SIMULATION OF COASTAL FLOOD IN KUANTAN CITY USING ARC-GIS

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SIMULATION OF COASTAL FLOOD IN KUANTAN CITY USING ARC-GIS

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Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources
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JUNE 2017

ACKNOWLEDGEMENTS

Foremost, I would like to express my sincere gratitude to my supervisor Mr. Norasman Othman for the continuous support of my Bachelor Eng. (Hons.) of Civil Engineering. Thank you sir for your patience, motivation, enthusiasm and extensive knowledge. His guidance really helped me in all the time to accomplish this thesis. From zero and cannot understand anything about what I am going to do with my study until rite now I could know on how to write a thesis.

Besides my supervisor, I would like to thank my family because always and never stop to give me a moral support, and encouragement to the completion of this thesis.

Last but not least, I would like to thank my friends for willing to stay in the UMP library for half of their days, exchanging ideas, and all the fun we have had in the last four years.

ABSTRAK

Banjir pantai terbentuk daripada peristiwa air laut pasang surut, peningkatan aras air laut dan peristiwa lonjakan ribut, melimpah daripada laut dan membanjiri kawasan yang lebih rendah daripada julat ketinggian banjir pantai terutamanya di kawasan pinggir pantai. Banjir pantai juga merupakan salah satu malapetaka yang boleh menyebabkan kehilangan nyawa dan harta benda jika tidak ada kesedaran dalam kalangan penduduk di sekitar pantai. Oleh itu, agensi-agensi tempatan perlu mula mencari penyelesaian untuk menghalang daripada banjir teruk ini berlaku. Salah satu cara yang berkesan untuk mengatasi masalah ini adalah dengan menggunakan perisian ArcGIS. Perisian ArcGIS atau lebih dikenali sebagai Sistem Maklumat Geografi (GIS) adalah satu sistem komputer untuk merakam, menyimpan, memeriksa dan memaparkan data yang berkaitan dengan kedudukan pada permukaan Bumi. Objektif kajian ini adalah untuk mencari lokasi yang berisiko di Bandar Kuantan yang terjejas disebabkan oleh banjir pantai untuk 50 dan 100 tahun akan datang dan untuk mencadangkan pelan mitigasi. Bandar Kuantan telah dipilih sebagai kawasan kajian. Kajian ini dilakukan kerana lokasi Bandar Kuantan yang terdedah kepada risiko banjir pantai. Data yang digunakan untuk kajian ini diperolehi daripada Institut Penyelidikan Hidraulik Kebangsaan Malaysia (NAHRIM), Jabatan Ukur dan Pemetaan Malaysia (JUPEM), Jabatan Meteorologi Malaysia (MetMalaysia), Pusat Hidrografi Malaysia (NHC), dan juga daripada kertas-kertas penyelidikan. Data yang diperlukan adalah data tolok air pasang, data lonjakan ribut, dan data peningkatan kenaikan aras laut pada tahun-tahun yang telah diunjurkan. Dalam kajian ini, ArcMap dan ArcScene digunakan untuk menganalisa kesemua data justeru menyediakan peta banjir pantai yang berkemampuan untuk mengenal pasti kawasan yang terjejas. ArcMap digunakan untuk menghasilkan tiga jenis peta banjir pantai yang berbeza; peta banjir pantai pada tahun 2050 (8.46 meter), peta banjir pantai pada tahun 2100 (8.72 meter) dan peta banjir pantai pada 5 meter ketinggian air laut. Keputusan peta banjir pantai telah dibentangkan melalui Google Earth dan kesemua lokasi yang terjejas diklasifikasikan melalui peta topografi JUPEM. Peta banjir pantai ini akan memudahkan banyak pihak sama ada kerajaan mahupun penduduk di sekitar pinggir pantai untuk berwaspada dengan kehadiran banjir pantai. Tambahan pula, pelan mitigasi telah ditubuhkan untuk mengelakkan masalah ini sekali gus dapat menyelamatkan ekosistem pantai. Kajian ini telah membuktikan bahawa banjir pantai boleh diramal justeru pelbagai inisiatif atau langkah berjaga-jaga perlu diambil apabila bencana alam ini melanda.

ABSTRACT

Coastal flood is formed of tides event, sea level rise and storm surge event, overflow from the sea and inundated the lower area below the height range of coastal flood especially in the coastlines area. Coastal flood also is one of the catastrophe that could cause loss of life and property if there is no awareness among the population around the coast. Therefore, local agencies should start to find some solutions to prevent this severe flood. One of the effective ways to overcome this problem is by using ArcGIS software. ArcGIS software or well known as Geographical Information System (GIS) is a computer system for capturing, storing, checking, and displaying data related to the position on Earth's surface. The objectives of this study are to find the risky location in Kuantan City that was affected by the coastal flood for the next 50 and 100 years and to propose the mitigation plans. Kuantan City was selected as a study area. This study was formed because the location of Kuantan City was exposed to the risk of coastal flood. The data used for this study was provided from National Hydraulic Research Institute of Malaysia (NAHRIM), Jabatan Ukur dan Pemetaan Malaysia (JUPEM), Malaysian Meteorological Department (MetMalaysia), National Hydrographic Centre Malaysia (NHC) and also from the research papers. The needed data were tide gauge data, storm surge data and sea level rise data in projected years. In this study, Arc Map and Arc Scene was used to analyse all the data hence provide coastal flood map that could able to identify the affected areas. ArcMap was used to produce three different types coastal flood map; coastal flood map in year 2050 (8.46 meter), coastal flood map in year 2100 (8.72 meter) and coastal flood map in 5 meter height of seawater. The results of coastal flood map were presented in the Google Earth and all affected location were classified from JUPEM topographical map. This coastal flood map will be facilitate a lot of parties whether the government nor the people around the coast to be alert to the presence of coastal flood. In additional, the mitigation plans has also been set up to prevent this problem hence save the coastal ecosystems. This study also has proved that the coastal flood could be predicted thus various initiatives or measure precaution should be taken when this natural disaster happen.

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LIST OF ABBREVIATIONS

GIS	Geographical Information System
TIN	Triangulated Irregular Network
NAHRIM	National Hydraulic Research Institute Of Malaysia
JUPEM	Jabatan Pemetaan Malaysia
MetMalaysia	Malaysian Meteorological Department
NHC	National Hydrographic Centre
CSIRO	Commonwealth Scientific And Industrial Research Organisation
DEM	Digital Elevation Model
SRTM	Space Shuttle Radar Topography Mission
USGS	United States Geological Survey
DID	Department Of Irrigation And Drainage
NOAA	National Oceanic And Atmospheric Administration
CAD	Computer-Aid Design
SLR	Sea Level Rise
THESEUS	Innovative Technologies for Safer Europeans Coast in a Changing Climate
NASA	National Aeronautics and Space Administration

CHAPTER 1

INTRODUCTION

1.1 Introduction

Kuantan is near of the Kuantan River and faces the South China Sea. According to the Department of Statistics Malaysia 2010, Kuantan has 607,778 number of population. Large populations live in the coastal areas where they were exposed to a range of hazards, including coastal flooding (Small and Nicholls,. 2003). According to National Oceanic And Atmospheric Administration, coastal floods were extremely dangerous, and the combination of storm surge, tides, river inflow, and waves could cause severe damage. Coastal flood occurs when normally low-lying land was flooded by the seawater.

Coastal flood also have a big impact on humans, animals, and the national economy. Human and animals would be homeless and coastal flooding also would reduce the number of tourists to visit in the country because of fears about safety. Besides, the government need to spend huge amount of money to repair all the damaged such as road collapse, and all the facilities damaged.

Figure 1.1 Seawater Overflow at Pantai Remis, Klang
Source: Berita Harian (2016)

1.2 Problem Statement

Coastal flooding was very dangerous because it is not just an ordinary flooding. Coastal flooding was influenced by a number of natural factor such as rising sea levels. Sea level rise was caused by human irresponsibility and world development. Coastal flood never happen at Kuantan, Pahang but it just happened in Pantai Remis, Kuala Selangor, Klang. The seawater overflows due to sea level rise and caused area of neighbourhoods and town nearby were flooded by seawater. Coastal flood was the severest flood among others flood.

Besides, sea level rise was also one of the causes of this study. The sea level tends to be high when the rainy season due to the increase in the number of exceptional rainfall. Furthermore, global weather temperature rising due to natural and human factors. When the amount of sea level rise is higher than the rivers and lakes, the sea water cannot flow through it and the dry land area will be flooded with sea water. This matter would occur fairly quickly without warning and may cause loss of property and even death.

This study was needed to avoid from this severe flood occurs abruptly and the best solution was the government must provide preventive measures of coastal flood such as raising the height of retaining wall and propose sensor method as an early warning to the residents in the vicinity of the beach when the coastal flood occurs. The benefit of this preventive measures was to reduce the cost of repairs at areas affected by coastal flood, and reduce the number of deaths and property losses.

Coastal flood was rarely happen compared with other floods such as flash floods but it will happen if the sea level rises and its very dangerous because the waves of sea water could reach the roof of the house. A strong winds were the early signs before coastal flood happened. All beach activities were prohibited to the tourists and fisherman.

1.3 Objectives

The main objectives of this study were as following :

i. to identify the risky locations in Kuantan that were affected by coastal flood for next 50 and 100 years.

ii. to propose the mitigation plan due to effect of coastal flood risk.

1.4 Scope of Study

The scope of this study was focused on the location in Kuantan area that will be affected by the coastal flood. There were more than 15 villages and residential areas near to the coastline including the famous resorts and hotels such as the Teluk Cempedak, Swiss Garden Beach Resort and Mini Zoo Taman Teruntum that vulnerable to the risk of coastal flood. This study was performed using Geographical Information System (GIS). Using data collected from NAHRIM, JUPEM, NHC and MetMalaysia, at the end of this study, GIS software will be provide the exact location that was experienced coastal flood. Google Earth was used as a another medium to present the results of this study. By using data provided, GIS software capable to identify the lowest areas in the Kuantan area that was flooded by the seawater.

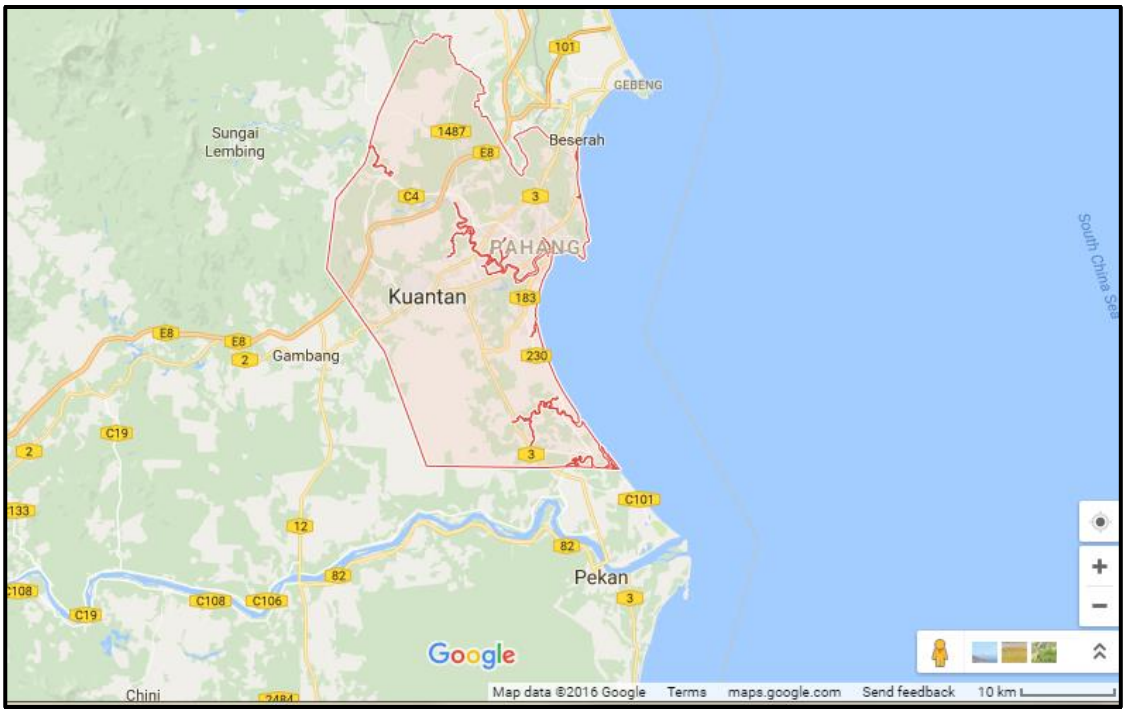

Figure 1.2 Kuantan Boundary Map

Source: Google Map

1.5 Significant of Study

The significance of this study was to understand about the issues of coastal flood, characteristic of flood and its impact to the community. The study was focused on the area in Kuantan that will be affected by coastal flood for next 50 and 100 years. In addition, this study would enhance the awareness level of community about coastal flood on their area.

Besides, flood-related information was a good for public. This is because the coastal flood maps was a product or a service that could be shared by many user in the world such as for individual, community and society. For example, land developers, property owners and government agencies.

Then, another significant was to reduces loss of lives and properties. This is because when the maps was shared by many users, they would more be alert on the coastal flood or their awareness towards the coastal flood would be increase. For example, the community that live in the flood risk area would followed the authorities instruction if they need to move to the evacuation flood centres. Thus, this action would reduced loss of lives and properties.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Human, flora and fauna need water for survival. Since water was the basic element of life support system on the planet, it was extremely important to understand the hydrological cycle. According to the USGS, about 71 percent of the Earth's surface was water-covered, and the ocean hold about 96.5 percent of all Earth's water. From figure 2.1 was stated that the hydrological cycle begin with the evaporation of water from the surface of the ocean. As moist air was lifted, it cools and water vapour condenses to form clouds. Moisture was transported around the globe until it returns to the surface as precipitation. Once the water reaches the ground, one of two processes may occur; firstly some of the water may evaporate back into the atmosphere or the water may penetrate the surface and become groundwater. Groundwater either seeps its way to into the oceans, rivers, and streams, or was released back into the atmosphere through transpiration. The balance of water that remains on the earth's surface is runoff, which empties into lakes, rivers and streams and was carried back to the oceans, where the cycle begins again. However, excessive water also will be caused adversely affect to the life on earth. Excessive runoff on the earth combined with sea level rises will be contributed to the coastal flood. Too much amount of runoff caused the water catchment areas cannot cope then release the water to rivers and lakes. This will be contributed to the flood.

