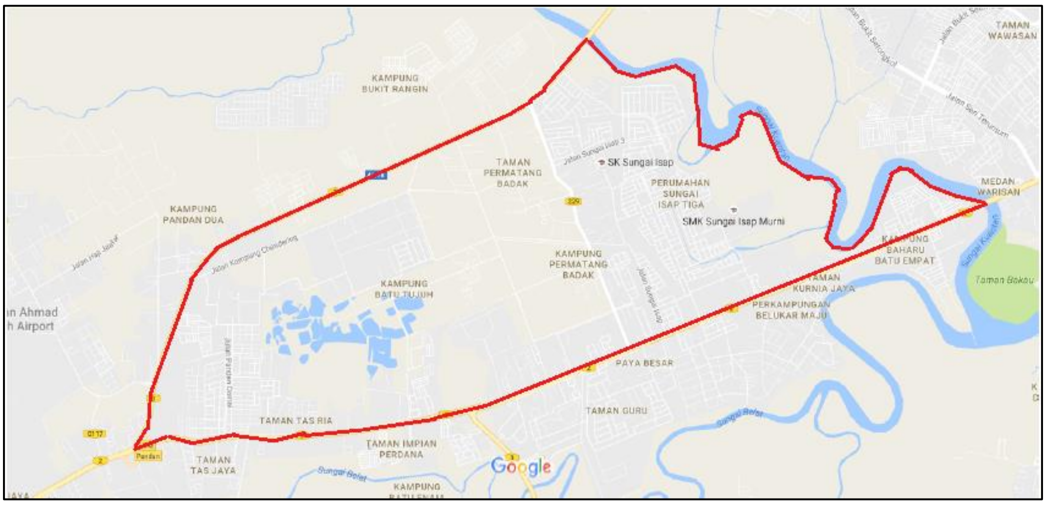

Figure 1.7: The Location of Study Area
Source: Google Maps

This study focused on the development of the flood risk map for flood event in 2013 which is during Northeast Monsoon season from November until January. The development of the flood risk map is using ArcGIS and Google Earth software and the information needed are topographic data, river distance data, and population intensity data. Risk parameter used for risk analysis are hazard, likelihood, and vulnerability.

1.5 SIGNIFICANCE OF STUDY

This significance of study is to determine flood potential risk at Sungai Isap area. The data collected is important in order to develop the flood risk map. With the information given from flood risk map, high risk flood area is determined. Furthermore, all the communities lived at high risk flood area have to be alert and prepared on facing flood which frequently occurred during the monsoon season. Thus, the location of evacuation centre for flood victims can also be placed at safe and high place at low risk flood area. This study also will provide an information for rescue team such as Jabatan Pertahanan Awam Malaysia and Bomba to focus on rescuing communities at the high risk area in advance. In addition, flood risk map can educate communities about flood and preparation on facing flood problem and it will represent the awareness level of the community towards flood issues in Sungai Isap especially during monsoon season.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Water is very important to living for human, animals, plants and all living things and sometimes water can become a hazard to surrounding. Water is used as drinking water, irrigation in agriculture, washing, cleaning, industrial purpose and hydropower. Sometimes water can create problems such as flooding, droughts, bad quality of water and might harmful for constructions. Too much or too little or in the wrong time or wrong kind of water may arise a problem. Hence, understanding the hydrological process and adapt or control the water quality can reduce or solve water problem.

2.3 HYDROLOGY CYCLE

This case study is about hydrology. Hydrology explain the complexity of the water system of the Earth in term of how water will formed under different circumstances through water cycle or hydrologic cycle. Problem related to water such as controlling flooding, flood or drought warning, flood risk assessment, planning long-term water reservoirs, water supply and protect or clean up pollution from hazardous wastes can be solved by hydrologists by applying mathematic principles and scientific science.

2.3 HYDROLOGY CYCLE

Water exist in three different states such as in solid, liquid and gas state and the formation of water in various aspect can be explained in water cycle process. Figure 2.1 shows water cycle process. The phases involved in water cycle are evaporation, condensation, evapotranspiration, precipitation, run off and infiltration. The starting point to explain the water cycle is in the water surface like pond, ocean, lakes, and reservoirs. Water from the surfaces will evaporates due to the heat energy provided by sun. These water vapour rises and form clouds, resulting in droplet growth. Cloud melt and burst resulting in precipitation of different forms like drizzle, rain, glaze, sleet, snow, snowflakes, hail, dew, frost, fog and mist.

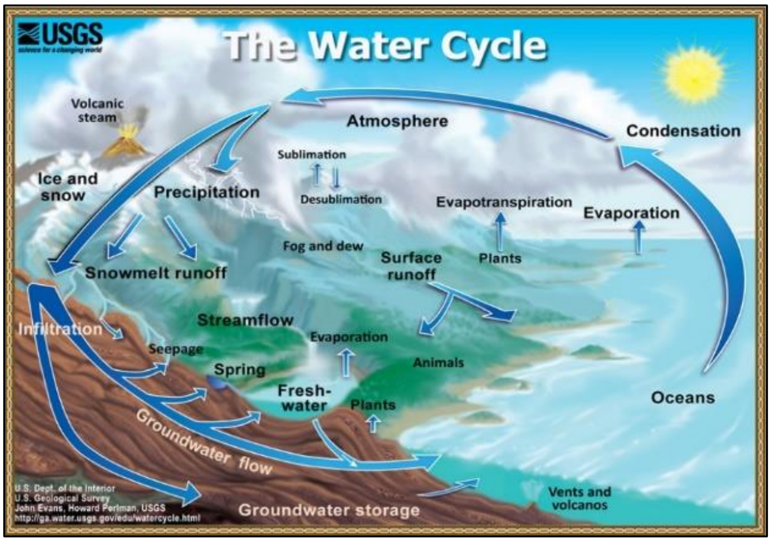

Figure 2.1: Water Cycle Process

Source: USGS Water Science School

All the precipitation fall on Earth will infiltrated into the ground until it reach the groundwater and a part of it will undergo intercepted process by vegetation and surfaces from which it may evaporated or move to ground. Vegetation sends the water from the ground surface to atmosphere through transpiration process. Another part of the precipitation will flow over the ground which is called runoff. Runoff that flow through stream and river which is called stream flow will stored water in reservoir, lakes, pond and ocean. This water cycle is a continuous cycle that there is neither a beginning nor an end or a pause.

2.3.1 Evaporation

Process changes from a liquid state to the gas state, below the boiling point through heat energy transfer at the free surface area is known as evaporation. Heat energy that hit the water molecules at the free water surface like ocean, causes the constant motion of the instantaneous velocity and average speed of the molecule to increase. When the molecules experienced kinetic energy, they may break from the water surfaces (Subramanya, 2013). Figure 2.2 below show the process of evaporation.

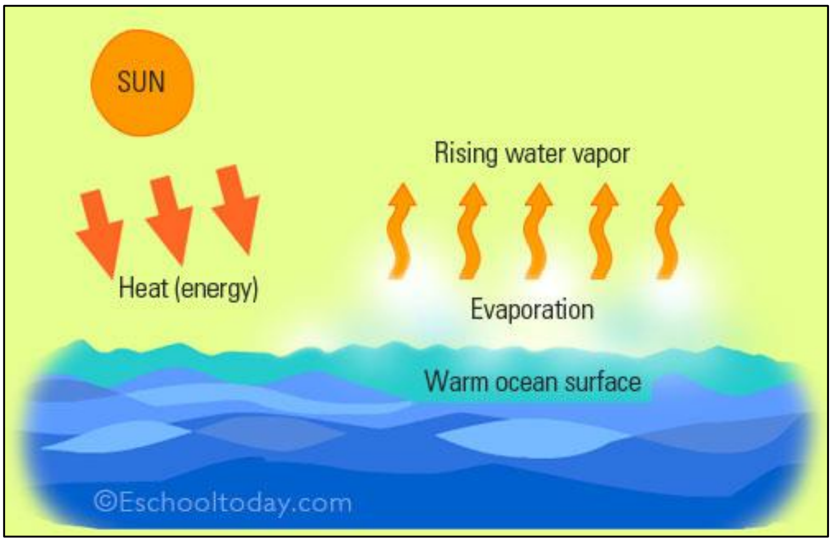

Figure 2.2: The Process of Evaporation
Source: Eschooltoday

Evaporation not only occur on the free water surface but it can even occur on raindrops, wetted soil, rock, snow, vegetation caused by human activities. Evaporated molecules lifted to the atmosphere from free water surface as water vapour.

The rate of evaporation is dependent on the water and air temperature, vapour pressure at the free water surface and air above, atmospheric pressure, speed of wind, quality of water and the size of the water body.

2.3.2 Condensation

Figure 2.3 shows the condensation process. Condensation is a crucial process where the water vapour in the atmosphere is change into a tiny liquid water. Water vapour will condenses onto small airborne particles to form fog, dew and clouds. Sea salts is the most active particles that form clouds, atmospheric ions caused lightning, and combustion products containing sulphurous and nitrous acids. Cooling of the air or increasing the amount of the vapour in the atmosphere to its saturation point will caused condensation. When the water vapour condenses back into a liquid state, heat energy is needed to make a vapour release to the air (Northwest River Forecast Center, n.d.).

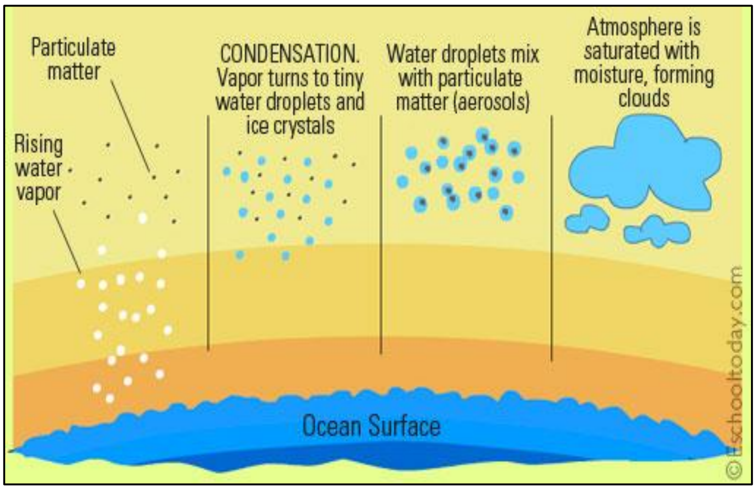

Figure 2.3: Condensation Process
Source: Eschooltoday

2.3.3 Precipitation

Precipitation is all forms of water that fall from atmosphere to Earth. Precipitation can be in different forms like drizzle, rain, glaze, sleet, snow, snowflakes, hail, dew, frost, fog and mist as shown in Figure 2.4.

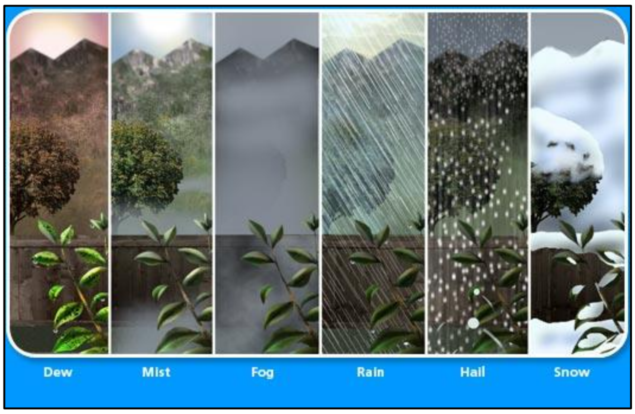

Figure 2.4: Different Forms of Precipitation
Source: Civil Engineering Forum

All different forms of precipitation can be differentiate by its appearance and physical characteristic. Drizzle is a fine of numerous small drop of size less than 0.5mm and less than 1mm/h intensity that appear to float in the air. Size of water drops in between 0.5mm and 6mm that fall from clouds is known as rain. The intensity of rain determine the category of the rain whether it is light, moderate and heavy rain. Light rain intensity is trace to 2.5mm/h, moderate rain intensity is in between 2.5mm/h and 7.5mm/h and heavy rain intensity is more than 7.5mm/h (Subramanya, 2013). Sleet or ice pellets can be known as the frozen rain drops that fall in the air at subfreezing temperature. Snow can be describe as the formation of white ice crystals at temperature below freezing point. Cold water droplets freeze onto dust particles will formed snowflakes in the air. The large effect on formation of snowflakes is the temperature of the atmosphere which is below -22ºC (Libbrecht, 2016). The formation of snowflakes can be shown in Figure 2.5.

Figure 2.5: Formation of Snowflakes On Car Window
Source: Earthsky

Hail is a precipitation that fall on Earth with small lumps of ice (more than 5mm diameter) formed by freezing and melting that is occurred in high turbulent air current (Raghunath, 2006). A small drops of moisture condensed in the air that occur upon cool surfaces is known as dew. Frost is the formation of ice that formed on the ground or exposed surface by frozen dew or water vapour. Fog is a thin cloud that usually interfering visibility at the atmosphere and mist is a formation of a very thin fog.

There are several condition in formation of precipitation which are the atmosphere must have a moisture, good weather conditions for condensation process take place and the condensation products must reach the Earth. Formation of the precipitation is depend on the meteorological factor such as the weather element like humidity, temperature and wind (Subramanya, 2013).

2.3.4 Interception

Interception is known as the volume of water or precipitation caught by vegetation. As shown in Figure 2.6, there are three possible movement of the interception which are the interception may be retained by the vegetation and evaporated to the atmosphere, water drip off from the plant leaves to join the ground surface and the precipitation may run along the leaves and branches and down the stem to reach the ground (Subramanya, 2013).