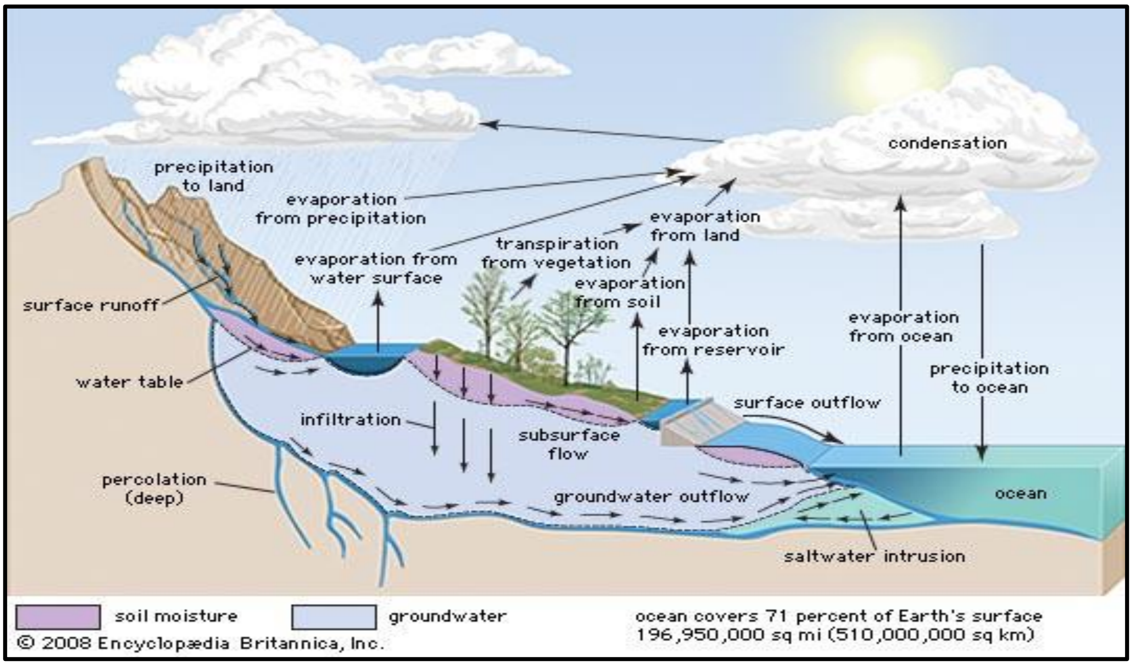

Figure 2.1 Hydrological Cycle
Source: Encyclopedia Britannica (2008)

A flood is a situation in which water temporarily covers land where it normally does not. According to the Webster's New International Dictionary, 'a flood is defined as a great flow of water especially a body of water, rising, and over-flowing land not usually covered; a deluge; a freshet; an inundation'. Flood bring misery to those that live in the area. Which destroyed agricultural crops, caused loss of human lives and property (Rahaman,. 2014). Flood have several types such as flash flood, river flood, urban flood, and coastal flood. The most severe flood was a coastal flood because its wave could cause severe damage.

Malaysia is vulnerable to flood because of geographical location and tropical climatic condition (Syeda Maria et al,. 2014). Flood in Malaysia usually occurs at the end of the year. This is because Malaysia have two monsoon which are southwest monsoon and northeast monsoon. The southwest monsoon usually begins in the last half of May or early June and ends in September. Northeast monsoon usually begins in early November and ends in March. East coast states of Peninsular Malaysia such as Kelantan, Terengganu and Pahang were more affected by the wind. The east coast part of Malaysia's flood often experiences flooding during the northeast monsoon season. Kuantan is one of the flood vulnerable area of peninsular Malaysia (Syeda Maria et al,.

2014). Due to the monsoon winds, extraordinary rainfall will be occur throughout the month and will be caused all the catchment areas, lakes, and rivers full. When all the water storage area are full, the water will overflow and inundated low and dry areas.

The effects of the flood will be caused the people lost their homes, lost contact with other states, loss of property, and the death of family members. Entrepreneur also cannot run business because of damaged stock supplies due to flood. Besides, the government have to spend a lot of money to repair the damaged and help the victims. Floods occur every year, the government must find a solution to mitigate the adverse impact of floods on people and communities should take precautions for safety.

2.2 Types Of Flood

Flood could be classify into two categories which were come from natural disaster and human behaviour. A flood was defined as ‘a body of water which rises to overflow land which is not normally submerged’ (Ward,. 1978). Coastal flood is the one of perfect example that occurs from natural disaster. Coastal flood happen when seawater level rise. Besides, failure of dam also could cause flooding. This flood was happened when the structure of the dam, which was designed to accommodate a number of water could no longer support because the volume of water exceed the limit of design. Flash flood was the perfect example that occurs from the human behaviour. This is because flash flood normally happen due to drainage problem, number of population increase and development area. Flood is one of the examples of environmental hazard resulted from inequity of the water cycle usually associated with building of urban areas and insufficient drainage design (Schueler,. 1994).

2.2.1 Flash Flood

Flash-flood history in Malaysia was first occurred in January 1971 whereby the affected area was in Kuala Lumpur. The flash flood caused 32 people were killed and 180,000 people were affected (Fernandez,. 1988). Flash food was defined as a body of water submerged a piece of land which is normally not being submerged in water and this phenomenon will subside only after a few hours. Two key factors that lead to flash flood were the intensity of the rainfall and its duration. According to the National Oceanic and Atmospheric Administration (NOAA), the most flash flood was caused by slow-moving thunderstorms, thunderstorms that move repeatedly over the same area, or heavy rains from hurricanes and tropical storms. Flash floods carried debris that elevate their potential to damage structures and injure people. The reason for flash flood occur was unplanned township. The risk of flash flood increase because of constructing buildings, road which heads to the impervious surface (Weng Chan,. 1997). Improper waste disposal also was the another point to the occurrence of flash floods. Oftentimes, garbage that was not properly disposed enters into drainage systems and clogs drains. This obstructs the free flow of the water that enters into these drains causing water to back up during rainfall flooding the surrounding area. A build-up of garbage could also obstruct the natural flow of water in rivers and streams.

Figure 2.2 Flash Flood in The Sprint Highway, Jalan Dato Abu Bakar Junction
Source: The Star Online (2017)

Figure 2.3 The Condition in Jalan Bangsar, Kuala Lumpur 1971 after the Flash Flood Subsided

Source: Utusan Online (2013)

2.2.2 Overtopping Flood

Overtopping flood occurs when rising of water over top of a barrier and flow down into dry areas. Failure of dams due to overtopping was a common failure mode. Around 40 dams have been built throughout Malaysia and five dams was built in the state of Pahang which are Chini Dam, Chematu Dam, Chereh Dam, Kelau Dam and Sultan Abu Bakar Dam. Dam in Malaysia comprises of embankment and concrete. Embankment dams typically cannot withstand any significant amount of overtopping, due to limited erosion resistance of the soil material used in their construction. The amount of erosion was dependent on the quality and type of vegetation cover, material in the embankment, depth, and duration of the overtopping flow. Concrete dams were generally perceived to be more resistant to overtopping failure, due to the durability of the dam itself as well as the erosion resistance provided by a rock foundation. However, weak and fractured rock may be susceptible to significant erosion during overtopping flows, and if foundation support was lost due to overtopping erosion, the dam could be lost.

Dams provide many functions for a community, including recreation, flood control, irrigation, water supply, and hydroelectric power but dams also could increase the risk for flooding. Intense storms could raise water levels and produce a flood within a few hours or even minutes. Dam failure may occur within hours of the first signs of breaching or overtopping. Other factors, such as debris jams or an accumulation of melting snow, could cause breaches days or weeks after the first sign of trouble. Flooding could occur downstream when excess water was released in an effort to avoid overtopping or a breach at the dam.

There were the factors that contribute to catastrophic flood such as changes in land use. Dams were designed and built based on the state of the watershed at the time. When the landscape was changed, it could have a big impact on water absorb into the ground or runs off toward the dam. Besides, dams failure were caused by an out-dated design. When the old design was not suitable, the structure of the dam needs to be improved according to the results of the tests that have been done to ensure that the dam is safe to use. Other than that, lack of maintenance also lead to the dam failure. Dams also have to undergo testing to ensure the structure strong enough.

Figure 2.4 Overtopping Along the Riverland Way, Australia
Source: US Army (2015)

2.2.3 Coastal Flood

Currently, weather was no longer like a century ago. Carbon emission was released day by day and the number is increasing. Carbon dioxide emission rise to 2.4 million pounds per second just in Washington, United States (CBSNEWS,. 2012) due to burning of fossil fuel such as coal and oil. High amount of carbon emission lead to increased global warming and ice at the poles will be start to melt into liquid thus contributing to sea level rise. People those live around the beach was affected to coastal flood. Besides, coastal flood also related with full moon phenomenon and monsoon rains.

Figure 2.5 Coastal Flood in Mantoloking, New Jersey, United States
Source: The Philadelphia Daily News (2016)

2.3 Definition of Coastal Flood

A coastal flood, or the inundation of land areas along the coast was caused by higher than average high tide and worsened by heavy rainfall and onshore winds such as wind blowing landward from the ocean. According to National Oceanic and Atmospheric Administration, coastal floods were extremely dangerous, and the combination of storm surge, tides, river inflow, and waves could cause severe damage. Coastal flooding is a natural disaster that occurs in coastal areas when the mass of seawater overwhelms or floods the land along the coastal line, particularly low-lying land (Kalakan et al,. 2016). A low and dry area which never have been flooded then were flooded by sea water was known as coastal flooding. According to Geography Dictionary, coastal flood was prolonged strong onshore flow of wind and or high astronomical tides causing a rise in sea level that floods coastal area.

2.4 Caused of Coastal Flood

Factors that contribute to the natural disaster such as coastal flood was divided into two which from human being and nature process. The Earth become older from time to time and the population of human in the world become increase. Nowadays, there was no longer moral values in the human soul. People do not feel embarrassed to make mistake especially to the environment. The community deliberate throw the rubbish inside the river and would cause a clog river problem. This small action could contribute to the flash flood especially in the urban areas. Flash flood event also was a natural disaster and it would inflict some inconvenience to all the community in the flood area.

Natural disaster also could be happened from nature process. This is because the Earth would experience tidal phenomenon when there was a gravitational pull from the moon. Besides, sea level rise and storm surge event also contribute to the natural disaster. The main reasons of sea level rise was the increment of climate change.

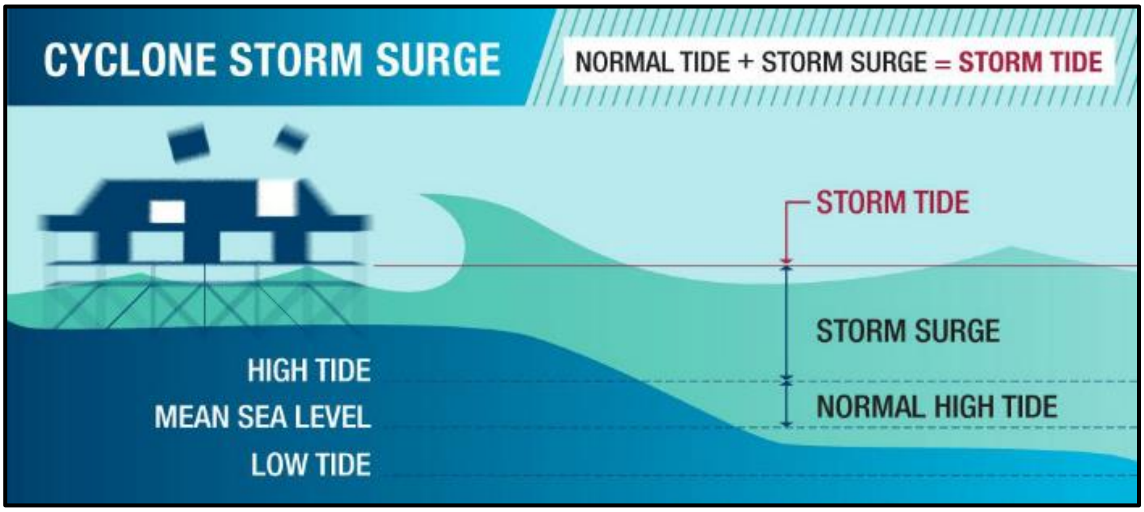

Figure 2.6 Formation of Coastal Flood
Source: Bereau of Methodology

2.4.1 Sea Level Rise

Rising of seawater level start since 20th century and it became critical on 21st century. Estimation the global mean sea level rise rate to be 1.8 ± 0.5 mm/year for the period of 1961 – 2003, and 1.7 ± 0.5 mm/year over the 20th century (Bindoff et al,. 2007). According to the National Ocean Service, analysis of a global network of tide gauge records shows that sea level has been rising at the rate of about 0.6 inches per decade since 1900. Since 1992, satellite altimeters indicate that the rate of rise has increased to 1.2 inches per decade, a significantly larger rate than at any other time over the last 2000 years. In the next several decades, continued sea level rise and land subsidence will cause tidal flood frequencies to rapidly increase due to typical storm surges and high tides in many coastal regions. Rising sea levels will raise flood levels, all other things being equal (Smith and Ward,. 1998). Sea level rise would be one of the most significant potential impacts of climate change if the current trend of sea level rise (SLR) due to global warming continues to increase for the upcoming decades. Rising sea level is caused by three main factors are ocean thermal expansion, melting of the Greenland and Antarctica glacier and ice sheets and change in terrestrial storage with ocean thermal expansion as the dominant factor (Dasgupta et al,. 2007).

Seawater level rise would severely affect the coastal areas of many countries of the world through inundation of coastal areas and islands, shoreline erosion, and destruction of important ecosystems such as wetlands and mangroves. Moreover a significant increase of sea level will hamper the economy, trade, tourism, biodiversity, and livelihood and so on. Seawater level rise due to climate change is a serious threat to countries with heavy concentrations of population and economic activity as well as ecosystem in coastal regions.

2.4.2 Tidal Phenomenon

The phenomenon of tidal rise and fall of sea level on a regular basis due to the attraction of celestial bodies, especially the sun and moon on the water mass of the earth. Meanwhile, the ocean tides was the phenomenon of the rise and fall of sea levels periodically caused by a combination of gravity and the gravitational pull of astronomical objects, especially by the sun, earth and moon. Effect of other celestial bodies could be ignored because it is more or smaller. The tide phenomenon was also often associated with the movement of the moon, earth and sun. The tide was the result of gravitational force and centrifugal effect. Centrifugal effect was a force that compels the earth to assume the shape of an oblate spheroid because of its rotational on its axis. Whenever a body in its forward motion was compelled, by any means, to move in a curved path, there would be centrifugal force exerted in the direction of the radius of the curve and away from its centre (Godfrey,. 1934). Prone areas to tidal phenomenon were around estuaries and coastal areas. Usually, tidal phenomenon occurs daily, twice ups and downs. The tides was change every day.

2.4.2.1 Spring Tide

Tidal phenomenon was divided into two categories; spring tide and neap tide. Spring tide occurs when the position of earth, sun and moon was in a parallel line. The tides on the Earth also was created by The Sun. It was far more massive than the Moon, but much farther away, so in the end contributes about half as much to the tides on Earth as the Moon does. When the Moon and Sun were in a line these forces all add up, creating even higher high tides and lower low tides than usual. These were called as "spring tides", and it happen twice a month, when the Moon is full and when it's new (Plait,. 2016). At this point, the height of seawater level at high tide resulting in a very high level and low in a very low altitude. The spring tide occurs when the moon was in a state of full moon and new moon. This spring tide occurs when the distance between the sea and centre of the moon was closer than the distance between the centre of the earth and moon. The impact of spring tide was moon gravitational pulls seawater stronger than the earth. Thus, seawater surface would be inflated at the deep ocean and form high tide. In contrast, part of the earth that experience new moon, distance between seawater and centre of the moon is farther than distance between the earth and moon. The impact of new moon was moon gravitational pulls earth more stronger. Thus, seawater would be inflated on the earth surface.

2.4.2.2 Neap Tide

Neap tide was formed when the position of earth, sun and moon was in a right angle. At this stage, the resulting seawater level was low because seawater at the other side had pulled by the spring tide. This situation has occurred when the moon in a half condition.

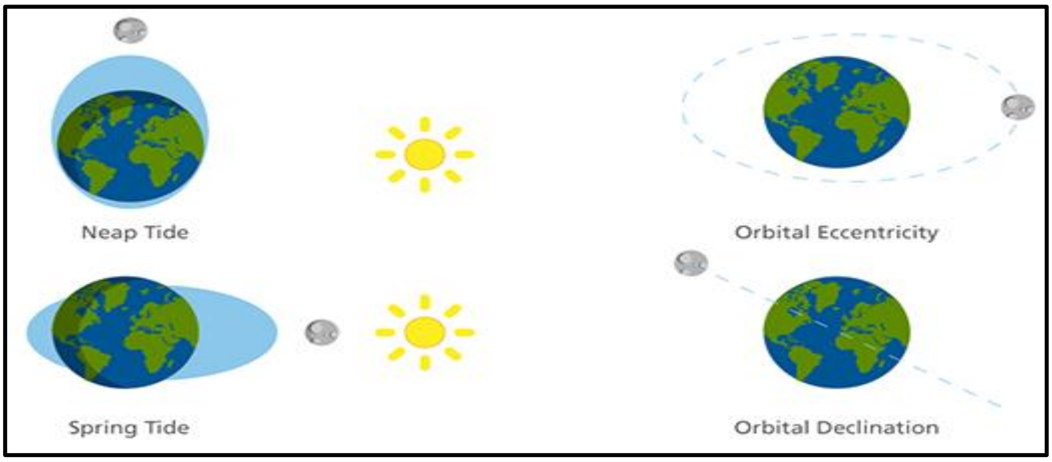

Figure 2.7 The Left Column Depicts the Earth, Sun and Moon Alignment that Generate Spring and Neap Tides. The Right Column Depicts the Moon's Orbital Eccentricity and Declination that Cause Departures from Mean Tidal Ranges

Source: Air Worldwide (2015)

2.4.2.3 Supermoon Phenomenon

Moon has two phase when it circle the earth; perigee and apogee. Because of the moon's orbit was elliptical, the position of moon was tended to be closer with the earth at the perigee phase. Distance between moon to the earth could reach 356,000 at perigee phase. Moon at perigee stage could cause seawater to experience ups and large. The moon period around the earth from perigee to apogee and turns back to perigee takes approximately 27.55455 days (27 days 13 hours 18 minutes 33 seconds). This phenomenon was also known as the Supermoon. The supermoon phenomenon occurs when the moon was at perigee phase. This phenomenon could affect the tide. When the moon was closer to the earth, it would cause moon gravitational to the earth increased and cause the water mark of the sea becomes extraordinary.

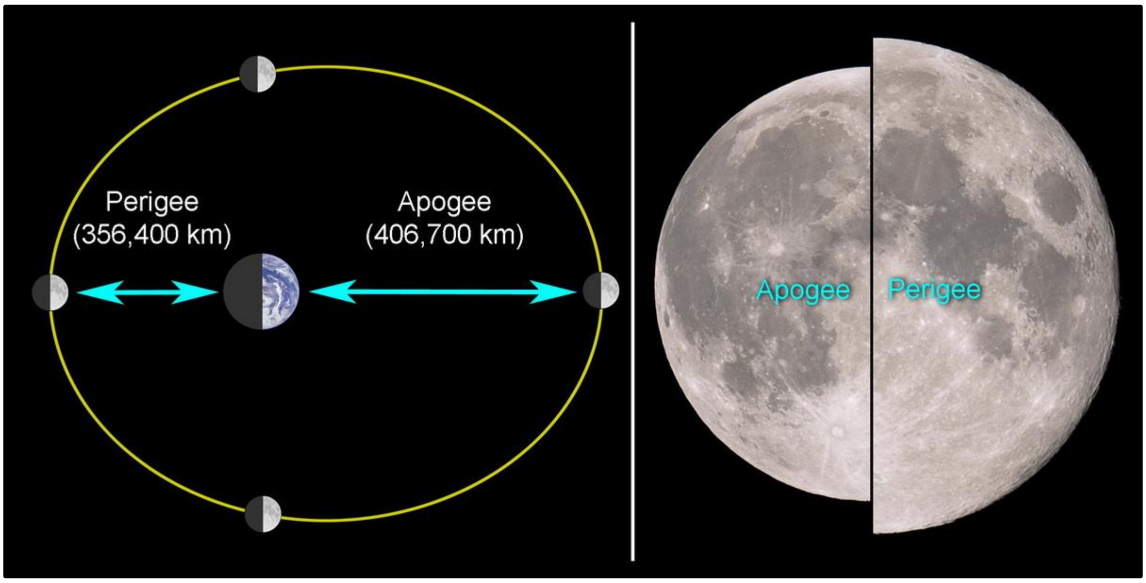

Figure 2.8 Distance Between Perigee and Apogee and Its Size
Source: SkyNews Magazine (2016)

Figure 2.9 View of Supermoon at Perth
Source: WAtoday News (2016)

2.4.3 Storm Surge

According to the National Weather Service, storm surge was an abnormal rise of water generated by a storm, over and above the predicted astronomical tide. A storm surge was a rise in sea level that occurs during tropical cyclones, intense storms also known as typhoons or hurricanes. Storm tide was the water level rise during a storm due to the combination of storm surge and astronomical tide. Storm surge was the rising of the sea level due to the low pressure, high winds, and high waves associated with a hurricane as it makes landfall.

Storm surges was hazardous to the coastal residents because storm surge consist of strong wave and wind that often become the greatest threat to life and property from hurricanes. Most of the surge happens when the force of the wind pushes of water toward the shore. The storm surge was divided into several categories; tropical storm, hurricane and tropical depression .Violent storms that was formed in the tropical waters regions and have a diameter of several hundred kilometres known as tropical cyclones. Normally, the ocean surface that was exposed to a temperature of 26 degrees Celsius or more will be form a tropical cyclone and it was known as typhoons in Asia region. Factors that catalyse storm surge was a storm intensity, the shape and characteristics of the coast features such as bays and estuaries, wind speeds, and tide. Besides, width and the slope of continental shelf also is one of the factor to storm surge. The influence of the topography of the sea floor, wide shallow areas on the continental shelf was more susceptible to damaging surges than those where the shelf slopes steeply (Bell,. 2003). A shallow slope would be produce a greater storm surge than a steep slope. This was because the seawater would be easily reach up to the shore due to high tide. Otherwise, from figure 2.10 the tropical storm could build up the water and pushed it to the shore with the forward motion and it could be cause of significant damage and inundating entire area of communities. Storm surge also could reach height up to 28 feet from the normal dry ground (The Weather Channel,. 2016). Thus, with the huge number of water, storm surge enough to make inundation areas.

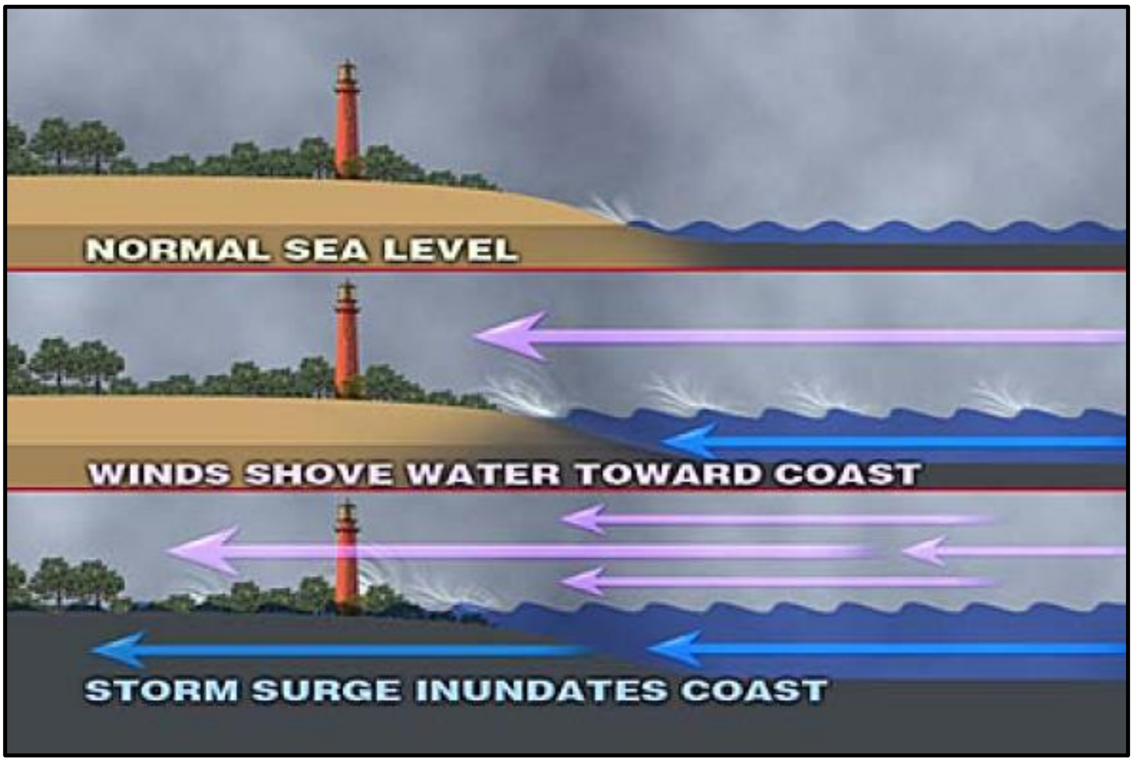

Figure 2.10 Formation Of Storm Surge
Source: Acu Weather (2012)

2.5 Impact of Coastal Flood

Coastal flood would give adverse impact to all lives in the world. Either human nor the flora and fauna also implicate into this problem. The main impact of coastal flood was divided into two which to the nature and to the economy.

2.5.1 Impact of Coastal Flood to Nature

Coastal erosion was a loss of sub-aerial landmass into a sea or lake due to natural processes such as waves, winds and tides or even due to human interference. Wind and waves create the energy that erodes the rocks along coastlines. The coastal zone includes all areas from the deep ocean normally up to 320 km offshore to 60 km inland. Although it is difficult to quantify, the cumulative reduction in sediment supply from human activities may contribute substantively to the long-term shoreline erosion rate. Along coastlines subject to sediment deficits, the amount of sediment supplied to the coast is less than that lost to storms and coastal sinks (inlet channels, bays, and upland deposits), leading to long-term shoreline recession (Herrington,. 2003). Coast consist of upper beach of backshore, the foreshore and the offshore area. A coastal zone was the interface between the land and water. These zones were important because a majority of the world's population inhabit such zones. Coastal zones was continually changing because of the dynamic interaction between the oceans and the land.

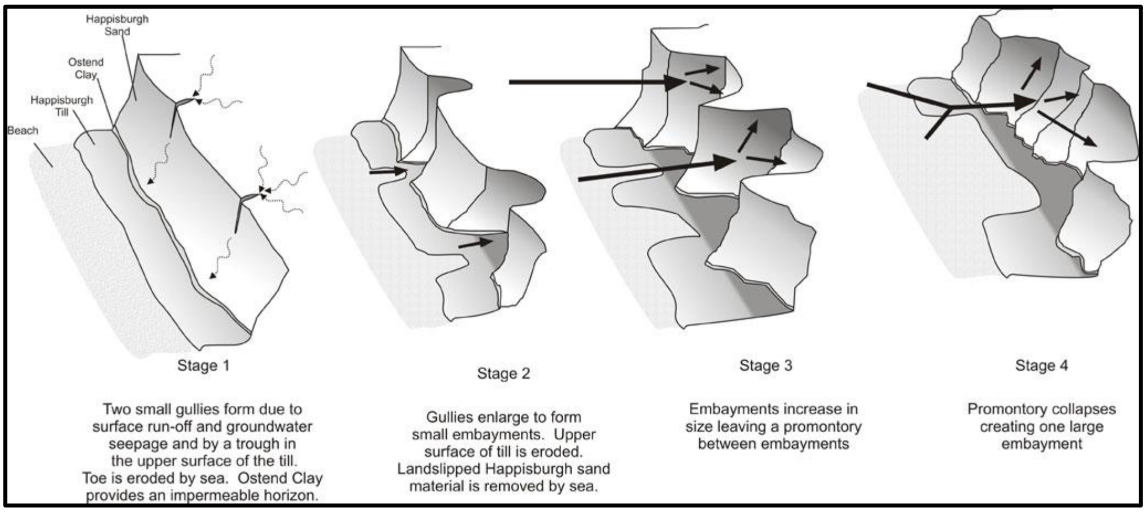

Figure 2.11 Formation of Coastal Erosion
Source: British Geological Survey

Coastal erosion processes include hydraulic action, abrasion, corrosion and attrition. Hydraulics action was results from larges waves hurling beach or eroded material against a cliff. The force of waves hitting a cliff or sea wall compresses water and air into cracks and joints. Abrasion was when waves cause rock and pebbles on the beach to bump into each other and wear down in size. Corrosion was the sheer force of the waves especially when it trap and compress air in cracks and holes in a cliff. Salts and acids in seawater could react with rocks and slowly dissolve in the seawater. Attrition was a certain types of rock types in a cliff were actually slowly dissolved by the seawater. Rock fragments which have been detached by hydraulic action and abrasion were worn down into smaller and more rounded pieces. Current and tidal movements cause the fragments to be swirled around and to grind against each other. This type erosion produces pebble beach.