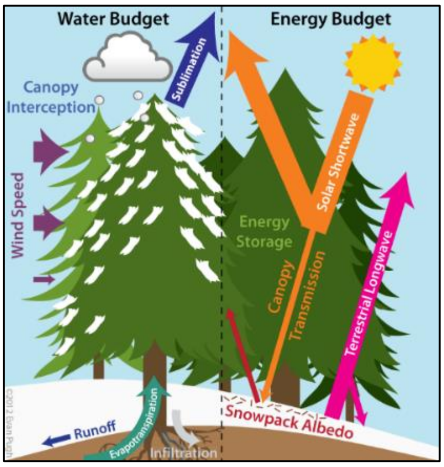

Figure 2.6: Interception Process

Source: Eric Small

2.3.5 Infiltration

A physical process involving the flow and movement of the water into the ground through the soil surface is called infiltration. Figure 2.7 shows the infiltration process. The distribution of water into the ground is related to the permeability and porosity of the soil profile. Water and precipitation will less infiltrated in the non-porous soil. The water that infiltrate in the soil will moves downward to the groundwater storage by the force of the gravity. Capacity that infiltrate in the soil is dependent on the factor of vegetative cover, soil temperature, current moisture content, characteristics of the soil and the condition of the soil surface. A clayey soil hard to infiltrate compared to a loose, permeable, sandy soil which will have a larger capacity (Subramanya 2013).

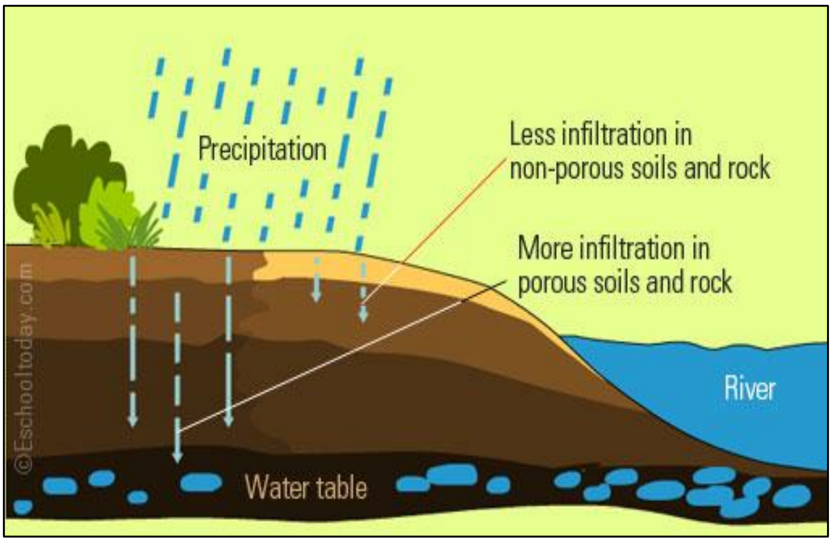

Figure 2.7: Infiltration Process

Source: Eschooltoday

2.3.6 Transpiration

Transpiration as shown in Figure 2.8 is known as the process where water leaves the body of a living plant and reaches the atmosphere as water vapour. Plant-root system will absorb the water and escapes through the leaves of the plant. There are five important factors that affecting transpiration which are temperature, atmospheric vapour pressure, light intensity, wind and characteristics of the plant, such as leaf and root systems. There are a major difference exists between transpiration and evaporation. Transpiration confined to daylight hours and the rate of transpiration is depend upon the growth periods of the plant. Evaporation continues all through day and night although the rates are different (Subramanya, 2013).

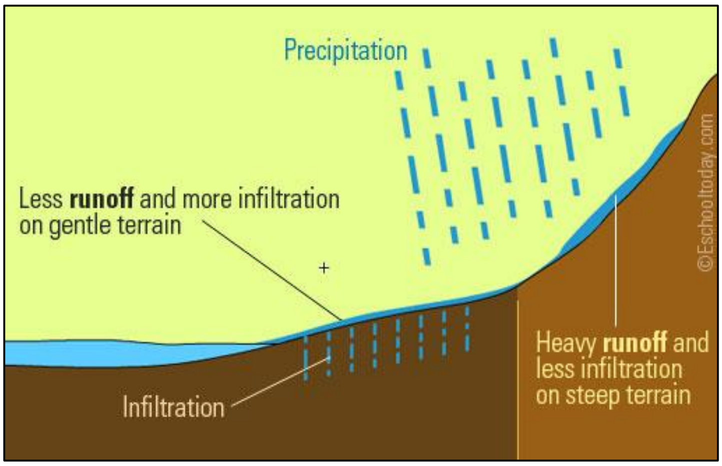

Figure 2.8: Transpiration Process

Source: Eschooltoday

2.3.7 Runoff

Runoff as shown in Figure 2.9 below is a flow of water from drainage basin or watershed in the surface streams. Precipitation flow falls directly on the stream, surface runoff that flow over the land surface and through channel, subsurface that infiltrate into soil surface and move toward the stream, and the groundwater runoff from deep percolation through the soil horizons. All the subsurface flow will enter the stream and form the total runoff. Total runoff in the stream channels is called stream flow and it is generally regarded as direct runoff (Northwest River Forecast Center, n.d.).

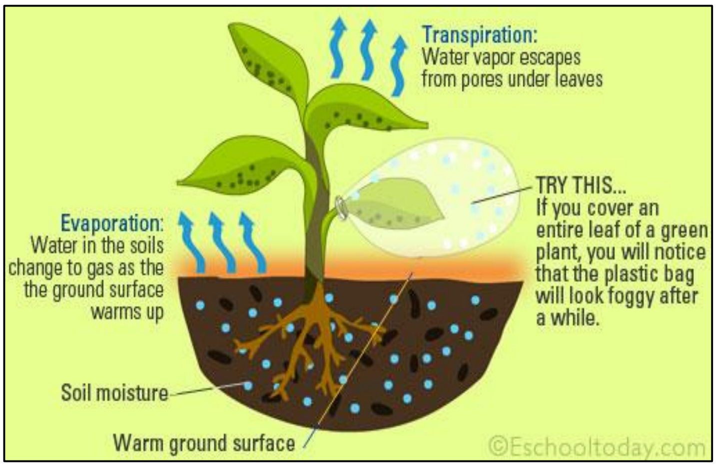

Figure 2.9: Runoff Process

Source: Eschooltoday

2.3.8 Storage

Three location of water storage are atmosphere, surface of the Earth and in the ground. Water stored in the atmosphere can be moved faster from one part to another part. The type of water storage at the surface of Earth and in the ground is depend on the geologic features. Water storage at the surface of Earth is in lakes, reservoirs, oceans and glaciers and underground water storage occurs in aquifers and soil (Northwest River Forecast Center, n.d.). Figure 2.10 below shows the water storage that exist in Earth.

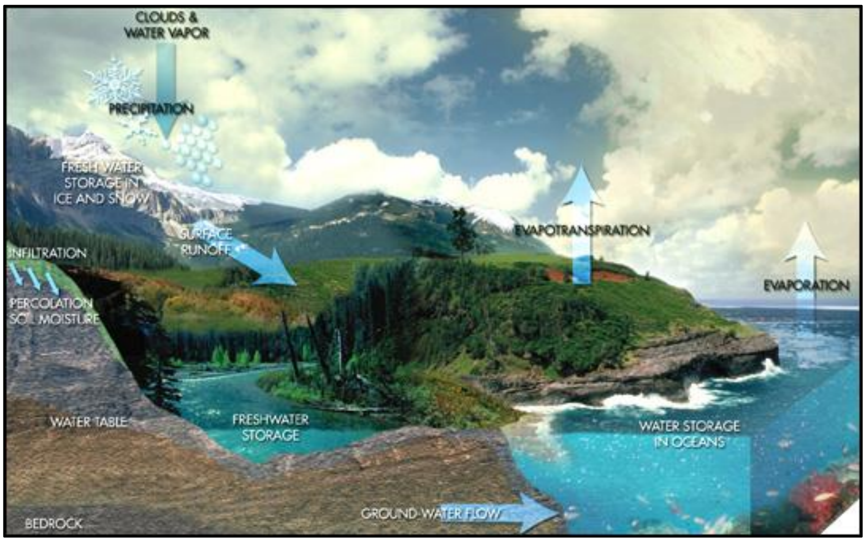

Figure 2.10: Water Storage

Source: Earth Observatory

2.4 FLOOD

Flood as shown below in Figure 2.11 is known as a regular natural disaster. According to Fifth Assessment Report of the Intergovermental Panel on Climate Change, flood can be defined as the overflow of normal limits of stream or other source of water, or accumulated water area that usually not submerged (Meyer et al. 2014). Besides that, flood also can be described as an unusual high level of river due to runoff from snow melting or rainfall in a large quantities to be confined in the normal level of water surface elevations of the stream or river, as the unusual result of meteorological combination (Raghunath, 2006).

Figure 2.11: Flood at Sungai Isap on 4th December 2013
Source: DID

Flood can be a disaster to human life, animals, plants, crops, properties, economics, buildings and all things on Earth. In September of 1900, more than 6000 people was killed at Galveston, Texas due to hurricane and subsequent storm surge. After 53 years later in February, a storm surge hit the coasts of the Netherlands and Eastern England, Europe and broke the coastal defences until it cause more than 2000 people killed and inundating 324000 hectares of land. In Italy year 1963, a huge wave caused 2000 people killed and the town of Longarone destroyed during that flood. The disaster flood in 1993 had inundating 13.5million acres of land which consists of 354 counties in 9 states of USA, erased towns, displaced 50000 people, killed 45 people and destroyed other infrastructures such as bridges and airports. In year 1998 at Bangladesh, flood affected two thirds of the country and lasted for two and half month because of the rainfall was increased during monsoon season caused by El Nino in 1997 and La Nina in 1998. During the flood peaks, 23 million people were homeless and more than 1500 people had died. The flooding was exacerbated by the construction of impermeable surfaces such as bridges, roads and homes that interfered with drainage patterns, increasing the surface runoff. Hurricane Katrina in year 2005 was the strongest storms hit the USA in 100 years and the storm surges broke levees caused widespread flooding. 80% of New Orleans, USA submerged up to 6ft as the majority of New Orleans, USA lies below sea level (Natural Disasters Association, n.d.).

2.4.1 Type Of Flood

There are several type of flood which are monsoon flood, river floods (fluvial), flash floods, urban floods, surface floods (pluvial), sewer floods, coastal floods and glacial lake outburst floods (Myles et al. 2014). Type of flood that usually occurred in Malaysia are monsoon flood, river flood, flash flood, urban flood and coastal flood. Figure 2.12 and Figure 2.13 below shows the flood prone areas in Malaysia.

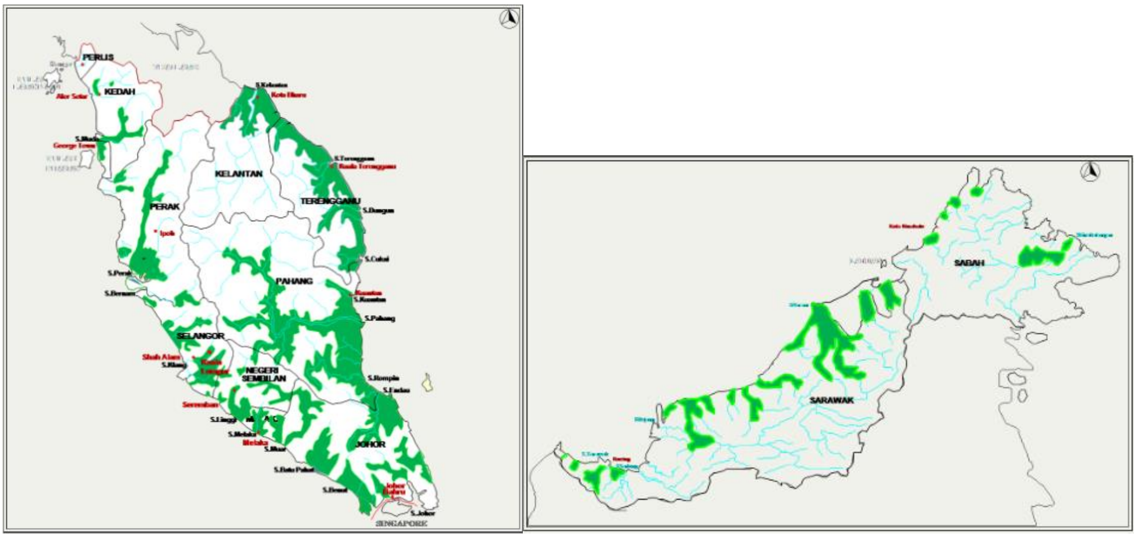

Figure 2.12 & 2.13: Flood Prone Areas in Malaysia

Source: DID

2.4.1.1 Monsoon Flood

Type of flood that usually occurred in Malaysia is monsoon flood which is as shown in Figure 2.14 below. Monsoon flood only occurs during monsoon season. Monsoon also known as the rainy season. This rainy season takes a few day of unstoppable rain either heavy rain or light rain. Unstoppable rain will cause the water rise and takes times to recede. It takes time to recede because so much water will infiltrated into the soil until the soil becomes saturated. When the rain stop, water inside the saturated soil will squeeze out slowly until its level reach normal level. Flood will become worst for the shallow area and near to the beach where as the water flow from river will collided with sea tide.

Figure 2.14: Monsoon Flood

Source: Euronews

2.4.1.2 River Flood

River flood as shown in Figure 2.15 below or known as fluvial flood occurs when excessive rainfall over an extended period of time causes a river to exceed its capacity. Besides that, ice jams and heavy snow melt can cause river flood. The damage from a river flood can be widespread as the overflow affects smaller rivers downstream. Flooding also can occur if the free flow of a river gets blocked by fallen trees, natural overgrowth or rubbish.

Figure 2.15: River Flood

Source: Zion Adventures

2.4.1.3 Flash Flood

Type of flood that usually occurred in Malaysia is flash flood as shown in Figure 2.16 below. Flash flood is a direct response to rainfall with a very high intensity and it can occurs quickly without any warned in advance. It formed from gathered steam within six hours of the event that spawned them. There are several factors contribute to the occurrence of flash flood which are rainfall intensity, surface condition, topography and duration. Urban areas are more susceptible to flash floods due to the lack of natural drainage systems and the high amounts of impervious surfaces such as concrete. These tend to increase the rate of run off into water systems.

Flash flood are characterized by a rapid rise of fast moving water. Fast moving water is extremely dangerous which water will moves at 16 kilometre per hour can exert the same pressures as wind gusts of 434 kilometre per hour. A common speed for flash flood which is 2.7 metres per second, can move rocks weighing almost 45 kilograms. Flash flood can carry debris and large object such as tress, rocks or even a vehicles that elevate their potential to damage structures and injure or might killed people.

Figure 2.16: Flash Flood in Kuantan

Source: Borneo Post

2.4.1.4 Urban Flood

Figure 2.16 below shows urban flood occur at overseas. Urban pluvial or urban flood or surface water flooding is flood that occurred in urban areas caused by intense or prolonged rainfall which overwhelms the capacity of the drainage system. This urban flood is one of the principal hazards in modern towns and cities which will leads to major economic losses and devastating social and environmental impacts.

Figure 2.17: Urban Flood
Source: NBC Philadelphia

Urban flood often happen with a little warning and in areas not obviously prone to flooding, making it is hard to predict and manage. Intense and prolonged rainfall events also can also happen in rural areas, urban flood is a predominantly urban phenomenon, as it is in urban areas that its effects are more pronounced and damaging.

Urban flood usually occur in the urban areas because of the proportion of paced surface which limit water infiltration and increase the amount of water running off the ground surface. This is worse by the fact that natural drainage routes are often changed in cities, which will result in reducing capacity for excess water. Moreover, the growing number of population in urban area and degree of urbanisation puts great pressure on the existing drainage systems, increasing the likelihood of them being overwhelmed.

In future, urban flood risk is expected to increase significantly as a result of climate changes and demographic shifts likely increase the magnitude and frequency of extreme storm events, the driving force of flooding, while the latter will increase exposure and hence, risk.

Global warming is expected to increase the frequency and intensity of the extreme rainfall events, which will cause urban flood in urban areas. Flood hazard is likely to increase even further due to the prediction of warmer and wetter winters, with increasingly more frequent rain and less frequent snow. Urban flood risk increased together with the rapid growing of urbanisation and urban population (Susana, 2006).

2.4.1.5 Coastal Flood

Coastal flood as shown in Figure 2.18 occurs along the coast of the ocean, sea or other large body of open water and it is driven predominantly by storm surges and wave damage or typically the result of extreme tidal conditions caused by severe weather. The strength, speed, size and direction of the storm is a several factors of coastal flood. This type of flood is usually connected to tropical storms, tsunamis or hurricanes. When low atmospheric pressures occurred in a storm over the ocean or sea, they sucked the water toward the centre. Problems are minimized as long as the eye is over deep water, but as the storm moves toward land it carries a dome of water that can exceed 25 feet (7.6 meters) in diameter. It will cause damage if the dome of water reaches the shoreline. At the same time, waves will broke along the shoreline assault beaches and structures nearby. 9 out of 10 fatalities are caused not by the wind in a hurricane but by fast moving of the storm surge.

Figure 2.18: Coastal Flood
Source: Times Union

There are three levels of coastal flooding can be categorized which are minor, moderate and major. A slight amount of beach erosion will occur but expected no major damage is in minor categorized and a fair amount of beach erosion will occur as well as damage to some houses and buildings is in moderate categorized. A major can be categorized as a serious threat to life and property. There will be a large scale beach erosion, many structures damage and numerous roads will flooded. Citizens live along the coastal should review on safety precautions and prepare to evacuate to a safe place if necessary.

2.4.2 Factor of Flood

There is an important factor of flood from human activities which is climate change which leads in increasing the intensity of the extreme rainfall. Other factors which may contribute to flooding are rainfall, drainage, agriculture and deforestation and human development. Other than that, disposal of solid waste into drainages and rivers and construction at rivers also will contribute to flooding.

2.4.2.1 Climate Change

According to one of the article in Journal of Hydrology, frequent and intense flood for many area around the world is caused by a warmer climate (Lu et al. 2016). Climate change leads in increasing the frequency and intensity of the extreme rainfall. Therefore, changes in term of seasonal and annual rainfall pattern will be an important factors of flood.

In United States, there are changes in extreme weather including less frequent and intense cold waves, more intense and frequent heat waves and regional changes in droughts, floods and wildfires. This extreme weather events is due to a warming planet. Scientists project that climate change will make some of these extreme weather events more likely to occur and or more likely to be severe.

Bad effect of climate change in physical impacts are wildfires, drought, flooding, heat stress, changing in temperatures, rising of sea levels, storms, stress on freshwater resources and changing in growing seasons. This physical effects of climate change can be felt everywhere.

Higher temperatures will result in increasing evaporation occurred over the oceans and seas, and leading to a greater precipitation. It also proved that higher temperature over the oceans and seas will cause the increasing frequency and severity of tropical storms. Such storm will bring a heavy rainfall and storm surges along the coast. Scientist also reported that average sea temperature rises 3 degrees Celsius and predicted that the hurricane season will occurred particularly savage in the Caribbean and the southern states of the USA. Proved that Hurricane Katrina leads to flooding of New Orleans, USA.

2.4.2.2 Rainfall

The most common cause of flooding is prolonged and high intensity of rainfall. The soil will saturated if rains for a long time and the soil will no longer be able to infiltrate leading to increasing the surface runoff.

In Malaysia, almost every year we heard news about flood. The most common flood happened especially on monsoon season or known as rainfall season roughly fall in November to February. Malaysia faces two type of monsoon which are Southwest Monsoon which fall in May to August and Northeast Monsoon which fall in November to February (Jamaludin et al. 2010).

2.4.2.3 Monsoon

During Southwest Monsoon season, the highest amount of rainfall, rainfall intensity and frequency of wet days was found in the northwestern Peninsular Malaysia area. In contrast, the greatest impact of rainfall patterns was found in the eastern Peninsular Malaysia area during Northeast Monsoon season (Jamaludin et al. 2010). Figure 2.18 below shows the rainfall pattern and direction of wind during Southwest Monsoon and Northeast Monsoon. Peninsular Malaysia which located at west Malaysia and Sabah and Sarawak which located at east Malaysia was separated by the South China Sea.

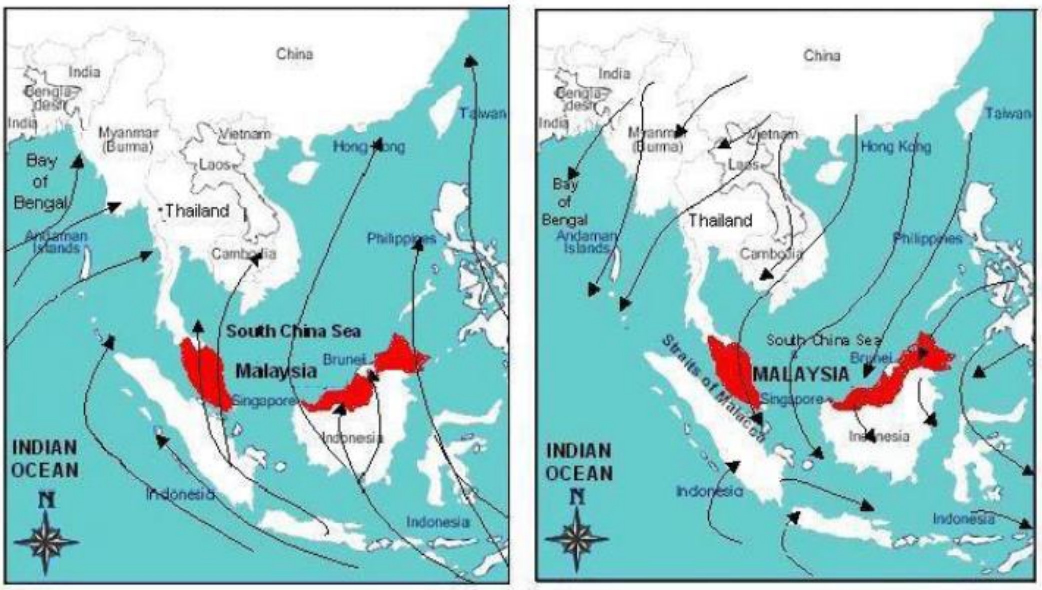

Figure 2.19: Southwest and Northeast Monsoon
Sources: (Jamaludin et al. 2010)

Pahang is located at the east coast of Peninsular Malaysia that always experience flooding event during the months of November to February during the northeast monsoon period. The floods that occur at Sungai Isap, Kuantan area of Pahang state was due to the combination of physical factors such as elevation and also its close proximity to the Sungai Kuantan apart from heavy rainfall received during the monsoon season.

2.4.2.4 Drainage

Drainage is designed to carried water away and reduce flood in urban area. When rain falls, some water will naturally infiltrate into the ground and the rest will makes its way through drainage system, into rivers and creeks and eventually into the bays, or directly to the bays through storm water beach outlets.

In residential area, commercial areas and roads need an alternative ways for this water to drain away. Large amounts of water can build up quickly during heavy rain and without proper drainage, water will flow towards low lying area that will cause flooding, damage and safety risks.

Sometimes overflowing water can lead to the road flooding or waterlogged. Material carried into the drains by floods can also lead to them becoming blocked. Drainage grills and gratings can become blocked very quickly when materials like mud are deposited on the road or when there is a heavy fall of leaves.

2.4.2.5 Agriculture And Deforestation

Large scale of agriculture can deplete topsoil, reducing the amount of nutrients present and degrading its quality. This can lead to a weakening of the surrounding plant life and reducing its ability to protect against floods.

Similarly, deforestation can remove the anchors that will keep rich soil in place and allows it to wash away and leaving dry. This will increase the amounts of water that washes into the rivers and streams, adding to the volume that passes through the water system and causing flood to occur.

Plants and geologic features are made as the natural defence against flood. Grasses, shrubs and trees help in keeping the topsoil in place to absorb all excess rainfall and extensive root systems can absorb some excess water before it overwhelms a region. Naturally occurring waterways, wetlands and flood plains are all serve as safety valves for floods, drawing high waters away and dispersing them safely. Unfortunately, human activities can disrupt both of these system, increasing the likelihood and severity of floods (Kazmeyer, n.d.).

2.4.2.6 Human Development

Urban and rural development can disrupt the natural system of waterways which will cause flood. Draining and paving over the wetlands and flood plains removes some of the natural overflow capacity of the water system, forcing the excess through the few channels still available and increasing the chances for spill over into the cities and towns. Introducing in the use of levees system potentially will give a danger situation where raising the level of river’s crest high above nearby human settlements. When one of the levees fails, it can result in a massive flood, destroying houses, crops, farms and businesses and threatening lives (Kazmeyer, n.d.).

2.4.3 Effects of Flooding

There are several effects of flooding which are in social effects, economic effects and environmental effects. Most of the flooding effect gives a negative impact towards human, nature, buildings and structure but it is also give a positive impact in term of economy, nature, agriculture, biodiversity and etc.

2.4.3.1 Social Effects

Flooding areas used for socio-economic activities will gives a variety of negative impacts. The impact is depending on the vulnerability of the population and activities, and the intensity, frequency and extent of flooding. The most and obvious effect of flooding is death. Flood, especially flash floods, will kill people because water can rise surprisingly fast with high velocity that can easily swept people away. It is also include the damage of property, destruction of crops, loss of livestock, non-functioning of infrastructure facilities and deterioration of health condition owing to waterborne diseases.

During flood, sewage pipes are often broken and raw sewage leaks into the floodwater. This will gives two effect to a social. First, it contaminates not just floodwater but drinking water too which leads to a spread of waterborne diseases such as cholera. Second, the sewage gets into people's homes which is just disgusting, horrible and incredibly difficult to clean later.

Famines during flood can lead to deaths. Usually farmland develops on floodplains, thus flood will inundated farmland. If the floodwater is polluted by sewage, it will contaminate the farmland and it is dangerous to eat any food grown. Farm animal are often killed by floods which can lead to people starving because they either don't have any source of food or any source of income to buy a food.

Also, the huge psychosocial effects on flood victims and their families can traumatize them for long periods of time. Traumatize is caused by stress either mentally or physically. Loss of property is one of the cause of mental stress. The way to overcome this from getting worse, counselling service is provided to community. Next, loss of property like television, furniture, vehicles and documents can be replaced. However, there are some documents that cannot be replaced such as heritage property. This type of important documents should be protected before anything worse happened in future. While, the loss of loved ones can gives a deep impacts, especially on children. Losing of property, homeless and disruption to business and social affairs can cause continuing stress. The stress of overcoming these losses can be overwhelming and produce lasting psychological impacts (Associated Programme on Flood Management, 2013).