Figure 2.12 Four Processes of Erosion
Source: Geographical Science Website

2.5.2 Impact of Coastal Flood to Economy

Economic was the main artery for the country development. The countries could generates economic growth through the wealth of the earth in their country. The highest income to raise the country's economy through the tourism sector. Like other countries, Malaysia also have states that could generate tourism activities such as Teluk Cempedak, Kuantan, Pahang. Pantai Teluk Cempedak was already known with its beautiful beach, therefore many tourism from around the world visiting Malaysia. Because the position of Kuantan was located near to the coast, it was prone to coastal flooding. When floods hit the beach, it would destroy the entire city of Kuantan and tourism activities. This caused the government would suffer a loss in terms of urban conservation and tourism sector. Government would incur substantial losses such as damage to government buildings, hospitals, parks, public telecommunication and transport and etc. Losses amounting to RM610 million was recorded in the flood disaster that affected Pahang recently following damages to properties, agricultural produce and infrastructure in the state (Astro Awani,. 2015).

Figure 2.13 Local Tourist Visiting the Gulf Coast Cempedak
Source: Harian Metro (2016)

2.6 Coastal Flood at Miami

Miami was a city in the United States. It was located in the southern state of Florida. Miami was the most high-risk city for coastal flood because it located nearly along the beach area. Floods in the major coastal cities would lead to higher costs for the city's economy. Climate change increases flooding risk both by raising sea level and triggering more frequent and powerful storms. Other cities facing the highest flood losses were Mumbai, Jakarta, Boston, Bangkok and Abidjan, while in Europe, the cities of Marseille, Naples and Athens.

Among the steps taken to mitigate the effects of coastal flooding in Miami, Flora were the city of Miami Beach was invested at least $400 million in raising street heights and installing water pumps throughout the barrier island’s most flood-prone areas (Gillis,. 2016). In addition, all new construction greater than 7,000 square feet must have Gold Leed Certified. According to the Robins, who chairs the Miami Beach Sea Rise Committee, discussed plans to raise roads, sidewalks, and right-of-ways in flood prone areas of the city such as West Avenue by one-and-a-half to two feet (Alvarado,. 2015).

Figure 2.14 Coastal Flood at Miami
Source: Independent News (2013)

2.7 Coastal Flood at Malaysia

Malaysia also was received the natural disaster which is coastal flood. In the last October , a total of 17 locations involving five districts of Klang, Sabak Bernam, Kuala Selangor, Sepang and Kuala Langat were expected flooded by the high tide phenomenon in the entire coastal area of shore in the state. Sea level was reported to have increased by up to a height of 5.4 meters and was expected to grow up to 5.7 meters and it caused some coastal areas at a high risk which might be flooded by the seawater (The Rakyat Post,. 2016). Tide in the country was reported to have reached the alert level and the danger that the two regions Klang and Sabak Bernam classified as red zone or high risk areas hit by the floods, while three districts namely Kuala Selangor, Kuala Langat and Sepang as the yellow zone, medium-risk areas.

Figure 2.15 The Coastline in State that Affected by the High Tide Phenomenon
Source: BHOnline (2016)

Figure 2.16 Seawater Overflow at Pantai Kelanang, Banting, Malaysia
Source: Harian Metro (2016)

CHAPTER 3

METHODOLOGY

3.1 Introduction

The study of coastal flood was implemented using software known as Geographical Information System (GIS). GIS was a system where it could connected automatically with the satellites to provide any data such as elevation data. GIS also have its own map which called as a base map. This base map was used to determine the location of study. Another methods to provide base map were using Google Earth and Earth Explorer. Earth Explorer software was used for this study as a method to find digital elevation model around studied areas. Kuantan, Pahang was selected to be the study area. The purpose to provide coastal flood map because the location of Kuantan City was fully with local community and industrial areas which could give bad impact to them when coastal flood happen. With the presence of coastal flood map, it able to identify which areas in Kuantan would affected with coastal flood hence the local agencies could make preparation to against it. At the end of this study, GIS software would provide the result on which areas have a significant potential to be flooded by the seawater around 50 to 100 years. In addition, Kuantan was flood-prone areas such as flash floods. Due to its location close to the beach, the potential of Kuantan City to experience coastal flood was high if there was an increment of seawater level .

3.2 Methodology Chart

Methodology chart was very useful and helpful in the study field. Methodology chart has been used as a guidance or research strategy for all the researchers. Methodology chart consist of title of case study, location of study, data collection, data analysis, results and solutions from the problem arise. Methodology chart also help to complete the study within the time given.

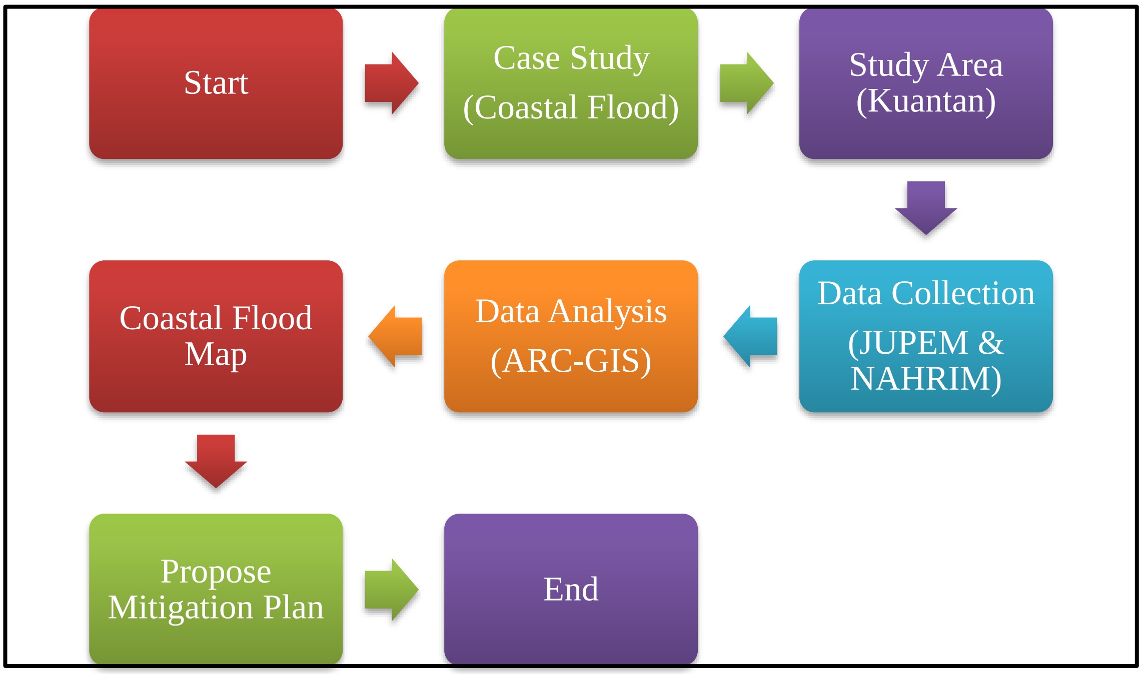

Figure 3.1 Methodology Chart of the Study

3.3 Geographical Information System (GIS)

A GIS was basically a computerized information system like any other database, but with an important difference which mean all the information in GIS should be linked to a geographic spatial reference such as latitude and longitude, or other spatial coordinates. According to the Environmental Protection Agency, a GIS, which refers to Geographic Information System, works by combining database functions with computer mapping to map and analyse geographic data. It uses a "layering" technique to combine various types of data. Special GIS software was used to analyse layered data and create new layers of data. Geographical was a geographic reference, means it referred to data of spatial coordinates on the surface of the earth map. Information systems data base of attribute data corresponding to spatial location and procedure to provide information for decision making.

GIS consist of two component which were spatial component and attribute component. Spatial component defined as the location of an information. Basically, it was constructed from three forms which were lines, points and polygons. Spatial data was categorized into two which were in raster and vector. Individual cells in a matrix, or grid, format was used in the raster data to represent real world entities. It was obtained from satellite imagery, aerial images of space, and a map scan. Meanwhile, the coordinate was used in the vector data to store the shape of spatial data object. It was perform in CAD Software, Shapefile, Map info table, delimited text file (with coordinates), Triangulated Irregular Network (TIN). Attribute component was the information in the database. The information that was mentioned before was related to geographic information, the position and size of plots of land and ownership status, the system's network of roads and railways, drainage, sewerage, ranked rivers and swamps, building, conditions and altitude terrain, geological information, population, land use information, etc. related to the geographical position of a place. The information disclosed was displayed either through the computer screen in the form of a graph (map), or schedule reports so it easily to understood by the consumer and, if necessary, this information may be plotted or printed using a plotter or printer.

GIS could use any information that includes location. The location could be expressed in many different ways, such as latitude and longitude, address, or ZIP code. Many different types of information could be compared and contrasted using GIS. The system also include data about people, such as population, income, or education level. It could include information about the land, such as the location of streams, different kinds of vegetation, and different kinds of soil. It also include information about the sites of factories, farms, and schools, or storm drains, roads, and electric power lines.

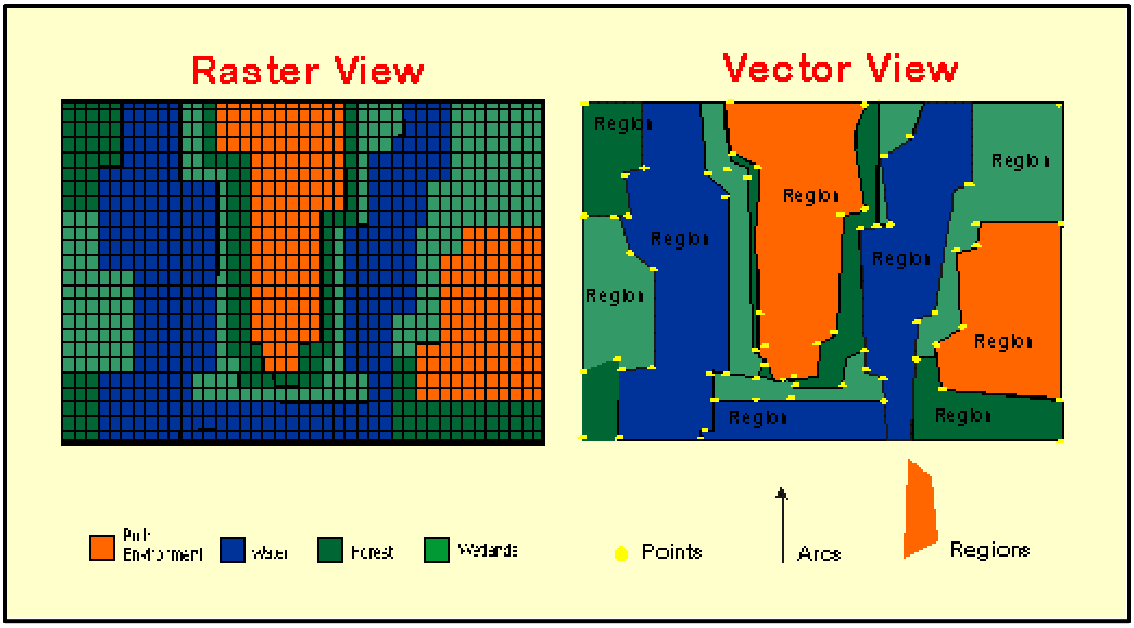

Figure 3.2 Comparison between Vector Data and Raster Data

Source: Kenneth E. Foote and Donald J. Huebner, The Geographer's Craft Project, Department of Geography, The University of Colorado at Boulder (1996)

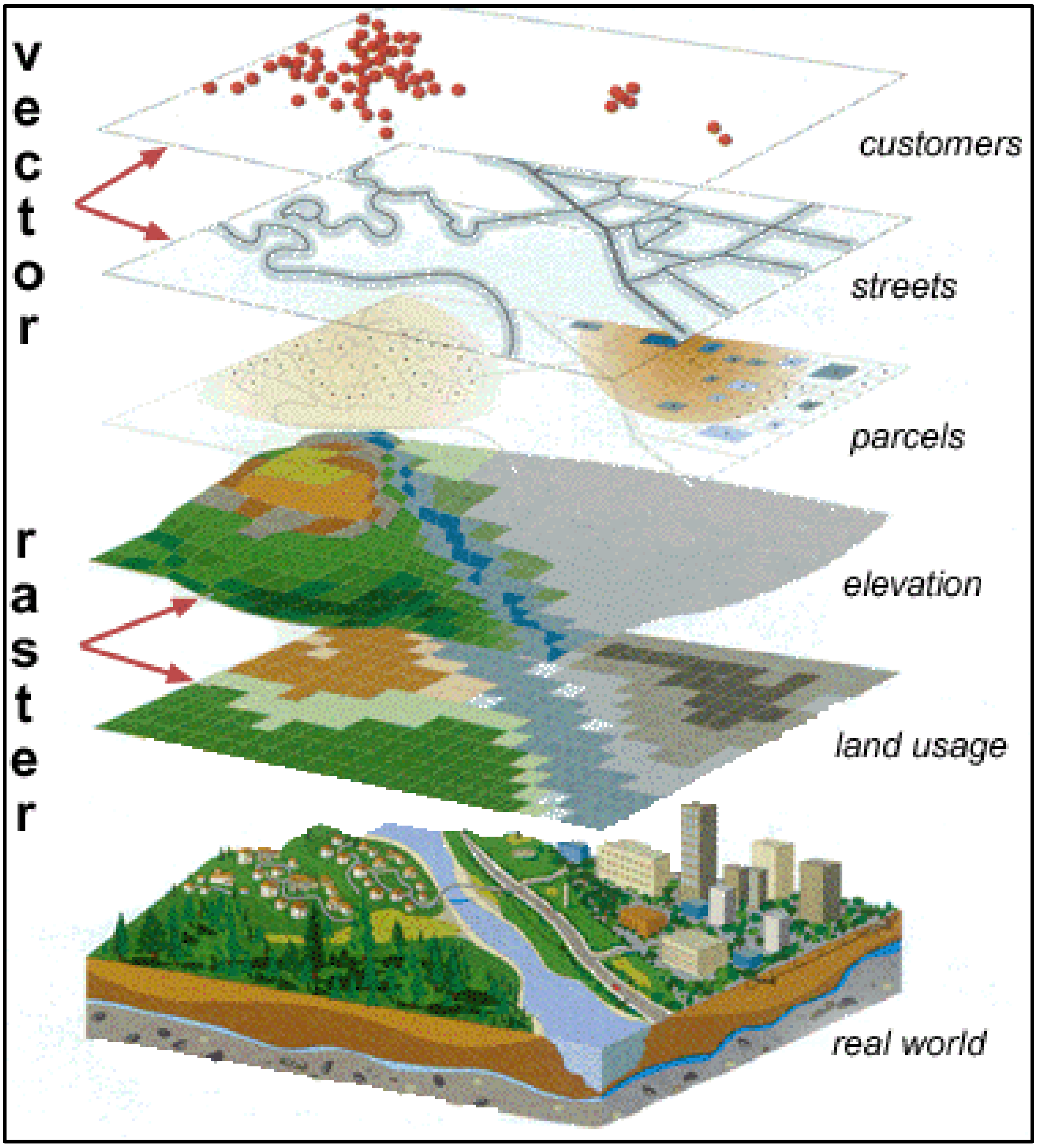

Figure 3.3	Real World in GIS was Formed by Several Layers Data

Source: National Coastal Data Development Centre (NCDDC), National Oceanic and Atmospheric Administration (NOAA), USA

3.4 Advantages Of GIS

Geographical information system software was used for this study because it great for Coastal Development and Management. The coastal zone represents varied and highly productive ecosystem such as mangrove, coral reefs, see grasses and sand dunes. GIS could be generated data required for macro and micro level planning of coastal zone management. GIS was used in creating baseline inventory of mapping and monitoring coastal resources, selecting sites for brackish water aquaculture, studying coastal land forms.