2.4.3.2 Economic Effects

The biggest economic effect of flood is property damage. Water can cause a lot of damage to property and a very large and powerful flood can even dislodge buildings from their foundations and even moves them.

High cost of recovery and relief may adversely impact investment in infrastructure such as roads, power lines, water pipes etc. and other development activities in the area. During large flood event in 2009, the Northside Bridge in Workingston, Cumbria collapsed as the bridge was not designed to withstand the high discharge of the river. It is very costly for repairing bridges and other types of infrastructure. It is also can lead to a decline in the local economy as businesses are unable to operate without power and road connections. There will be an increasing in unemployment if businesses are unable to fully recover from a flood. The economic impact of infrastructure damage and unemployment is larger for countries have modern and expensive infrastructure in place. In fact, flood can lead to positive economic effects in the long term. An influx of funding to a less developed area from NGOs and charities after a flood can result in new infrastructure being constructed that is substantially better than the previous existing infrastructure. This will creates new economic opportunities in an area by for example, creating new trade routes.

Another economic benefit comes from when a river floods and deposits sediment across the floodplain. This will improves the fertility of the floodplain and agricultural yield (assuming that there is no water pollution) (Jackson, n.d.).

2.4.3.3 Environmental Effects

Polluted floodwater with sewage will pollute land and rivers when it drains back into the river. It is same cases if the river floods onto farmland, the water can be polluted by pesticides and other chemicals sprayed onto the farmland that, when the water drained back into the river, can pollute it and kill off wildlife that inhabits the river. Flooding can create wetlands that can help introduce new habitats for many species of animals if the floodwater is not polluted (Jackson, n.d.).

2.5 FLOOD MAP

Flood map is an interactive map viewer that enables users to access the information about latest flood hazard. This flood map is designed to help community and others to plan and manage to reduce flood risk, encourage people living and working in flood prone area to take fast and appropriate action and enable better planning decisions to avoid unnecessary development in flood risk areas.

Flood map will not increase the probability of flooding and identify individual property affected by flooding because flood map only provide a level view for community to make decision during flood.

There are many types of flood map such as flood hazard map, flood extent map, flood depth map and flood risk map. Figure 2.20 shows the flood inundation map in Kuantan during flood event 2001 and Figure 2.21 show the flood inundation map in Kuantan during flood event 2013.

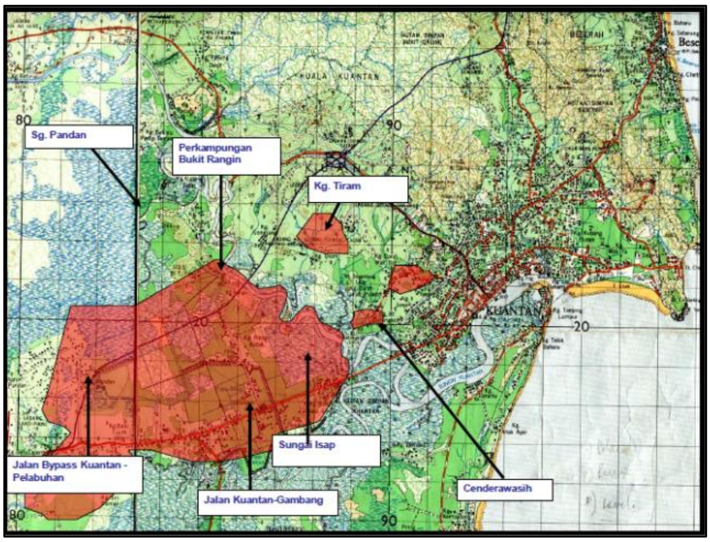

Figure 2.20: Flood Inundation Map in Kuantan During Flood Event 2001

Source: DID Pahang

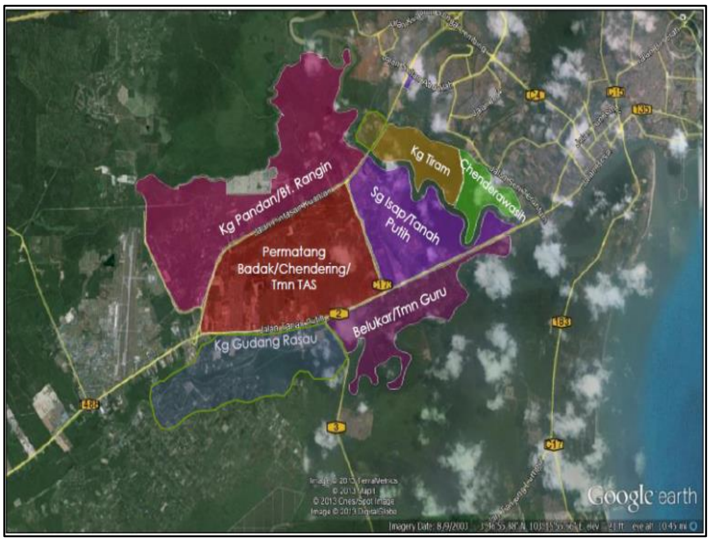

Figure 2.21: Flood Inundation Map in Kuantan During Flood Event 2013

Source: DID Pahang

2.5.1 Flood Hazard Map

Flood hazard maps contain information about the probability and / or magnitude of an event (Moel et al., 2009). According to Bapulu & Sinha (2005), flood hazard mapping is vital component for appropriate land use planning in flood-prone areas. This map is readable, rapidly accessible charts and maps which facilitate the identification of areas at risk of flooding and also helps in prioritize mitigation and response efforts. Flood hazard map is designed to increase awareness of the likelihood among the public, local authorities and other organisations. It is to encourage people living and working in flood prone areas to find out more about the local flood risk and to take fast and appropriate action (Environment Agency, 2010). Climate change must be consider when developing flood hazard map. The example of flood hazard map is shown in Figure 2.22.

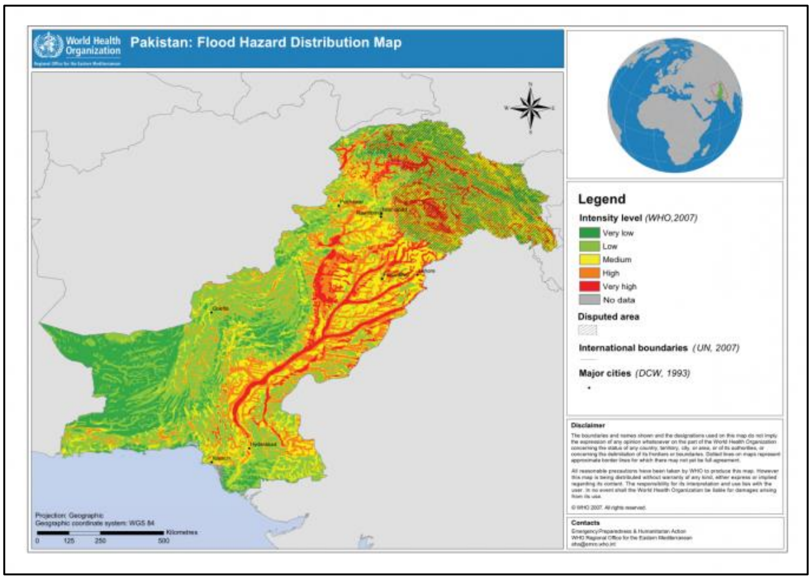

Figure 2.22: Flood Hazard Distribution Map at Pakistan

Source: World Health Organization

Flood hazard map covered geographical areas which could be flooded in three level such as low (green colour), medium (yellow colour) and high (red colour) probability of occurrence as shown in Figure 2.20. Flood hazard map represent flood extent, water depth or water level and flow velocity of the water. According to the Guide of best practices on flood prevention, protection and mitigation, “The flood hazard maps include historic as well as potential future flood events of different probability, illustrating the intensity and magnitude of hazard in a selected scale and are at the basis of considerations and determinations in land use control, flood proofing of constructions and flood awareness and preparedness” (European Exchange Circle on Flood Mapping, 2007).

2.5.2 Flood Extent Map

Flood extent maps are the most commonly produced flood maps. This type of flood map displayed the inundated areas of a specific event like historical event and hypothetical event with a specific return period such as once every 50 years or 100 years. The extents of a single or multiple flood events can be displayed and the extent of historical floods also can be shown (Moel, Alphen and Aerts, 2009). This type of flood map is use as land use planning, city and village planning, rural planning, risk management and awareness building. Figure 2.23 below shows an example of flood extent map at Hawkesbury City.

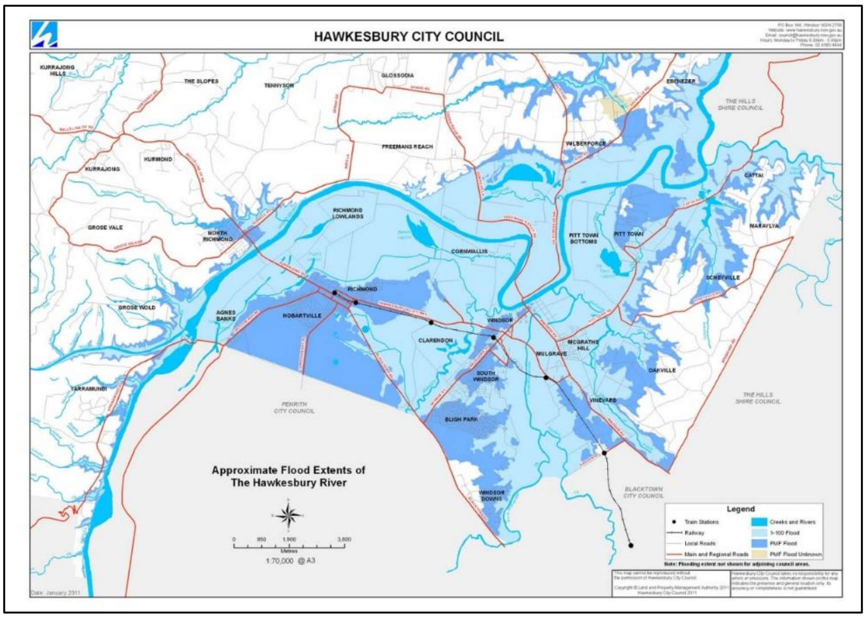

Figure 2.23: Flood Extent Map at Hawkesbury City

Source: Hawkesbury City Council

2.5.3 Flood Depth Map

Flood depth maps is regularly produced. This type of flood map is designed based on the values of water depth which can be derived from flow models on 2 dimensional and one dimensional for river flooding, from statistical analyses or from observations. The use of flood depth map are serve as a basic product to establish danger and flood damage maps, city and village planning and risk management for evacuation process

(European Exchange Circle on Flood Mapping, 2007). In most cases the depth of are presented in various colour as shown in Figure 2.24.

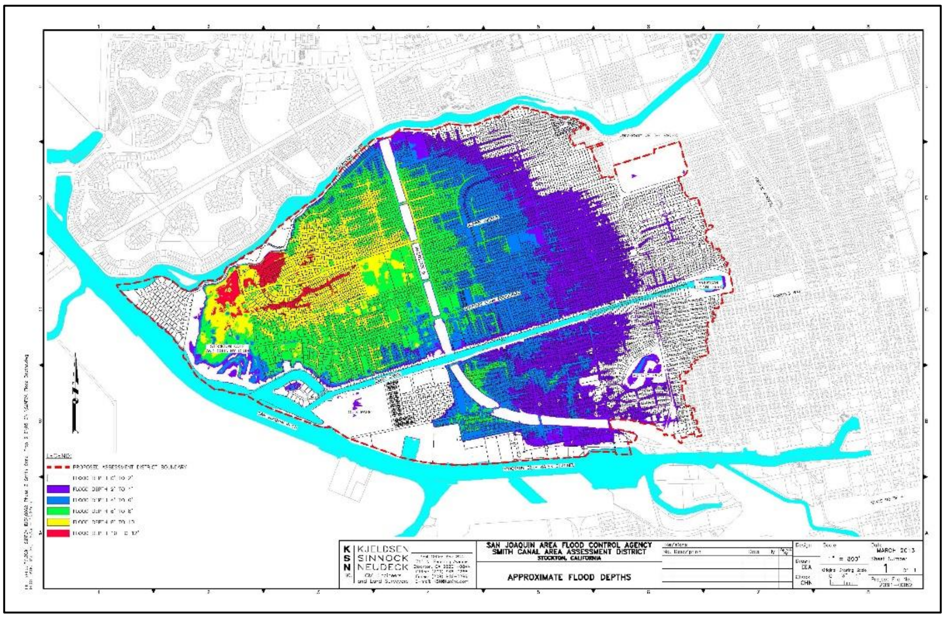

Figure 2.24: Flood Depth Map Stockton, California

Source: San Joaquin Area Flood Control Agency

2.5.4 Flood Risk Map

A very few countries have developed flood risk maps that include information on the consequences of flooding. This type of flood map are mostly developed by governmental organizations and primarily used for emergency planning, spatial planning and awareness raising (Moel, Alphen and Aerts, 2009). European Flood Directive stated that "flood risk is the combination of the probability of a flood event and potential adverse sequences to human health, economic activity, environment associated with a flood event". In particular, flood risk maps should not be considered as homogeneous as flood hazard map because of the many indicators that are available for the consequence of a flood compared to the relative few indicators for the flood hazard. In most Europe countries flood risk maps are much less developed compared to flood hazard maps. Addressing risks is more complex than addressing hazards alone. Figure 2.25 shows flood risk map for Kota Tinggi, Johor.

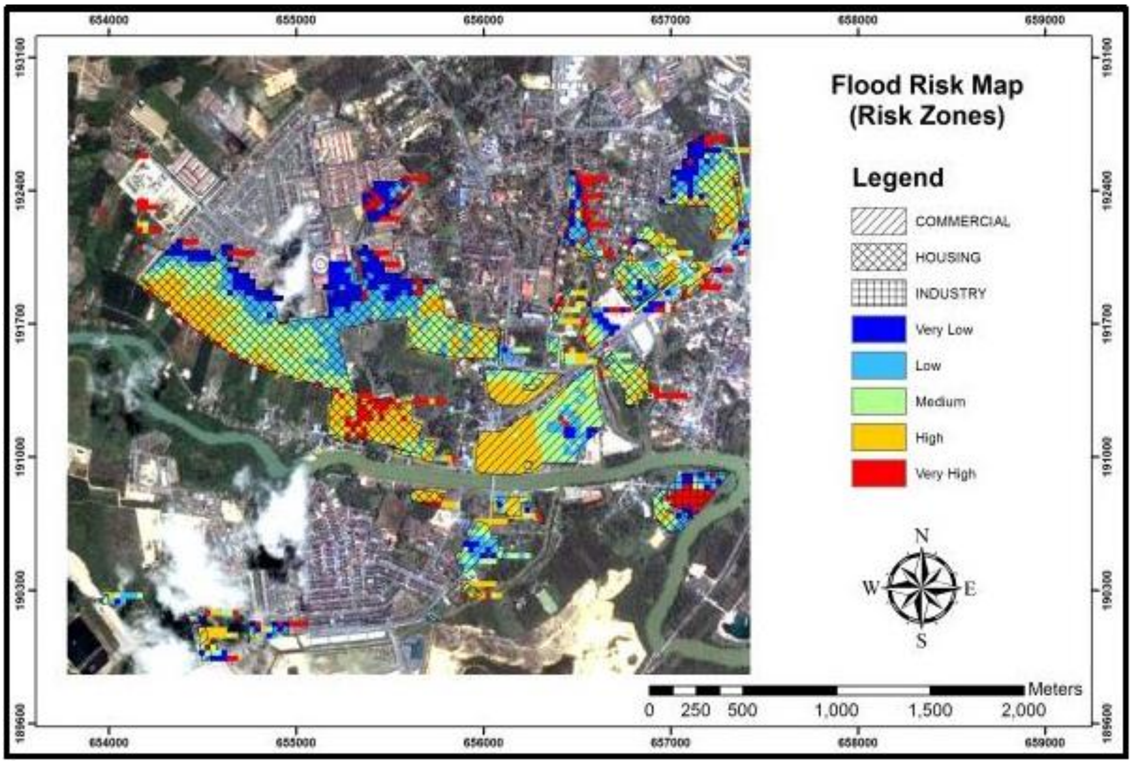

Figure 2.25: Flood Risk Map for Kota Tinggi, Johor

Source: Tam (2014)

2.6 METHOD IN DEVELOPING FLOOD RISK MAP

There are many method used to develop the flood risk map. First method used by Hassan et al. (2006) in Development of Flood Risk Map Using GIS for Sg. Selangor Basin, a hydraulic modelling is required to carry out the flood simulation to produce flood level at various location along the river and flood plain. The analysis of a river system requires data such as rainfall distribution, river properties and flood plain topography and the output of the hydraulic simulation can be transferred to GIS software to generate flood layer. Combination of GIS software and hydraulic software able to speed up the process of producing flood risk map.

Second method used by Meyer et al. (2009) in A Multicriteria Flood Risk Assessment and Mapping Approach. Meyer et al. stated that two different multicriteria decision rules, a disjunctive approach and an additive weighting approach are used to come to an overall assessment and mapping of flood risk. The risk calculation and mapping of single criteria as well as the multicriteria analysis are supported by a software tool named FloodCalc which has been developed for this purpose.

Third method used by Safaripour et al. (2012) in Flood Risk Assessment Using GIS, overuse layer was obtained using land use, slope information and susceptibility to erosion in the GIS environment. Flood hazard was obtained by overlapping three effective layer, including floodplain area, flood prone hazard and flood prone intensity. Then, the overuse layer and overlapping the layer of floor hazard and intensity are important factors in the flood risk of the region, which in turn can be an effective step toward determining the risk factors.

Fourth method used by Tam (2014) in the Development of Flood Risk Mapping in Kota Tinggi, Malaysia is primarily based on 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. Pre-processing part is mainly focus on radiometric correction which is used to produce land use or cover map using maximum likelihood technique. Main processing is to stimulate different flood scenarios using hydrodynamic modelling which will produce maximum flood extent and maximum flood depth. Generally, flood risk is a product of hazard (probability) and vulnerability (consequence). Flood risk also defined as the potential damage associated with a flood event and expressed as monetary losses.

Fifth method used by Armenakis and Nirupama (2014) in the Flood Risk Mapping for the City of Toronto, flood risk is evaluate risk by a combination of catchment characteristics including terrain slope, drainage network, and land depression as well as people’s vulnerability. Flood hazard layer (H) defined as the union of two spatial layers which are slope values of less than 2% and land depressions and vulnerability (V) defined as the combination of various vulnerable groups estimated such as population. The final flood risk (R) map was generated by the integration of the two spatial layers (H) and (V) respectively as shown in Eq. 2.1 below.

$$\text{Risk (R)} = H \times V \tag{2.1}$$

where, R = Flood Risk

H = Hazard

V = Vulnerability

Sixth method used by Elsheikh et al. (2015) in the Flood Risk Map Based on GIS, and Multi Criteria Techniques (Case Study Terengganu Malaysia), flood potential areas is determined by using Spatial Multicriteria Evaluation techniques, Pairwise Comparison (Analytical Hierarchy Process – AHP) and Ranking Method. The overlaying soil, drainage network, slope and rainfall layers were using Boolean Method. Ranking Method is used and factor rank 1 indicates the least important and 8 indicates the most important factor and Pairwise Comparison is the method involved the comparison of two criteria for flood risk parameters.

Seventh method used by Danumah et al. (2016) in Flood Risk Assessment and Mapping In Abidjan District Using Multi-Criteria Analysis (AHP) Model and Geoinformation Techniques. The Analytic Hierarchy Process (AHP) method used as a multi-criteria analysis allowed the integration of several elements under two criteria, hazards and vulnerability, for flood risk assessment and mapping.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This study is focused on developing the flood risk map at Sungai Isap area based on the worst flood event in 2013 and the most risk location in that area is determined by using Geographical Information System (GIS) software based on selected risk parameters. The study area is located in the urban area and this area is the main factor that contributes to the flood event.

Information about topographic data, river distance data and population intensity data are collected as shown in Figure 3.1 before proceed on making analysis for the flood risk map. All the data needed is derived and measured using GIS and Google Earth software. Study area was divided into 16 zones. The data that have been collected is analysed in order to transform into the flood risk map by using GIS software. The flood risk map will show the potential risk area which is in very high risk, high risk, moderate, low risk and very low risk. The colour will be used to differentiate risk type within the area. The flow chart of methodology is shown in Figure 3.1.

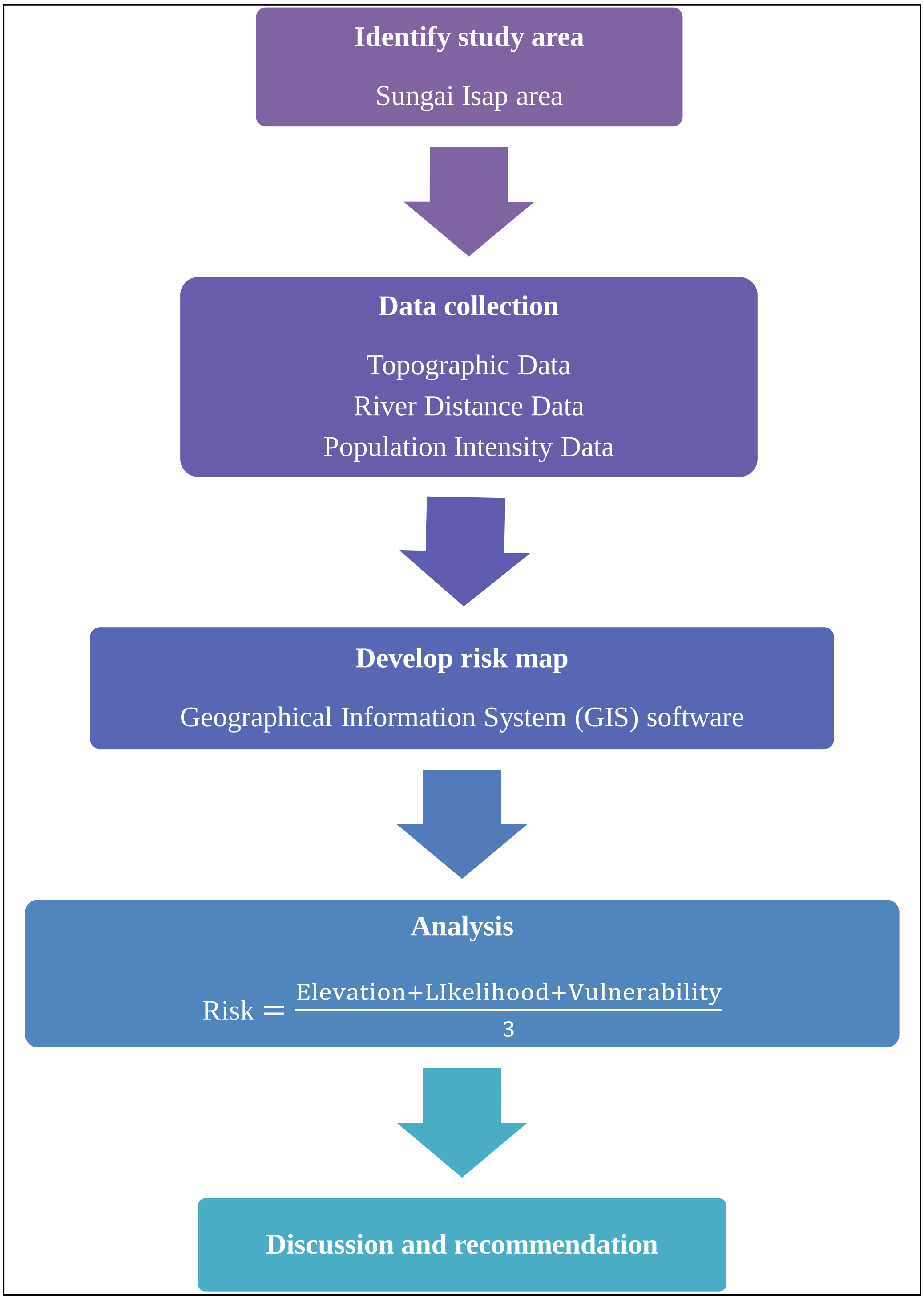

Figure 3.1: Flow Chart of Methodology

3.2 STUDY AREA

Area that covered in this study is located from Taman Tas to Sungai Isap which is shown in the red zone in Figure 3.2. This study area have been used for development purposes such as construction of residential, buildings, school, clinics, supermarket, factory etc. The population in this study area increased rapidly and more development have been carried out because of the urbanization.

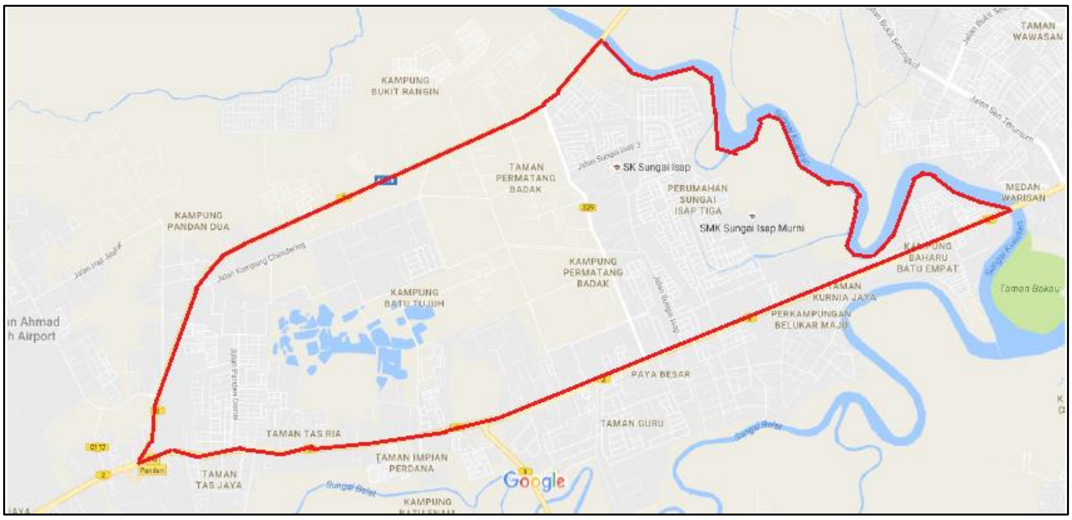

Figure 3.2: Study Area

Source: Google Map

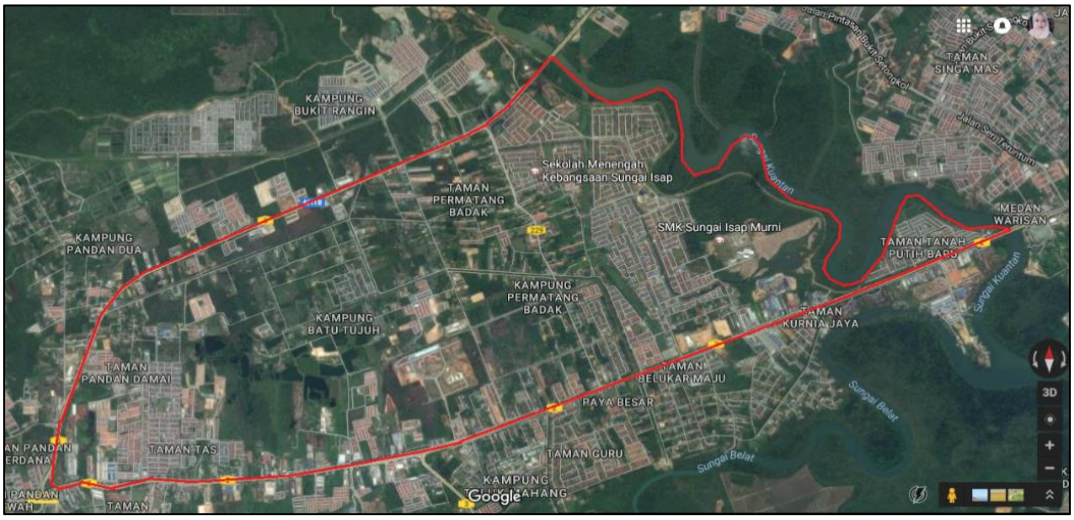

Figure 3.3: Study Area

Source: Google Earth

Study area is be divided into 16 zones as shown in Figure 3.4.