Besides, GIS also could be as geologic mapping. GIS was an effective tool in geological mapping. It becomes easy for surveyors to create 3D maps of any area with precise and desired scaling. The results provide accurate measurements, which helps in several field where geological map was required. This system cost effective and offers more accurate data, there by easing the scaling process when studying geologic mapping.

Then, GIS could be as flood damaged estimation. GIS helps to document the need for federal disaster relief funds, when appropriate and could be utilized by insurance agencies to assist in assessing monetary value of property loss. A map flood risk areas was needed by local government to evaluate the flood potential level in the surrounding area. The damage could be well estimate and could be shown using digital maps.

In additional, GIS helps in location identification. It helps to find out the existing at a particular location. A location could be described in many ways, using, for instance, name of place, post code, or geographic reference such as longitude or latitude or X/Y.

Other than that, GIS was the application that could collect information about geographic features. GIS was not simply a computer system used for making maps. A map was simply the most common way of reporting information from a GIS database. These systems was not only for creating maps but also most importantly the collection of information about the geographic features such as building, roads, pipes, streams, ponds and many more that are located in community surrounding.

GIS also could works as Disaster Management and Mitigation. Today a well-developed GIS systems was used to protect the environment. It has become an integrated, well developed and successful tool in disaster management and mitigation. GIS could help with risk management and analysis by displaying which areas were likely to be prone to natural or man-made disasters. When such disasters were identified, preventive measures could be developed.

GIS was used to identify environmental health risks in a Baltimore community (Choi et al,. 2006). The researchers then surveyed patients at a non-profit community clinic. Linking the survey information to GIS data, community stakeholders uncovered relationships between geographical location and environmental exposure. The researchers concluded that GIS mapping makes health information more accessible and easier for community stakeholders to interpret. Because public health programming hinges on information, the graphic depiction of data is invaluable, as it links health information to its geographical location. As a result, communities find new solutions to address public health problems (Graham et al,. 2011).

3.5 Study Area

Kuantan is the capital of the state of Pahang, located in the eastern part of the country has an area of 2960 square kilometers (296,042.09 hectares), or about 8.2 percent of the total area of the State. Kuantan consist of six region whereby are Berserah, Kuala Kuantan, Penor, Sungai Karang, Ulu Kuantan, and Ulu Lepar. The statistical of population lives had been acquired by the Pejabat Daerah dan Tanah Kuantan. The highest population lives were in the Ulu Kuantan (88,616.53), followed by Kuala Kuantan (79,446.92) and Ulu Lepar (75,340.96). Meanwhile, the lowest population lives were in the Berserah (3,102.72), followed by Penor (22,286.16) and Sungai Karang (27,248.80). This study was focused only around area near with the coastlines which was in the Kuala Kuantan, Penor, Berserah and Sungai Karang. This is because, coastal flood prone areas only happen around the coastlines. Kuantan City was located at the Kuala Kuantan, so that coastal flood map was developed around the Kuala Kuantan, Berserah, Penur and half of Sungai Karang.

Figure 3.4 Map of Kuantan District
Source: Pejabat Daerah Dan Tanah Kuantan

3.6 Data Collection

Data collection was a process to gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes. There were several data needed to realize this study, these data reflect back to the sources of coastal flood was formed. The data were tide gauge data, sea level rise data and storm surge data.

3.6.1 Tide Gauge Data

Tide gauge data used in this study was taken from National Hydrographic Centre, Malaysia. National Hydrographic Centre Malaysia (NHC) had published Tide Tables 2017 as a guidance for researcher or local agencies to make a prediction about the current sea water level especially in the monsoon season. The tide tables was recorded by days. Each of days consist of three to four readings based on the high and low water reading in the station. In this study, Tanjung Gelang in Pahang was selected as a nearest tide gauge station in the Kuantan. The highest reading was identified from the tide tables as a method to determine the tide gauge data. From the tide tables 2017 in the figure 3.5 below, the highest tide gauge reading was recorded in 3.7 meters on 7 December 2017, at the midnight. Thus, this value was selected as input data for maximum tide gauge reading in Kuantan area for this study.

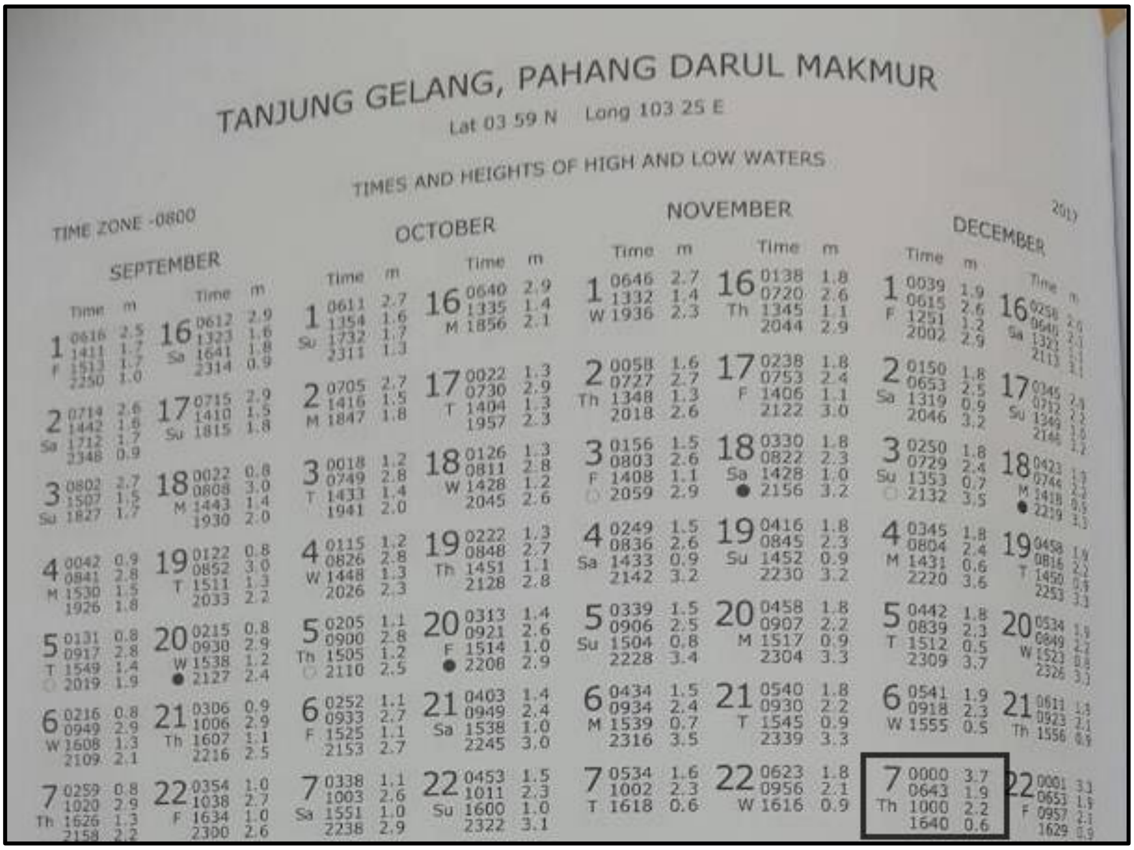

Figure 3.5 Tide Gauge Reading in Tanjung Gelang, Pahang
Source: The Tide Tables 2017, National Hydrographic Centre Malaysia

3.6.2 Storm Surge Data

Storm surge data was decided to be taken from a research that had been done by the Malaysian Meteorological Department (MetMalaysia). In the research from the figure 3.6 below state that there were three categories of strong wind that would contribute to the storm surge. Because of coastal flood was a severe flood, this study was decided to choose the higher categories in the list of strong wind that would allow the height of rough sea wave would be exceeding up to 4.5 meter.

Strong Winds Advisories/Warnings

Criteria/ Thresholds	There are three categories of strong wind warning/advisory due to TCs that is First, Second and Third category. i. First Category: Strong winds with speeds up to 50 kmph and rough seas with wave height up to 3.5 m. ii. Second Category: Strong winds with speeds up to 60 kmph and rough seas with wave height up to 4.5 m. iii. Third Category: Strong winds with speeds exceeding 60 kmph and rough seas with wave height exceeding 4.5 m.
Contents of Warning/Advisory Message	Warning/advisory stage (First, Second or Third category), date and time of issuance, TC information, associated severe weather phenomena, wind speed & wave height over affected areas, warning/advisory affected areas, duration of occurrence and potential disaster risks.

Figure 3.6 Third Category Show the Highest Reading of Wave
Source: Malaysian Meteorological Department (MetMalaysia)

3.6.3 Seawater Level Data

The sea water level data was taken from a projection research that had been proposed by the National Hydraulic Research Institute of Malaysia (NAHRIM). The research was a joint venture between NAHRIM and Commonwealth Scientific and Industrial Research Organisation, Australia (CSIRO). The title of this research was Research In Sea Level Rise And Adaptation Measures and it has been published as a book. From NAHRIM's research in figure 3.7 state that the sea water level in Malaysia was projected would be rise in the average between 0.25 ± 0.52 meter in year 2100. There was a different projection between Peninsular Malaysia, Sabah and Sarawak. This projection on the Sea Level Rise only applicable for Peninsular Malaysia. In this study, the projection on sea level rise for year 2100 was 0.52 meter, which the highest projection made by NAHRIM and the projection on sea level rise for year 2050 was 0.26 meter, which half of the 2100 projection.

	Sea Level Rise	Note
Projection 2100 (Peninsular Malaysia)	0.25m – 0.52m (~0.52 mm/yr)	Maximum SLR – Northeast and West coast of Peninsular Malaysia (Kelantan & Kedah)
Projection 2100 (Sabah & Sarawak)	0.43m – 1.06m (~1.06 mm/yr)	1. Maximum SLR– North & East coast of Sabah. 2. Inundation at low lying area and rivermouth/estuaries in Southwest coast of Sarawak (Meradong, located between Batang Igan & Batang Rajang). 3. Inundation at low lying area and rivermouth/estuaries in East coast of Sabah (Tawau, Semporna, Lahad Datu, Sandakan & Kudat).

Source: NAHRIM (2010)

Figure 3.7 Projection on Sea Level Rise at 2100 for Malaysia
Source: National Hydraulic Research Institute Of Malaysia (2010)

3.7 Data Analysis

Data analysis was the process of systematically applying statistical or logical techniques to describe and illustrate, condense and recap, and evaluate data. According to Shamoo and Resnik (2009) various analytic procedures “provide a way of drawing inductive inferences from data and distinguishing the signal (the phenomenon of interest) from the noise (statistical fluctuations) present in the data”.

3.7.1 Arc Map

This platform could integrate and manage all kinds of database effectively and achieve some function, such as exploring and inquiring map layers, overlapping map layers, editing map online, accounting, analysis, system management and so on. This platform supplies user-friendly interface and simple usage mode. It is convenient for different government functional departments, office and social public to inquire and account all kinds of information (Liu et al,. 2008). Arc Map was the main function in GIS because arc-map was able to produce map for the researcher’s necessity.

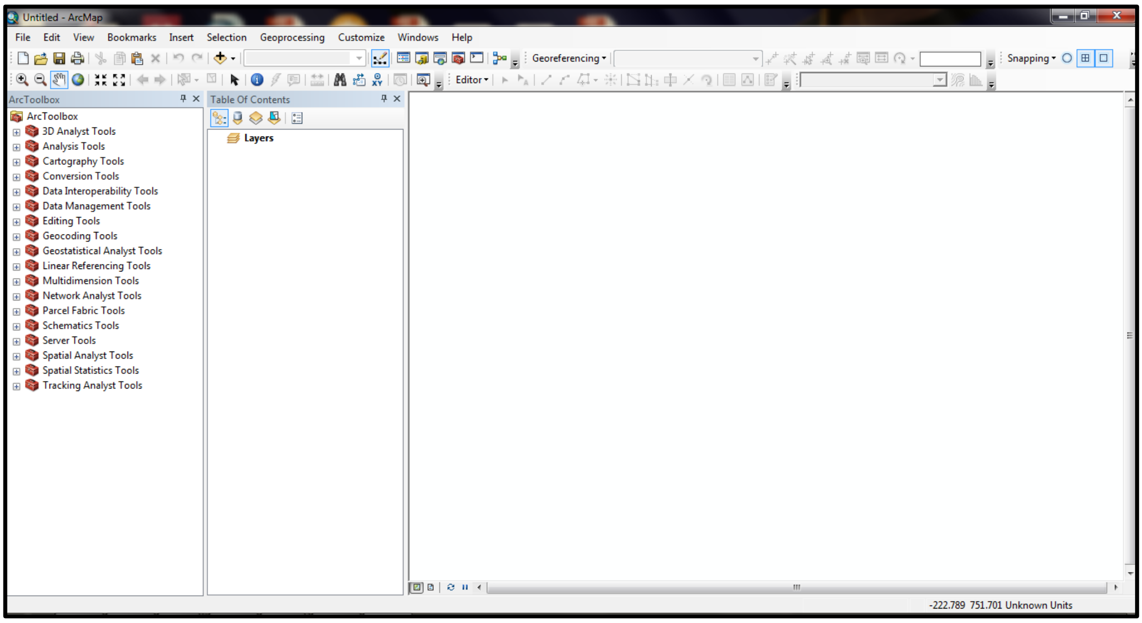

Figure 3.8 Main Display of Arc Map
Source: Geographical Information System (GIS), Arc Map

3.7.2 Digital Elevation Data (DEM)

A digital elevation model is a 3D representation of the bare ground surface without any objects, like plants and buildings (Elkhrachy,. 2017). DEM is also known as a digital model to represent a terrain surface. There were many types of DEM such as ASTER, LIDAR, SRTM, NED and etc. Each of the DEM have their own superiority. DEM was used often in geographic information system and were the most common basic to produce a relief map. Before that, the accuracy of DEM must be ascertained. The accuracy of DEM usually represented by spatial resolution and height (Takagi,. 1998). In this study, SRTM was chosen to be used as a base terrain for the coastal flood map in Kuantan area. All the elevation value for this area also would be automatically downloaded concomitant with the DEM which already was in the TIFF file format.