Figure 3.4: Zone Study Area

Source: Google Maps

The zones with place name is tabulated in the Table 3.1.

Table 3.1: Zone Name with Area

Zone	Place Name	Area (km^2)
1	Taman Pandan Damai	0.57780
2	Taman Tas	0.94900
3	Kampung Chendering	1.03230
4	Taman Tas Ria	1.10400
5	Kampung Baru Chendering	1.17600
6	Kampung Batu Tujuh	1.52640
7	Kampung Baru Permatang Badak	0.97940
8	Permatang Badak Perdana	1.23480
9	Taman Permatang Badak	1.12140
10	Kampung Permatang Badak	1.38000
11	Taman Bukit Rangin	1.19480
12	Taman Sepakat	1.25330
13	Sungai Isap Damai	1.06800
14	Sungai Isap	1.23820
15	Sungai Isap Satu	1.17215
16	Taman Tanah Putih Baru	0.48000

Due to the rapid development in this study area, most of the natural land has been covered by concrete surfaces. Drainage network has been set up in the study area but flooding still occur during monsoon season. The flood event in Sungai Isap area usually happen in November until January each year. The rising of water level at Sungai Kuantan during monsoon season has been a major factor of the flooding event in Sungai Isap (DID, 2012).

Within this study area, there are many houses and buildings such as shop lots, supermarkets, clinics, mosques, schools, TNB substation and etc. Figure 3.5 shows flooding area during flood event in 2013 and Figure 3.6 shows the movement of flood water.

Figure 3.5: Flooding Area During Flood Event 2013
Source: DID, Pahang

Figure 3.6: Movement of Flood Water Overflowing from River
Source: DID, Pahang

3.3 DATA COLLECTION

Valid and accurate data is important in developing the flood risk map. The information needed are topographic data, river distance data and population intensity data. All of this data derived and measured by using ArcGIS and Google Earth software.

3.3.1 Topographic Data

Topograhic data is an information about the elevation of the Earth surface. There are two type of data commonly used which is digital topographic map data that represents the information about contour lines, streams, roads, towns, railroads, etc and digital elevation models that represents the elevation or a certain point on the Earth. An accurate topographic data can be derived from the ASTER Global Digital Elevation Model (ASTER GDEM) and Shuttle Radar Topography Mission (SRTM).

Low and high lying area is determined from topographic data. Low lying area will be in a very high risk to flooding because the surface runoff will flow from higher area to lower area. Community lives in low lying area must be alert and prepared during the monsoon season while building such as school which is located in high lying area can be an evacuation centre during the flood event.

3.3.2 River Distance Data

River distance data is an information about the distance of the center of zone with the nearest river. In this study, the nearest river to the study area are Sungai Kuantan, Sungai Pandan and Sungai Belat.

Overflowed river water from the nearest river in the study area will caused flooded to the nearest area. In this study, the study area is located at the centre of the Sungai Kuantan, Sungai Pandan and Sungai Belat which can be shown in the Figure 3.7.

Figure 3.7: Nearest River to the Study Area

Source: Google Earth

3.3.3 Population Intensity Data

Population intensity data is a data collection of discrete group of people based on the land use for residential, economic, commercial, and industrial except agriculture. This type of data is needed to get the population intensity from each of study area and shows the potential number of people affected by flooding. The rescuer can prepare and provide adequately the necessities such as food, clothing and place for evacuation based on the potential number of people affected by flooding.

3.4 GEOGRAPHICAL INFORMATION SYSTEM (GIS) SOFTWARE

Geographical Information System or Geographic Information System (GIS) software as shown in Figure 3.8 is a type of software used in this study to develop the flood risk map. GIS software is a type of system designed to capture, store, manipulate, analyse, manage and display all type of spatial or geographical data. It is also a system of hardware, software, data, people, organization and institutional arrangements for collecting, storing, analysing and disseminating information about the area of the Earth that allows to do map, model, query and analyse large quantities of data within a single database according to the location.

GIS is a broad term that can refer to a number of different technologies, processes, and methods. It is attached to many operations and applications related to engineering, planning, management, transport/logistics, insurance, telecommunications and business.

In this study, GIS software have been used to analyse Shuttle Radar Topography Mission data to produce a numeric values which representing ground surface height which is above sea level based on a digital terrain model.

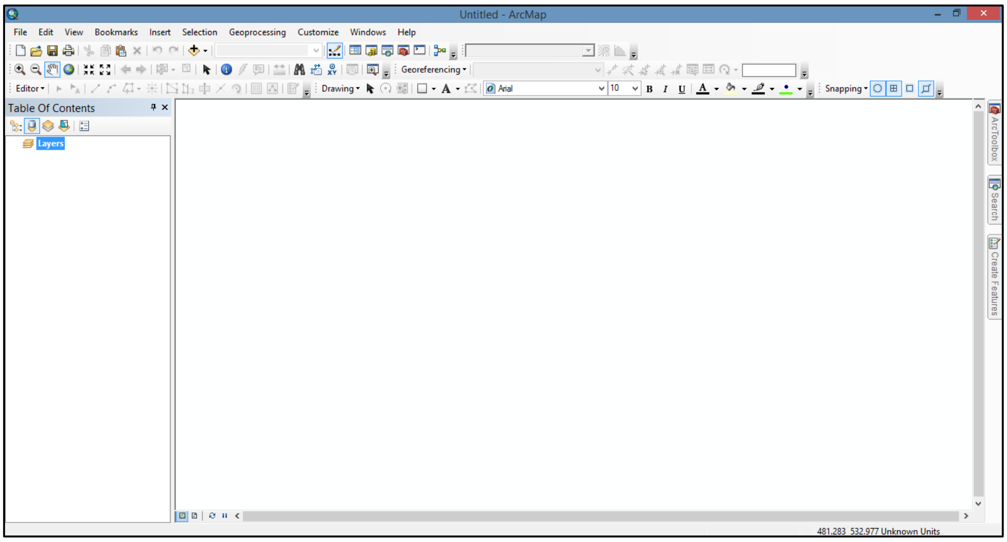

Figure 3.8: GIS Software

3.5 GOOGLE EARTH SOFTWARE

Google Earth software which is shown in the Figure 3.9 is one of the computer program that renders a simulacrum of the Earth based on satellite imagery. The Earth is mapped by the superimposition of images obtained from satellite imagery, aerial photography and geographic information system (GIS) onto a 3D globe. Google Earth displayed satellite images of varying resolution of the Earth's surface and allowed users to see things like cities and houses looking perpendicularly down or at an oblique angle or bird's eye view. Google Earth used digital elevation model (DEM) data collected by NASA's Shuttle Radar Topography Mission (SRTM).

Google Earth allowed users to search for addresses, enter coordinates, or simply use the mouse to browse to a location. In this study, Google Earth are used to measure the distance of zone to the nearest river and estimate the percentage of population intensity.

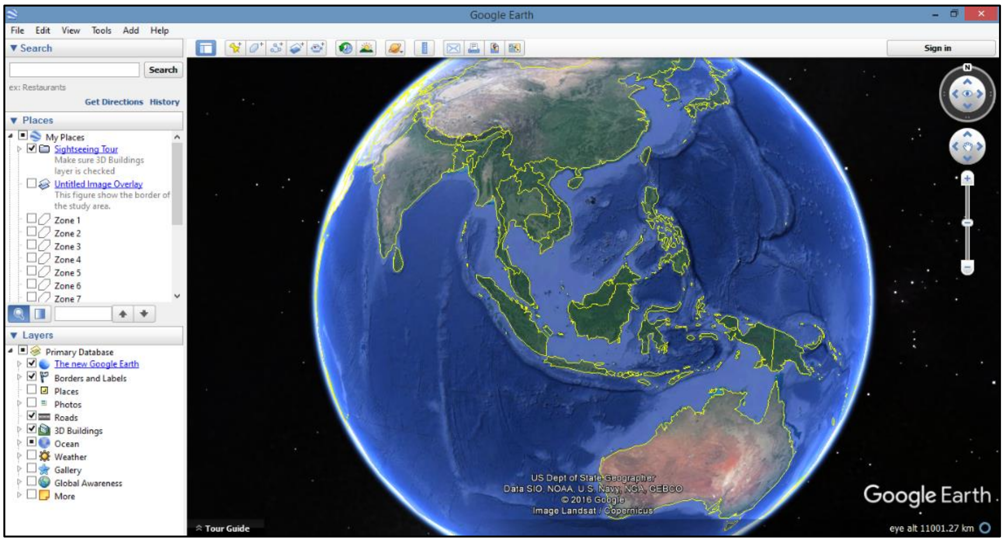

Figure 3.9: Google Earth Software

3.6 THE RISK OF FLOODING

After determined all the data needed in this study to develop the flood risk map, the next step is to obtain the risk of the location in the study area towards the flood. This method have been chosen because it is suitable and useful for small urban area. The risk parameter that required are elevation, likelihood, and vulnerability. The Eq. (3.1) will be used to calculate risk.

$$\text{Risk} = \frac{\text{Elevation}+\text{Likelihood}+\text{Vulnerability}}{3} \tag{3.1}$$

3.6.1 Measuring The Flood Elevation

Flood elevation is produced based on the result of the digital elevation model that have been derived from the Shuttle Radar Topography Mission (SRTM) data. The elevation level of each zone is determined by estimate the average of the elevation level. The high elevation level will be a low risk to be flooded while the low elevation level will be a high risk to be flooded during the monsoon season.

The data are categorized by 5 classes and the hazard scored is determined based on the elevation level which the lowest elevation level will scored 5 and the highest elevation will scored 1. Table 3.2 below shows the elevation level with its score. Elevation level in range 0 and 5 metre is rated as the very high risk which scored 5, elevation level in range 6 and 10 metre is rated as the high risk which scored 4, elevation level in range 11 and 15 metre is rated as the medium risk which scored 3, elevation level in range 16 and 20 metre is rated as the low risk which scored 2, and elevation level in range 21 and 25 metre is rated as the very low risk which scored 1.

Table 3.2: Elevation Score

Elevation Level (metre)	**Score**
21 - 25	1
16 – 20	2
11 – 15	3
6 – 10	4
0 - 5	5

3.6.2 Measuring The Flood Likelihood

The likelihood factor is measured based on the shortest distance of the center of an area to the edge of the nearest river. This measurement of river distance was done by using the Google Earth software.

The data will be classified into 5 categories. The distance from river in range 0 to 1 kilometre is rated as a very high risk which will scored 5, the distance from river in range 1.01 to 2.00 km is rated as a high risk which will scored 4, the distance from river in range 2.01 to 3.00 km is rated as a medium risk which will scored 3, the distance from river in range 3.01 to 4.00 km is rated as a low risk which will scored 2 and the distance from river in range 4.01 to 5.00 km is rated as a very low risk which will scored 1. Table 3.3 shown below is the river distance with its likelihood score. The nearer the distance of zone to the river, the higher the risk of flooding will occurred.

Table 3.3: Likelihood Score

River Distance (km)	Score
4.01 – 5.00	1
3.01 – 4.00	2
2.01 – 3.00	3
1.01 – 2.00	4
0 – 1.00	5

3.6.3 Measuring The Flood Vulnerability

This vulnerability map is developed by using population intensity data. The higher number of population will affected the higher number of people during the flood event. The most obvious factor to measure the field is based on the percentage of the population intensity in the study area.

From Table 3.4, level of risk in this study area is determined by the percentage of population intensity. The higher percentage of population intensity in range 81% to 100% is rated as a very high risk which scored 5, range 61% to 80% of population intensity is rated as high risk which scored 4, range 41% to 60% of population intensity is rated as medium risk which scored 3, range 21% to 40% of population intensity is rated as low risk which scored 2 and range 0% to 20% of population intensity is rated as a very low risk which scored 1.

Table 3.4: Vulnerability Score

Percentage of Population Intensity (%)	**Score**
0 – 20	1
21 – 40	2
41 – 60	3
61 – 80	4
81 - 100	5

3.7 CALCULATE THE FLOOD RISK

The scores that have been identified from the risk parameter is calculated using Eq. 3.1 to give a flood risk score for each zone. The risk score is categorized into five, which are very high risk, high risk, medium risk, low risk and very low risk. Table 3.5 below shows the risk level with its risk score.

From Table 3.5 below, risk level in the study area is determined by the risk score that have been calculated. The very high risk level is score 5, score range between 4.00 to 4.99 is rated as high risk level, score range between 3.00 to 3.99 is rated as medium risk level, score range between 2.00 to 2.99 is rated as low risk, and score range between 0.00 to 1.99 is rated as very low risk level.

Table 3.5: Risk Level

Score	**Risk Level**
0 – 1.99	Very Low Risk
2.00 – 2.99	Low Risk
3.00 – 3.99	Medium Risk
4.00 – 4.99	High Risk
5	Very High Risk

CHAPTER 4

RESULT & ANALYSIS

4.1 INTRODUCTION

In this study, the Google Earth software is utilized for population intensity analysis and river distance calculation while the ArcGIS software is used for mapping. First, digital elevation model of study area are derived from the Shuttle Radar Topography Mission (SRTM) data and prepared utilizing ArcGIS software.

The average of the risk factors which are vulnerability, hazard and likelihood functioned to give a flood risk score for each zone. The scores between 1 until 1.99 represented as the very low risk, scores between 2 until 2.99 represented as the low risk, 3 until 3.99 represented as the medium risk, scores between 4 until 4.99 represented as the high risk and 5 represented as the very high risk. The five categories is differentiated by using colours to make the flood risk map easily to be understood by the interested parties or agencies.

The developed flood risk map can be used as the most important medium for City Planning Division to develop and plan an effective flood mitigation to minimize the impact of monsoon flood which frequently occurred at the end of year. Besides that, this flood risk map will provide an information for the rescue team such as Jabatan Pertahanan Awam and Bomba to focus on rescuing communities at the very high risk zone in advance. The communities also have to be alert and prepared on facing the flood problem which will frequently occurred during the monsoon season.

4.2 ANALYSIS OF DIGITAL ELEVATION MAP

The data used in carrying out this study is derived from the Shuttle Radar Topography Mission (SRTM) data which is available in United States Geological Survey (USGS) website. The data obtained is analysed using ArcGIS to produce a numeric values which representing ground surface height which is above sea level based on a digital terrain model. Slope, hillshade and contour also can be produced and analysed by using ArcGIS software. The area of the SRTM data is larger than the study area. Thus to focus on the study area, the process of clipping map according to the shape of the study area map had to be run. Figure 4.1 show the result of the digital elevation map after undergo the process of clipping map. Contour for the study area also can be created through the digital elevation map.

The colours of the digital elevation map is changed according to the level of risk that had been identified. In this study area, the elevation level 0 m until 5 m was stated as the very high risk area which is shown in the red colour, the elevation level 6 m until 10 m was stated as the high risk area which is shown in the orange colour, the elevation level 11 m until 15 m was stated as the medium risk area which is shown in the yellow colour, the elevation level 16 m until 20 m was stated as the low risk area which is shown in the light green and the elevation level 21 m until 25 m was stated as the very low risk area which is shown in the dark green.

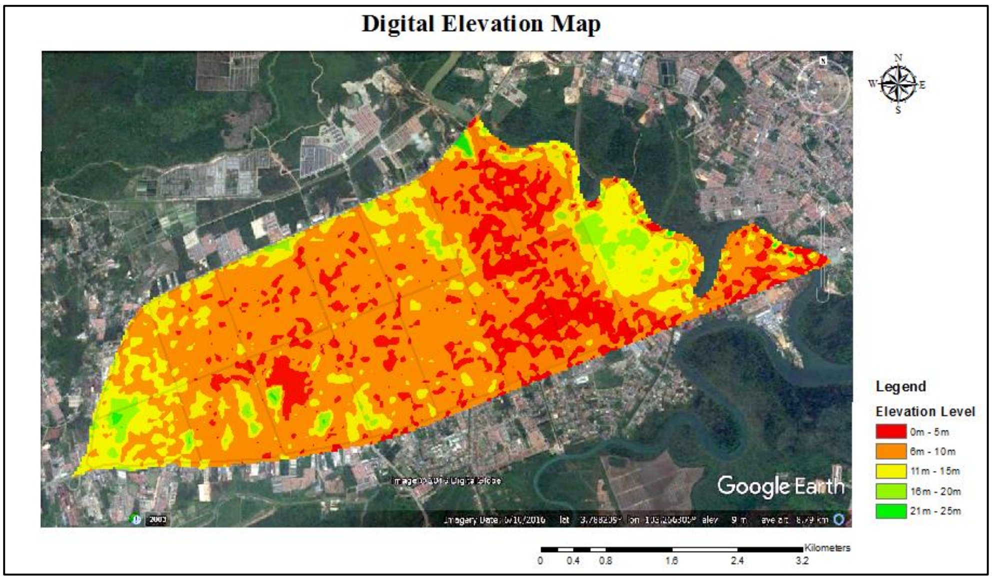

Figure 4.1: Digital Elevation Map of Study Area

4.3 ANALYSIS OF ELEVATION MAP

Elevation map is produced based on the result of the digital elevation map. The score for the elevation map was measured based on the average of the elevation level on each zone. The score for the elevation map were categorized into five colours which is red, orange, yellow, light green and dark green. The red colour represent as the elevation level with the depth below 5 m, orange is in the range of 6 to 10 m, yellow is in the range of 11 to 15 m, light green is in the range of 16 to 20 m and dark green is above 25 m. Each zone of the study area is coloured to make the map clear as the colours are different and easily to be understood.

Based on the Figure 4.2, the very high risk area are in Tmn. Bukit Rangin (Zone 11), Tmn. Sepakat (Zone 12), Sg. Isap Damai (Zone 13), and Sg. Isap (Zone 14), the high risk area are in Kg. Chendering (Zone 3), Tmn. Tas Ria (Zone 4), Kg. Baru Chendering (Zone 5), Kg. Batu Tujuh (Zone 6), Kg. Baru Permatang Badak (Zone 7), Permatang Badak Perdana (Zone 8), Tmn. Permatang Badak (Zone 9), Kg. Permatang Badak (Zone 10) and Tmn. Tanah Putih Baru (Zone 16) and the medium risk area are in Tmn. Pandan Damai (Zone 1), Tmn. Tas (Zone 2) and Sg. Isap Satu (Zone 15). Based on the map, 25% of the study area is in the very high risk area, 56% of the study area is in the high risk area and 19% of the study area is in the medium risk area.

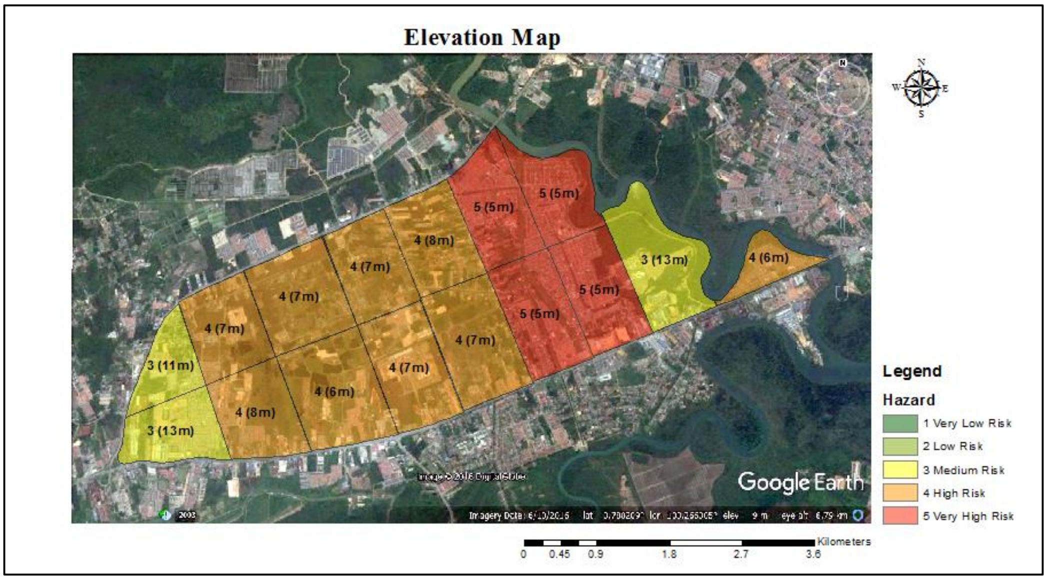

Figure 4.2: Elevation Map

The score data for elevation factor can be referred in Table 4.1.

Table 4.1: Score Data for Elevation

Zone	**Elevation level (m)**	**Score**
1	11	3
2	13	3
3	7	4
4	8	4
5	7	4
6	6	4
7	7	4
8	7	4
9	8	4
10	7	4
11	5	5
12	5	5
13	5	5
14	5	5
15	13	3
16	6	4

4.4 ANALYSIS OF LIKELIHOOD MAP

Likelihood is measured by considering the length from the centre of a zone to the nearest river which are consist of Sungai Kuantan, Sungai Belat and Sungai Pandan. The study area is located near to the river that will highly potential flooded the study area during the monsoon season. The score of the likelihood are categorized into five colours which is red, orange, yellow, light green and dark green. Each zone of the study area is coloured to make the map clear as the colours are different and easily to be understood.

As shown in the Figure 4.3, the very high risk area which is in the red colour area are at Tmn. Tas Ria (Zone 4)**,** Tmn. Bukit Rangin (Zone 11), Sg. Isap Damai (Zone 13), Sg. Isap Satu (Zone 15) and Tmn. Tanah Putih Baru (Zone 16) and the rest of the zone which is in the orange colour area are in the high risk area. Based on the map, 31% of the study area is in the very high risk area and 69% of the study area is in the high risk area.

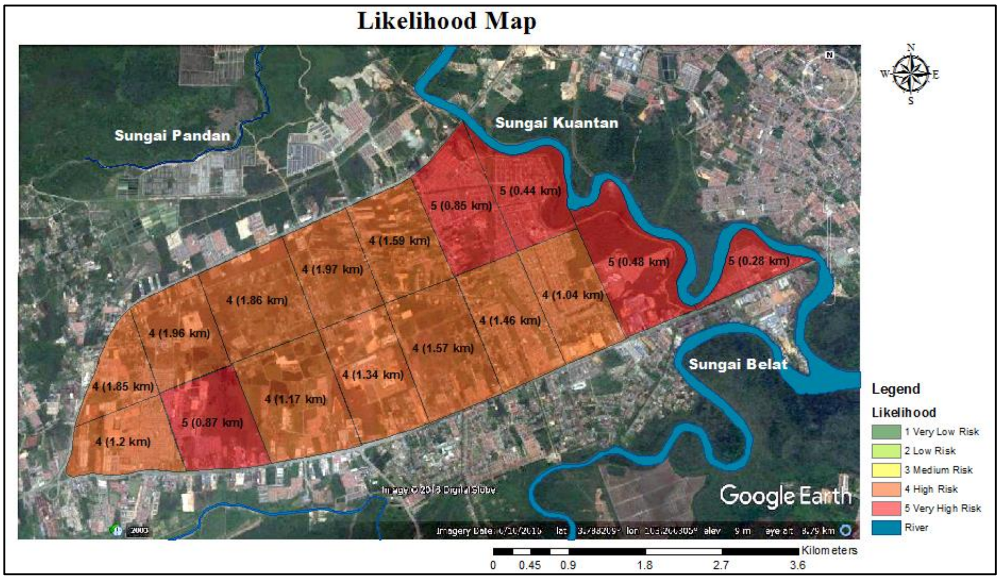

Figure 4.3: Likelihood Map

The data of the likelihood factor can be referred in Table 4.2.

Table 4.2: Score Data for Likelihood

Zone	**Distance From River (km)**	**River Name**	**Score**
1	1.85	Sungai Belat	4
2	1.20	Sungai Belat	4
3	1.96	Sungai Belat	4
4	0.87	Sungai Belat	5
5	1.86	Sungai Pandan	4
6	1.17	Sungai Belat	4
7	1.97	Sungai Pandan	4
8	1.34	Sungai Belat	4
9	1.59	Sungai Kuantan	4
10	1.57	Sungai Belat	4
11	0.85	Sungai Kuantan	5
12	1.46	Sungai Kuantan	4
13	0.44	Sungai Kuantan	5
14	1.04	Sungai Kuantan	4
15	0.48	Sungai Kuantan	5
16	0.28	Sungai Kuantan	5

4.5 ANALYSIS OF VULNERABILITY MAP

Vulnerability is measured by estimating the percentage of the population intensity in the study area. The score of the vulnerability are categorized into five colours which is red, orange, yellow, light green and dark green. Each zone of the study area is coloured to make the map clear as the colours are different and easily to be understood.

As shown in the Figure 4.4, the very high risk area which is in the red colour area are at Tmn. Bukit Rangin (Zone 11), Tmn. Sepakat (Zone 12) and Tmn. Tanah Putih Baru (Zone 16), the high risk area which is in the orange colour area are at Tmn. Pandan Damai (Zone 1), Tmn. Tas (Zone 2), Sg. Isap Damai (Zone 13), and Sg. Isap (Zone 14), the medium risk area which is in the yellow colour area are at Permatang Badak Perdana (Zone 8), Tmn. Permatang Badak (Zone 9), and Kg. Permatang Badak (Zone 10), the low risk area which is in the light green colour area are at in Kg. Chendering (Zone 3), Tmn. Tas Ria (Zone 4), Kg. Baru Chendering (Zone 5), Kg. Batu Tujuh (Zone 6), and Kg. Baru Permatang Badak (Zone 7) and the very low risk area which is in the dark green colour area are at Sg. Isap Satu (Zone 15). Based on the map, 19% of the study area is in the very high risk area, 25% of the study area is in the high risk area, 19% of the study area is in the medium risk area, 31% of the study area is in the low risk area and 6% of the study area is in the very low risk area.