3.7.2.1 Space Shuttle Radar Topography Mission (SRTM)

Space Shuttle Radar Topography Mission (SRTM) were categorized by two which in 30 meters and 90 meters. In this study, 30 meters was used as a raster for Arc Map and it also provide altitude information of a location. DEM also communicates or connected with satellites to obtain the elevation data. The DEM was downloaded from United States Geological Survey's (USGS) website without needed a payment.

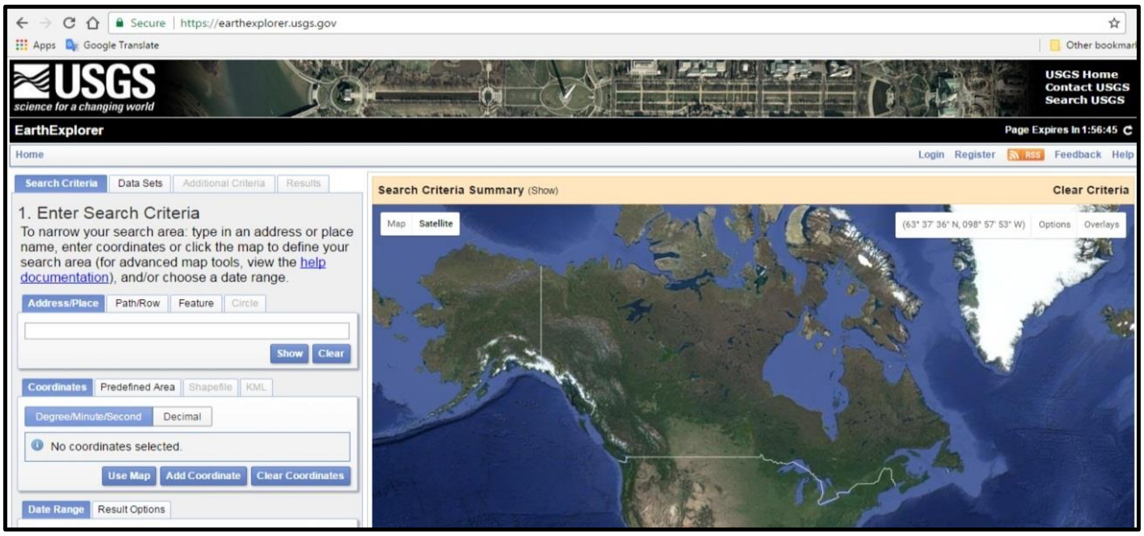

Figure 3.9 Earth Explorer Website

Source: United States Geological Survey (USGS)

There have two method for selecting raster, which were SRTM and ASTER. SRTM 1 Arc-Second Global has been used for this study which in 30 meter. There were few differences between SRTM 90 and SRTM 30. SRTM 30 was selected because it would provide clear view of terrain compare to SRTM 90. After searching the location, earth explorer application would directly give the digital elevation model and the scale location must be reduced from Kuala Kuantan boundary area into Kuantan area only. There were two major streams that connected from seawater which were at Sungai Pahang and Sungai Kuantan and many sub-streams such as Belat River, Galing River, Isap River, Cempedak River and etc.

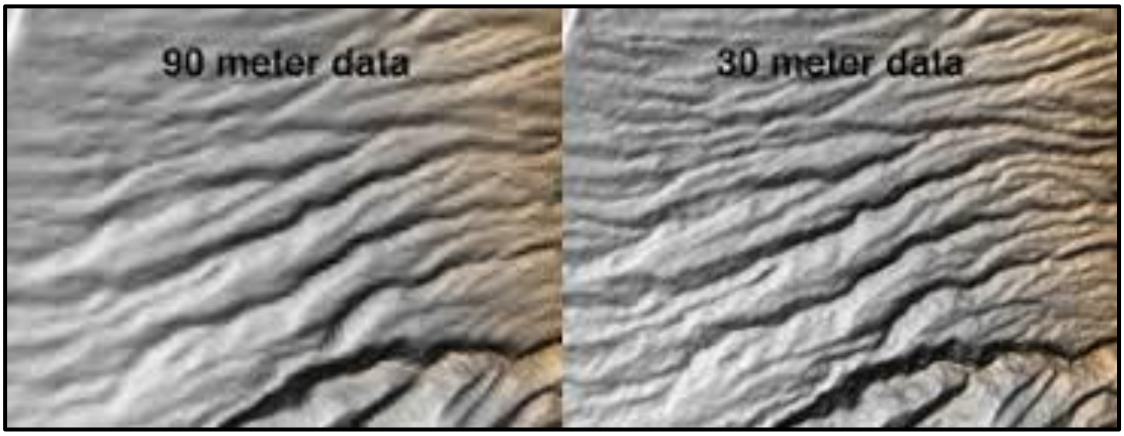

Figure 3.10 The Difference Between SRTM 90 Meter and SRTM 30 Meter
Source: Jet Propulsion Laboratory, National Aeronautics and Space Administration (NASA)

3.7.3 Clipping Method

The full view of digital elevation model in Kuala Kuantan's area was used in geographical information system as a base terrain and the area need to limit around the Kuantan city. Using sketching method, shape polygon in figure 3.11 was designed and sketched work initiated according to the boundary line in imagery base map. The polygon was stored in Arc Catalog. Then, this study was continued by using clipping method. Clipping method serves to separate full view of DEM according to the mold shape which has been designed before. This process was known as clipping method. The shapefile in the Arc Catalog was created as a mold to create a new DEM around Kuantan City. Arc Toolbox window was opened and it would automatically at the left side of Table Of Content. The Data Management Tools up to raster processing was choose and clip section would appear.

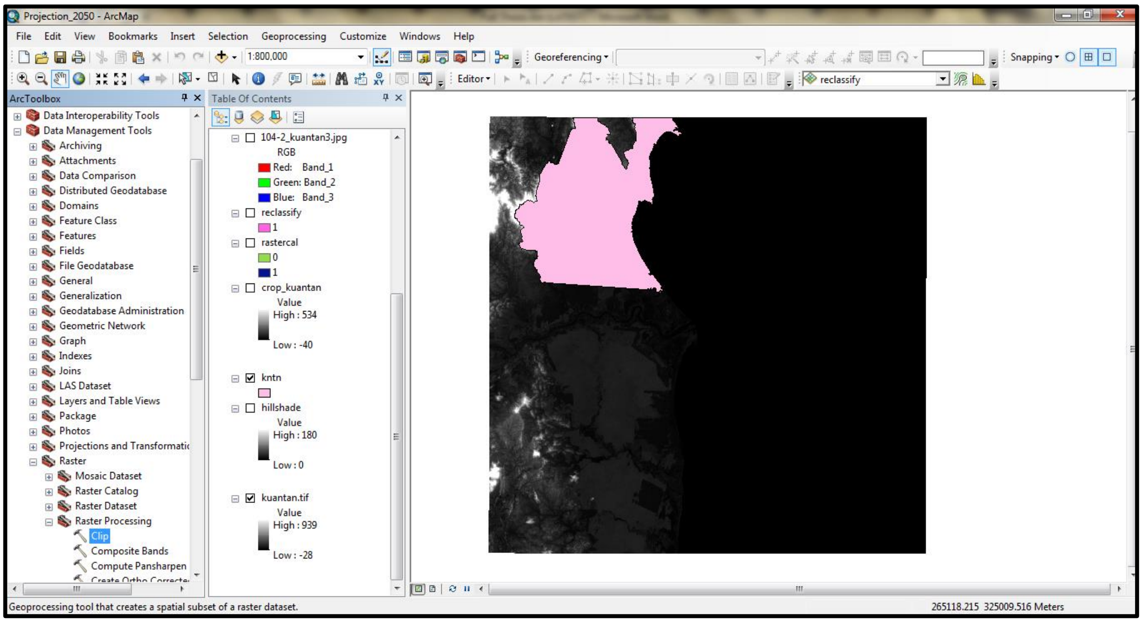

Figure 3.11 Process of Clipping Method

Source: Geographical Information System (GIS), Arc Map

3.7.3.1 Hillshade

Hillshade was used in map-making process. Hillshade was a grey scale lines to create a 3D representation of the surface, with the sun's relative position taken into account for shading the image of DEM. A gray scale colour ramp was used to display a hillshaded elevation model. Hillshading process for a map was a fastest way to determine the elevation for the area. Hillshade tool also could be found in the Arc Toolbox.

One of the criteria in the map is the overview must be clear enough to be seen by the consumer. Hillshade method must be applied to get a perfect topographical map. Function of hillshade is to inflict some different elevation into the map. If not, the map will be in zero elevation condition.

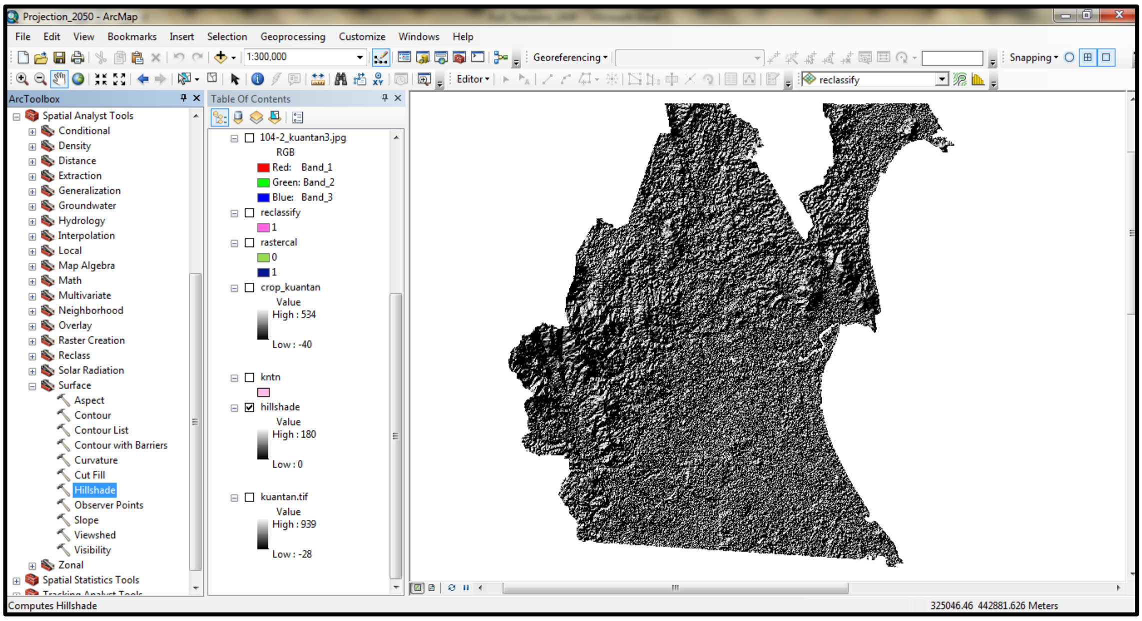

Figure 3.12 Hillshading Process Occur in Kuantan Boundary
Source: Geographical Information System (GIS), Arc Map

3.7.4 Spatial Analyst Tools

Spatial analyst tools consist of several different function. Many set of spatial analysis and modelling tools for both raster and vector features were provided in the spatial analyst extension. Spatial Analyst extension could derive new information from existing data such as slope, hillshade, elevation raster and etc.

Table 1.1 The Functional Categories of Spatial Analyst Used in this Study

Toolset	**Description**
Map Algebra	Map Algebra was a way to perform spatial analysis by creating expressions in an algebraic language. Map Algebra expressions was created using the Raster Calculator.
Reclass	The Reclass tools provide a variety of methods that allow the user to reclassify or change input cell values to alternative values.
Surface	With the Surface tools, the user could quantify and visualize a terrain landform represented by a digital elevation model.

Source: ArcGIS for Desktop website

3.7.4.1 Map Algebra

Map Algebra was a first stage to create coastal flood model in Arc Map. Without this extension, the seawater would flow using the elevation data of study area. This process only involve flood not a coastal flood. This extension could be found in the Arc Toolbox which in the part of Spatial Analyst Tools. In the Spatial Analyst Tools, there were many sub-section were appear including Map Algebra. When the analysing process has been done, two results of different colour was appear at the screen. The green colour in the figure 3.13 below show that the total region was calculated by the map algebra calculator and blue colour represent the lower elevation area in the Kuala Kuantan boundary that exposed to be affected by coastal flood.

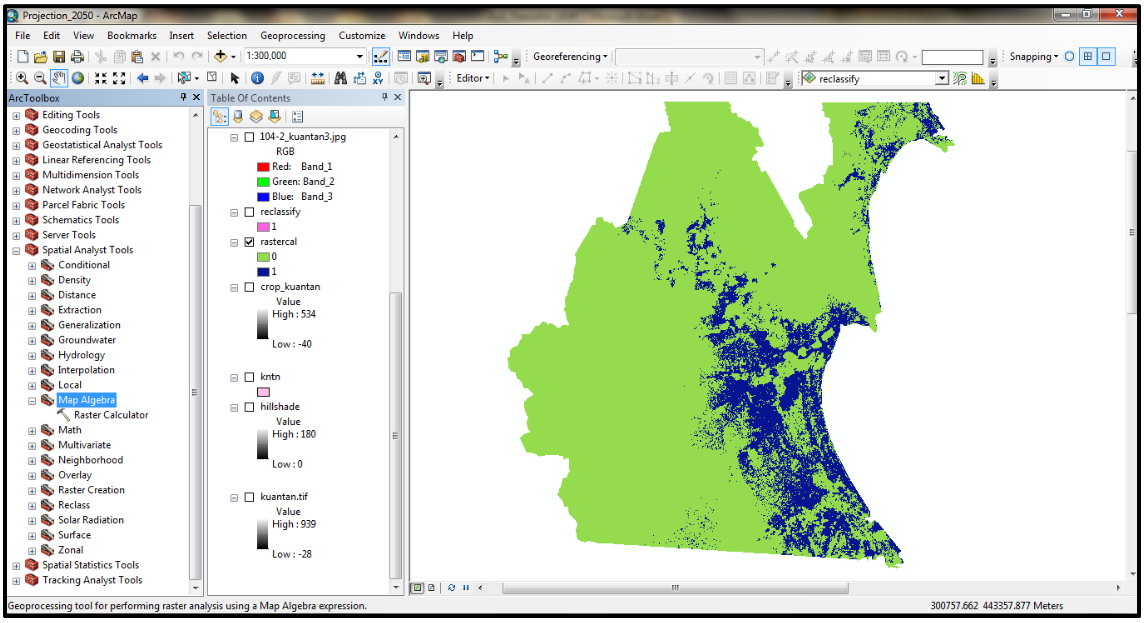

Figure 3.13 Result from Map Algebra Process

Source: Geographical Information System (GIS), Arc Map

3.7.4.2 Reclassify

Reclassify is the process to separate between the region which not flooded by the sea water and the regions were inundated by the sea water. It also could be found in the Arc Toolbox. Spatial Analyst Tools extension was opened and it would show many kind of another sub-extension. Reclass was selected and this sub-extension would show another four usage. Reclassify was chosen to create coastal flood model. The pink colour was appeared as a result from reclassify process. Pink colour also was a shapefile represent the low areas started from the coastlines up to the location that were submerged by the seawater in the coastal flood. This step also was connected from the previous step (Map Algebra). So that, all the input data were needed in this step need to refer from Map Algebra. The black colour in the figure below was a digital elevation model.

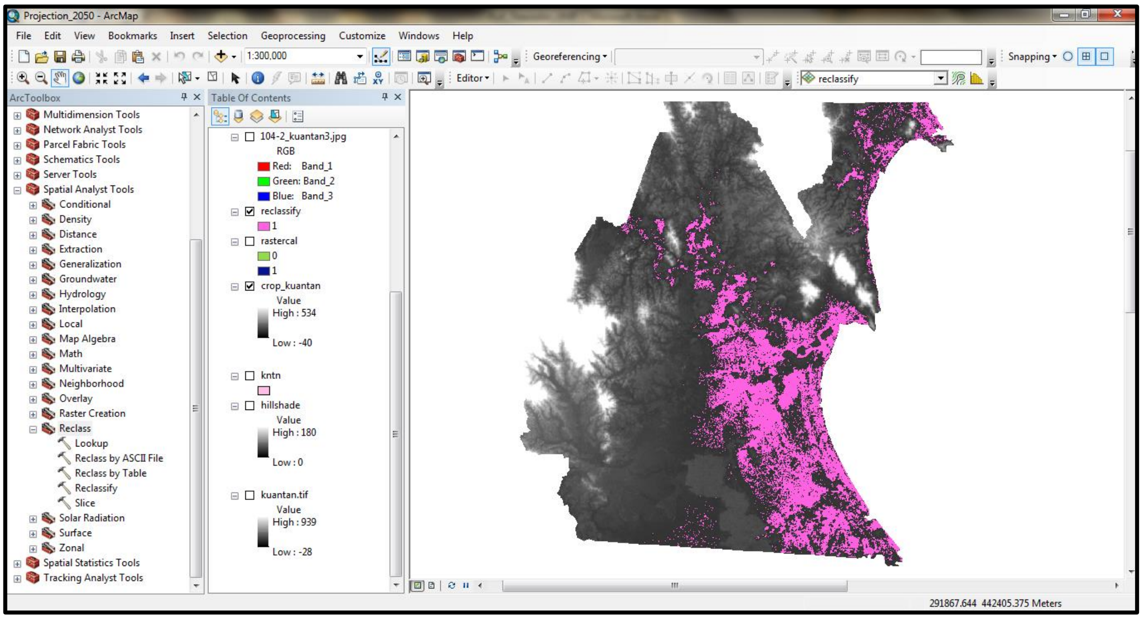

Figure 3.14 Result from Reclassify Process

Source: Geographical Information System (GIS), Arc Map

3.7.4.3 Conversion Tools

Step to produce coastal flood map was continued with the Conversion Tools. This tool was provided from the Arc Toolbox. From Raster was selected and it function as a conversion medium for all information in the dataset to a different type of data structure such as a feature class or to a different type of file such as binary or text file. All the needed data for Raster To Polygon was connected from the previous steps (Reclassify). This step would produce only the location that influence with coastal flood. Based on the figure 3.15 below with a projection in the year 2050, the turquoise lines show the risky location. Therefore, the turquoise lines were the locations which have ground elevation low from 8.46 meter.

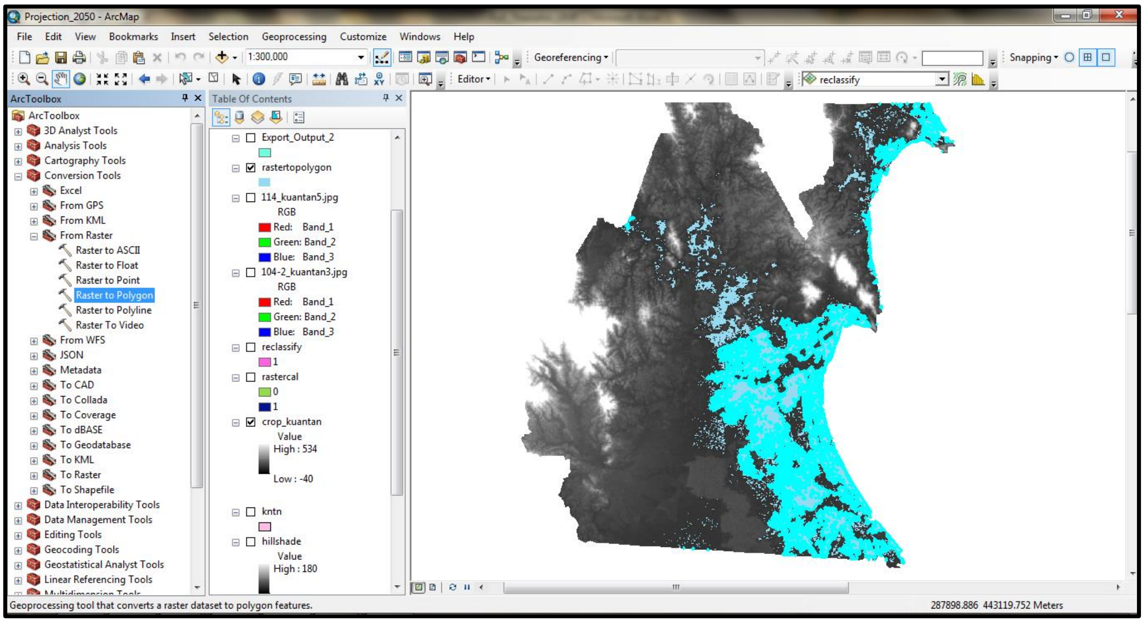

Figure 3.15 The Results After Processing Raster to Polygon

Source: Geographical Information System (GIS), Arc Map

3.7.5 Selection By Location

Next step was the Selection By Location. This step was used to fixed the location that influence with the coastal flood. All the location from the previous steps (Conversion Tools) that do not in the turquoise lines were eliminated from the map. Selection By Location was obtained from the Selection. In this study, the previous result in the Conversion Tools was saved as Export_Output_2, this result was used for the Target Layer or input data. Kuantan was used as an area for the sources layer. Last step in this part was a spatial selection method. This spatial selection method need to be changed to the “are crossed by the outline of the source layer feature”. The result was in the red colour shapefile.

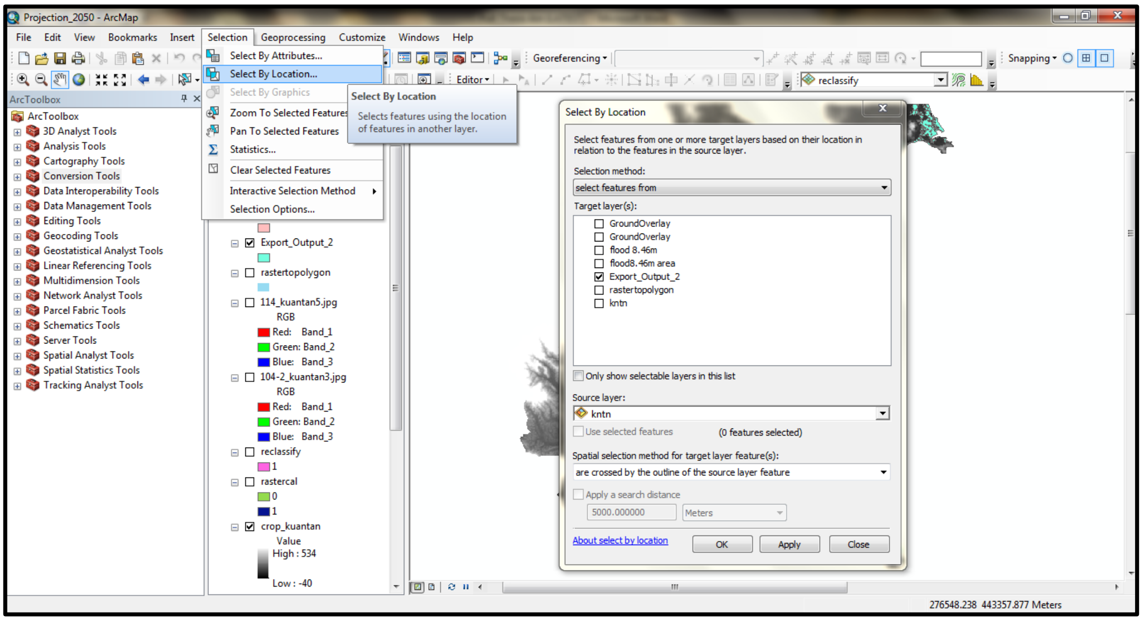

Figure 3.16 Process of Select by Location

Source: Geographical Information System (GIS), Arc Map

3.7.6 Export Data

The last step to produce the risky location for coastal flood map was in Export Data technique. This step could be done by right click the previous result (Selection By Location) and Data section was appeared at the screen. Export Data was selected and this result was saved in the personal geodatabase and was saved in "File and Personal Geodatabase feature classes". The red colour in the figure below show the fixed location which experienced coastal flood.

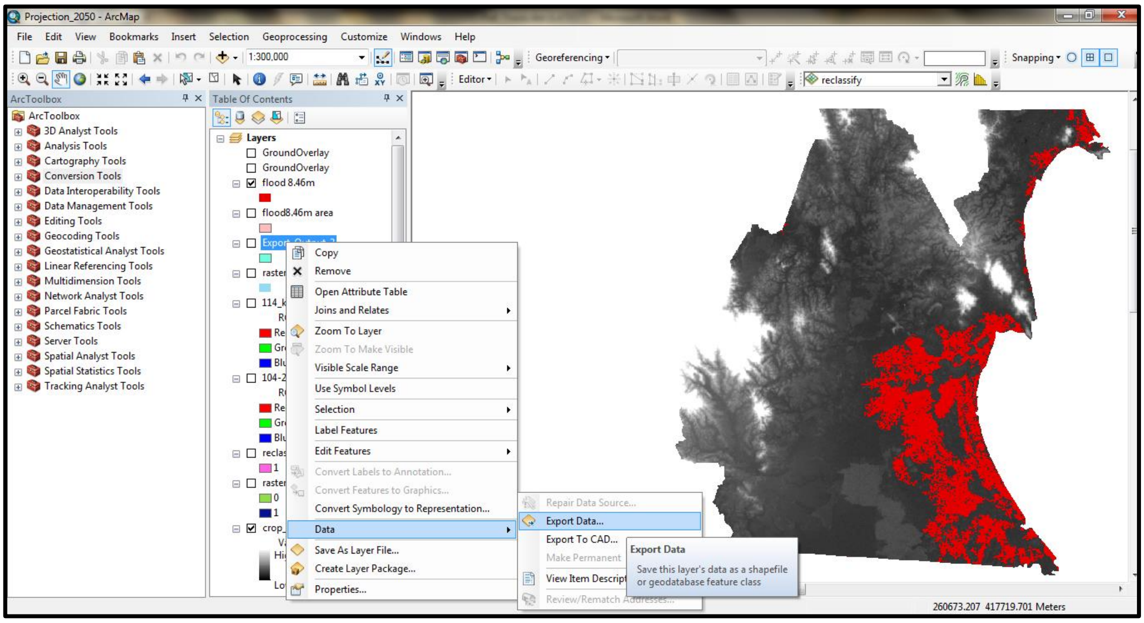

Figure 3.17 The Results After Running Export Data

Source: Geographical Information System (GIS), Arc Map

3.7.7 Arc Scene

ArcScene was a 3D visualization application that allow its user to view GIS data in three dimensions. ArcScene was designed to help the user to understand coastal flood event clearly. There were many function of ArcScene as state in the Table below.

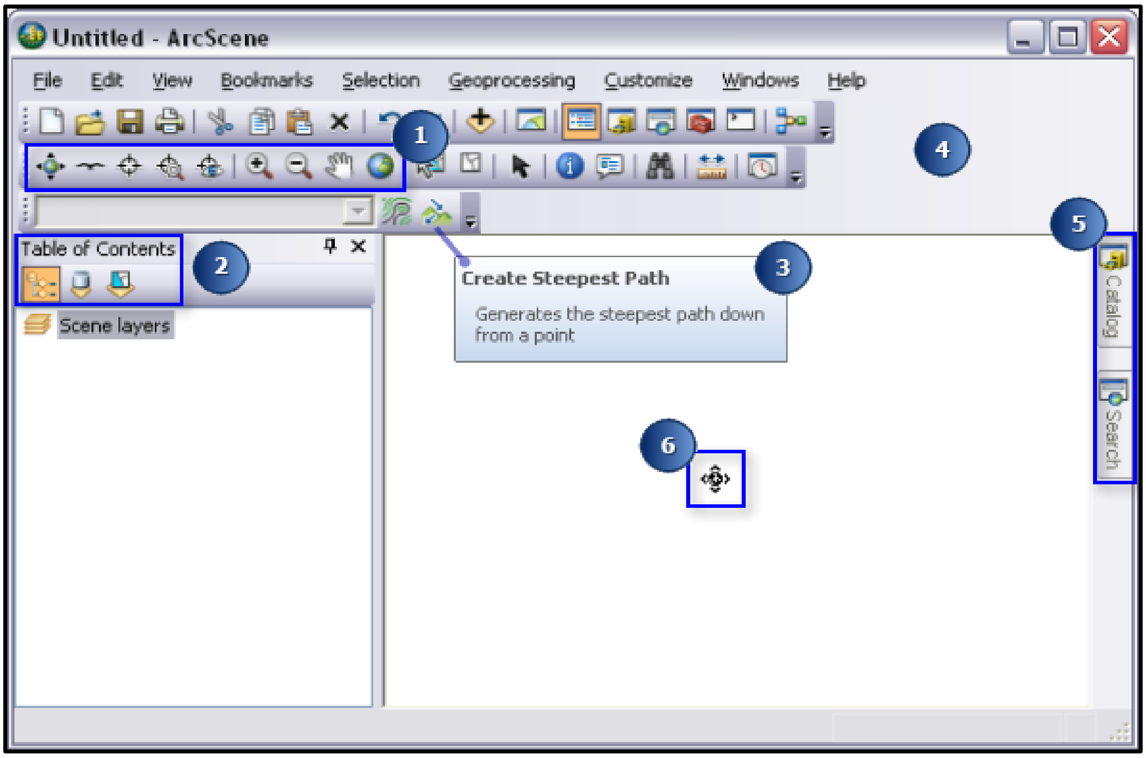

Figure 3.18 The Regular Tools Used in ArcScene

Source: ArcGIS Desktop

Table 1.2 Main Functions in the ArcScene

UI Feature Number	Description
1	The Tools toolbar includes several navigation tools was used to manipulate the observer and camera target positions. These tools optimize interacting with the 3D view and the user's data.
2	The table of contents has several ways of listing layers: by draw order, source, or whether layers was selectable. The storage path above the layers was display by source to list data.
3	ToolTips was revealed when the user hover over a tool on a toolbar. The user could quickly learn the name and more about its capabilities.
4	Access more toolbars to add to the user view by right-clicking this grey area. The user could also select or deselect toolbars from the Customize menu.
5	Dockable windows collapse from the 3D view when not in use. Click a tab to expand.
6	The navigation icon. This would change as the user use different navigation tools to move around the data and 3D environment. There is no 3D globe surface provided in ArcScene.