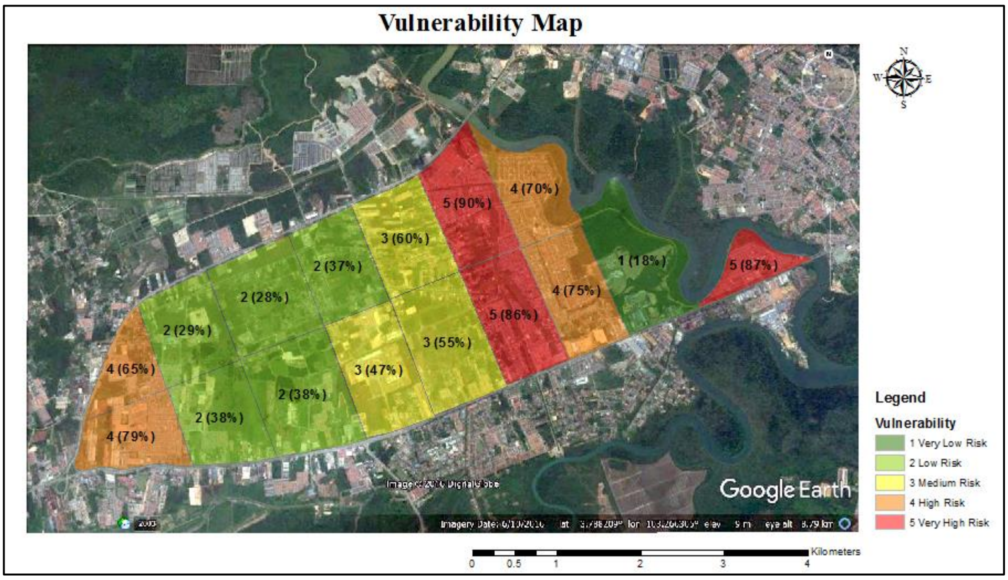

Figure 4.4: Vulnerability Map

The score data of the vulnerability factor can be referred in Table 4.3.

Table 4.3: Score Data for Vulnerability

Zone	**Percentage of Population Intensity (%)**	**Score**
1	65	4
2	79	4
3	29	2
4	38	2
5	28	2
6	38	2
7	37	2
8	47	3
9	60	3
10	55	3
11	90	5
12	86	5
13	70	4
14	75	4
15	18	1
16	87	5

4.6 ANALYSIS OF ELEVATION, LIKELIHOOD AND VULNERABILITY MAP

The combination of the three maps which are elevation, likelihood and vulnerability map can be shown in Figure 4.5 below. The scores of elevation, likelihood and vulnerability has been tabulated into the attributes table in the layer of each zone. The data that have been recorded is according to the number of zone and the layer of colours indicates the score of elevation, likelihood and vulnerability that shown in the Figure 4.5 below. The scores of three factors also can be categorized by using the five colours such as red, orange, yellow, light green and dark green. This process used the polygon shapefile as the main tool. From the Figure 4.5 below, the red colour indicates the very high risk area and the dark green colour indicates the very low risk area.

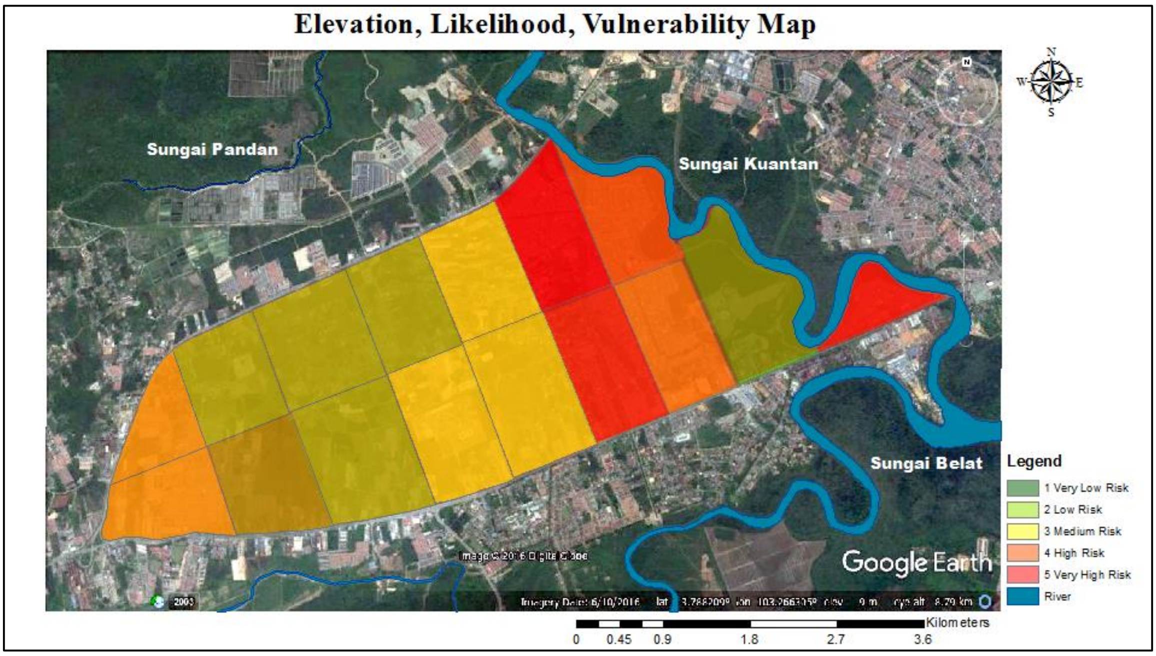

Figure 4.5: Elevation, Likelihood and Vulnerability Map

The score data of elevation, likelihood and vulnerability factor can be referred to Figure 4.4.

Table 4.4: Score Data for Elevation, Likelihood and Vulnerability

Zone	Hazard Score	Likelihood Score	Vulnerability Score
1	3	4	4
2	3	4	4
3	4	4	2
4	4	5	2
5	4	4	2
6	4	4	2
7	4	4	2
8	4	4	3
9	4	4	3
10	4	4	3
11	5	5	5
12	5	4	5
13	5	5	4
14	5	4	4
15	3	5	1
16	4	5	5

4.7 ANALYSIS OF FLOOD RISK MAP

The average of the elevation, likelihood and vulnerability score is calculated to form a flood risk map as shown in Figure 4.6 below. All of these zones is located exactly on the map based on actual longitude and latitude on earth and each zone is numbered. The risky zone is identified by looking at the overlaid colours on map. The red colour represent the very high risk area, orange colour as the high risk area, yellow as the medium risk area, light green as the low risk area and the dark green as the very low risk area.

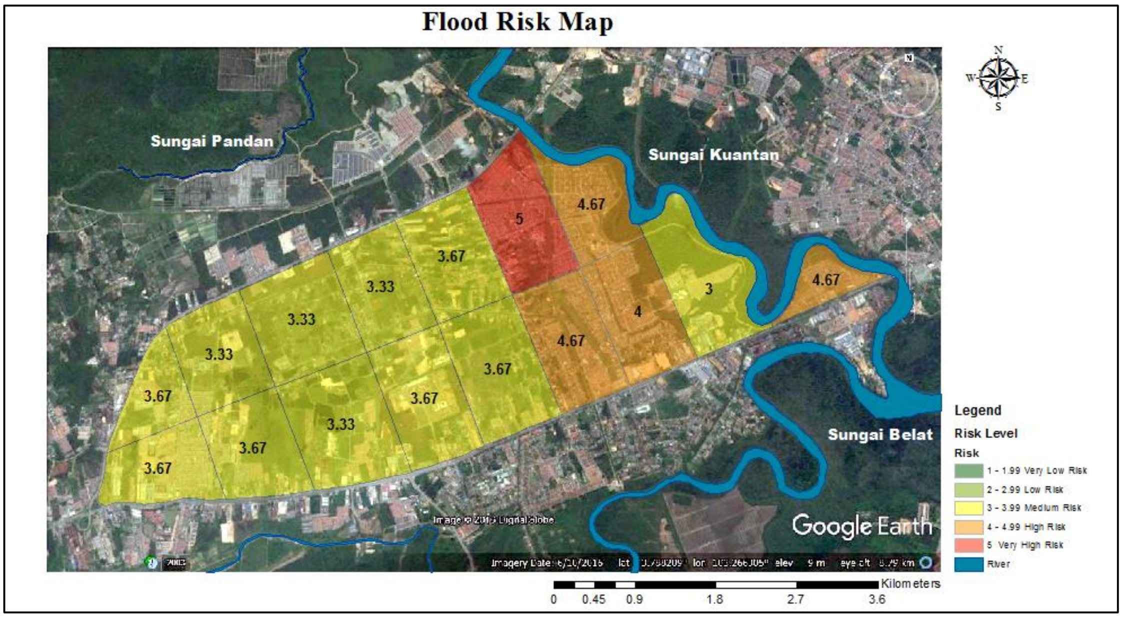

Figure 4.6: Flood Risk Map for Sungai Isap

As shown in Figure 4.6, most of the zone are located in the medium risk area. The very high risk area which is in the red colour area is Tmn. Bukit Rangin (Zone 11) because the score of elevation is higher which is 5, the score of likelihood is higher which is 5 and the score of vulnerability is also higher which is 5. The high risk area which is in the orange colour area are Tmn. Sepakat (Zone 12), Sg. Isap Damai (Zone 13), and Sg. Isap (Zone 14) and Tmn. Tanah Putih Baru (Zone 16) and the rest of the zone are in the medium risk area which is in the yellow colour area. The lowest risk in the study area is Sg. Isap Satu (Zone 15) with risk score 3. It is because the score of elevation is 3, the likelihood score is 5 and the score of vulnerability is 1. Based on the flood risk map, 6%

of the study area is in the very high risk area, 25% of the study area is in the high risk area and 69% of the study area is in the medium risk area. The score data for risk factor can be referred in the Table 4.5 below.

Table 4.5: Score Data for Risk

Zone	Risk Score	Risk Level
1	**3.67**	Medium Risk
2	**3.67**	Medium Risk
3	**3.33**	Medium Risk
4	**3.67**	Medium Risk
5	**3.33**	Medium Risk
6	**3.33**	Medium Risk
7	**3.33**	Medium Risk
8	**3.67**	Medium Risk
9	**3.67**	Medium Risk
10	**3.67**	Medium Risk
11	**5.00**	Very High Risk
12	**4.67**	High Risk
13	**4.67**	High Risk
14	**4.00**	High Risk
15	**3.00**	Medium Risk
16	**4.67**	High Risk

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

The development of the flood risk map is important in determining the risky area that exposed to the disastrous monsoon floods. Flood risk map can be an important medium to the related parties to implement effective flood mitigation in order to reduce the impact of floods in the study area. Besides that, flood risk map can educate the communities to be prepared to evacuate to the safest place during the monsoon season. The development of the flood risk map considering the physical factors in affected areas that encompasses the elevation level, distance of a zone from the nearest river and the population intensity. Classification techniques by colours are applied in the flood risk map to make better understanding for all the communities.

5.2 CONCLUSION

The factor of flood in the study area can be identified based on the development of the flood risk map by using ArcGIS software. From the analysis of using ArcGIS software, the causes of flood occurred at the study area are because of the low land area, the distance of the zone near to the river and high population intensity. Most of the area are classified as the medium risk, 4 zones are classified as the high risk area and 1 zone is classified as the very high risk area. Taman Bukit Rangin (Zone 11) is classified as the very high risk area because the low land area, near to the river and high population intensity. The western area are mostly in the medium risk area because the elevation level is higher compared to the eastern area. The continuous heavy rain in the monsoon season is the factor of increasing the water level in the river basin that will caused flooded.

The lowest elevation level in the study area are identified Taman Bukit Rangin (Zone 11), Taman Sepakat (Zone 12), Sungai Isap Damai (Zone 13), and Sungai Isap (Zone 14) which will be the major risk area flooded during the monsoon season Taman Tas Ria (Zone 4)**,** Taman Bukit Rangin (Zone 11), Sungai Isap Damai (Zone 13), Sungai Isap Satu (Zone 15) and Taman Tanah Putih Baru (Zone 16) are near to the river which will be the major risk area flooded when the water level in the river basin increased. The high populated area at Taman Bukit Rangin (Zone 11), Taman Sepakat (Zone 12) and Taman Tanah Putih Baru (Zone 16) are at the very high risk when the flood occurred as many life are in danger.

The risk is identified by considering the hazard, likelihood and vulnerability factor in the study area. From the result of this analysis, an effective flood mitigation can be implemented by the related parties in order to reduce the negative impacts of flood. Furthermore, the researchers can do a further research on the flood risk map in particular to plan a better city for Kuantan and reduce the loss of properties and life of communities. Rescue team also can be focused on rescuing communities in the very high risk area in advance and the safest place for evacuation can also be determine which is located at the lowest risk area.

5.3 RECOMMENDATION

In order to get more accurate and good analysis in this study, the scale of each zone should be smaller and the various data should be collected more. The statistic of the number of population in the study area also have to be done by doing the survey in order to produce and develop an accurate flood risk map. Risk map factors like hazard, likelihood and vulnerability should be more to give a good impact towards the development of the flood risk map. The study area have to be classified by place to make the flood risk map easily to be understood by the communities. All of this recommendation can be lead to develop an accurate and better result of the flood risk map. Thus, the further analysis can be done nicely.

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