Source: ArcGIS Desktop

Three-dimensional in ArcScene was designed same as the method in ArcMap, but some adding extension needed to be done to produce the 3D view. The coastal flood map in 3D was presented using JUPEM topographical map. This JUPEM map was used to establish in 3D view. Right click on the JUPEM map and layer properties was appeared at the screen. Base height was click and the elevation from surface section need was changed from "no elevation values from a surface" to a "floating a custom surface". The value of elevation also could be specify as wanted by the modeller. Besides, animation extension was used to provide the time and the elevation for coastal flood event. From the figure 3.20 show the translation Z in the animation manager was the height of coastal flood and animation control was served as time frame of coastal flood. In this study, the duration of coastal flood was set in ten second. In the figure 3.21 show the result of 3D ground elevation before coastal flood occur.

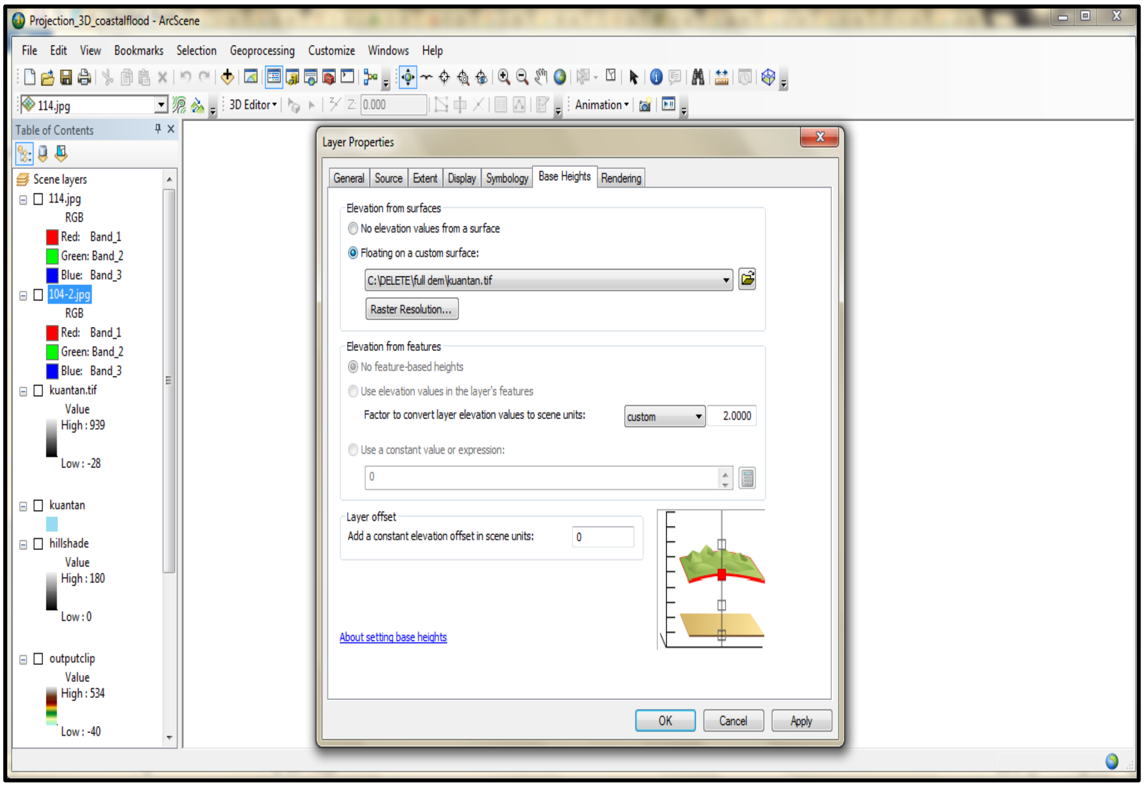

Figure 3.19 Base Height was Located in the Layer Properties

Source: Geographical Information System (GIS), ArcScene

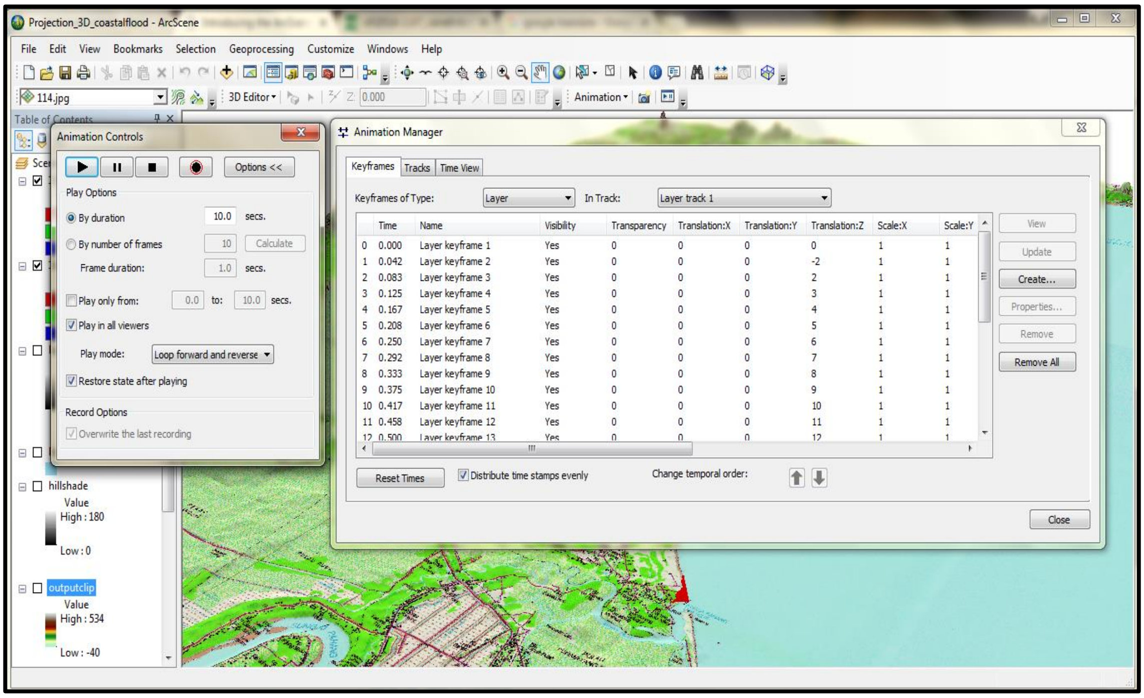

Figure 3.20 Animation Control and Animation Manager in Animation Extension

Source: Geographical Information System (GIS), ArcScene

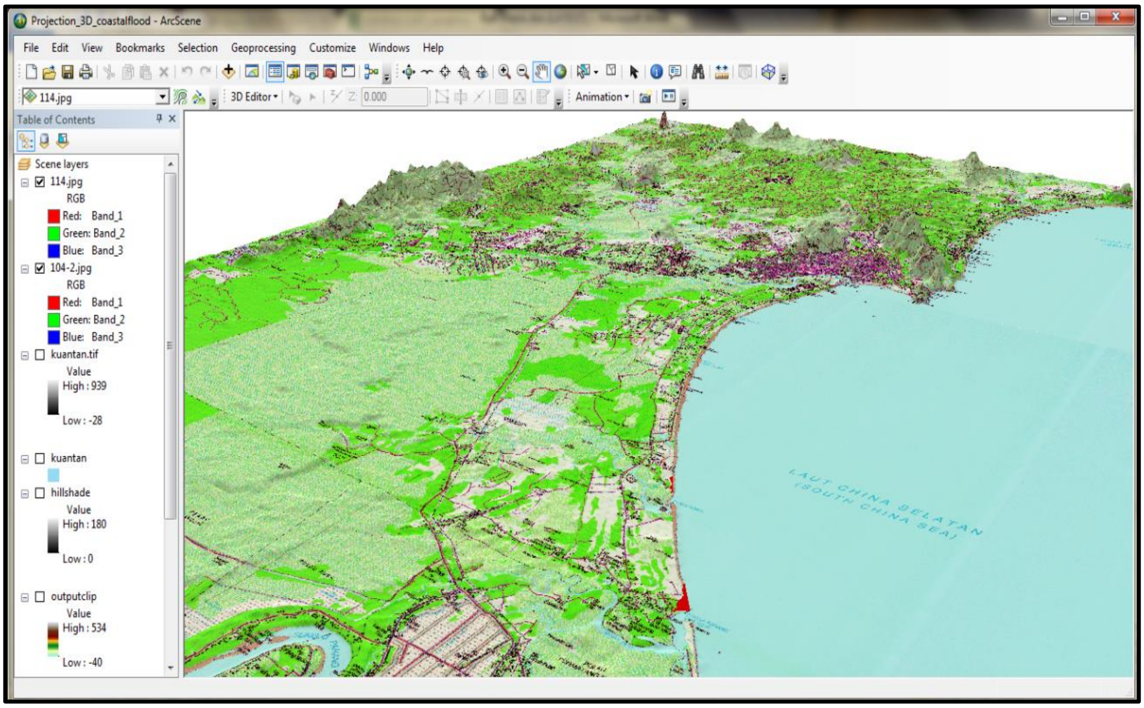

Figure 3.21 3D Representation in Kuantan City

Source: Geographical Information System (GIS), ArcScene

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

Kuantan city was located in Kuala Kuantan region, according to the Department of Irrigation and Drainage (DID), the population in Kuantan city up to 2015 is around 241,197 people. Kuantan also was famous with tourism activities, thus there were lot of hotels and resorts around the beach. Every year, tourists will travel to the Kuantan to enjoy the beautiful scenery of the beaches, nevertheless, what would happen if suddenly Kuantan was attacked by the coastal flood.

Among the method to forecast coastal flood was using Geographical Information Systems (GIS). GIS would visualize on what the location and how big areas in Kuantan that affected by the coastal flood. In this chapter, the result of projection on the simulation of coastal flood in Kuantan City would be presented.

4.2 The Simulation in Year 2050

The simulation of coastal flood in ArcGIS were invented in three different files. The first file was in the projection of coastal flood in year 2050. The figure 4.1 below show that the red colour serve as coastal flood seawater. The height of coastal flood was predicted in 8.46 meters in year 2050. The coastal flood was inundated all the coastlines area and was annihilate more than 20 villages. The farthest area in Kuantan that coastal flood could flooded were in Taman Tas and Kampung Batu Lapan. This is because, before these two areas, there was one village known as Kampung Sungai Isap and the village located near with Belat River. Previous studies had found that Kampung Sungai Isap was in flood prone area because of the Belat River. The seawater came from South China Sea, hit all the coastlines area and overflow into the main river in Kuantan which at Kuantan River thus the seawater continued flow up to the nearby streams such as Air Hitam River, Galing River, Isap River, Belat River, Talam River, Cempedak River thus flooded the surrounded residential areas.

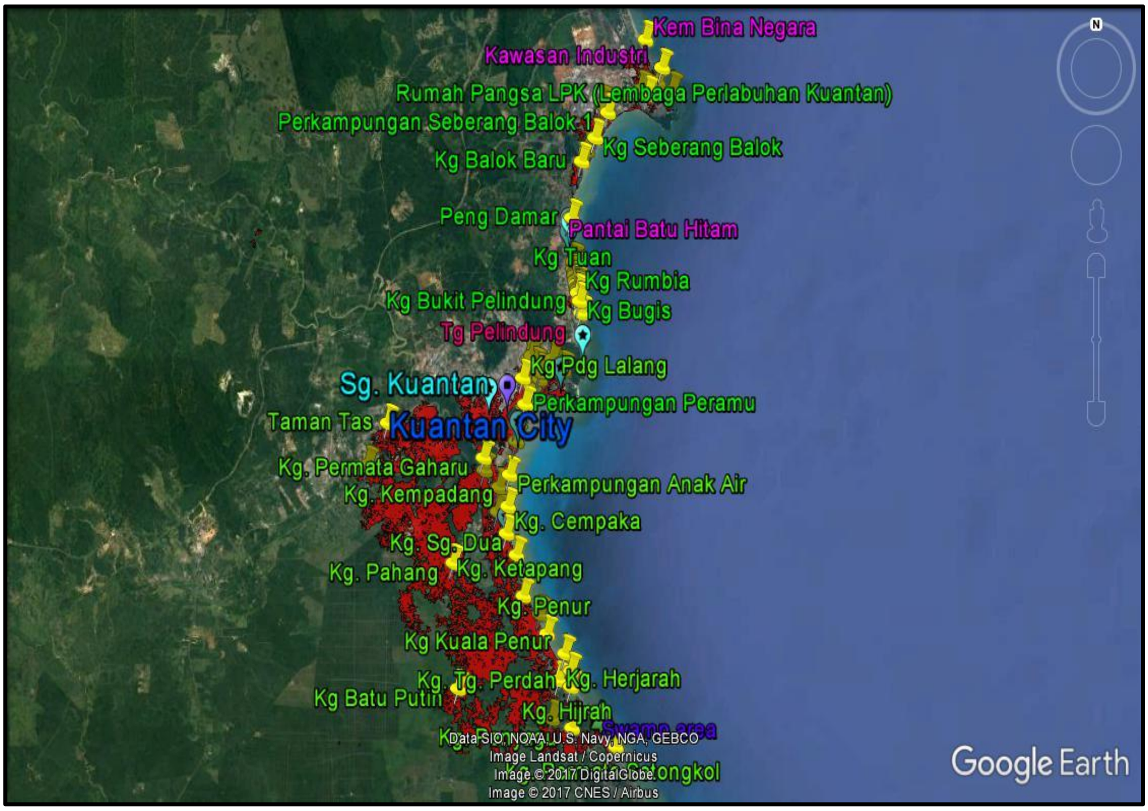

Figure 4.1 The Projection of Coastal Flood in Year 2050

Source: Geographical Information System (GIS), Presented in Google Earth

4.3 The Projection in Year 2100

The second files was in the projection of coastal flood in year 2100. The figure 4.2 below show that the blue colour serve as coastal flood seawater. After sum up all the data that used into the geographical information system, the coastal flood in year 2100 was predictable as 8.72 meters. There was not so much different between the result of projection in year 2050 and 2100. But still, there was more than 20 villages were affected by the coastal flood included Kuantan City, recreational areas and tourism areas.

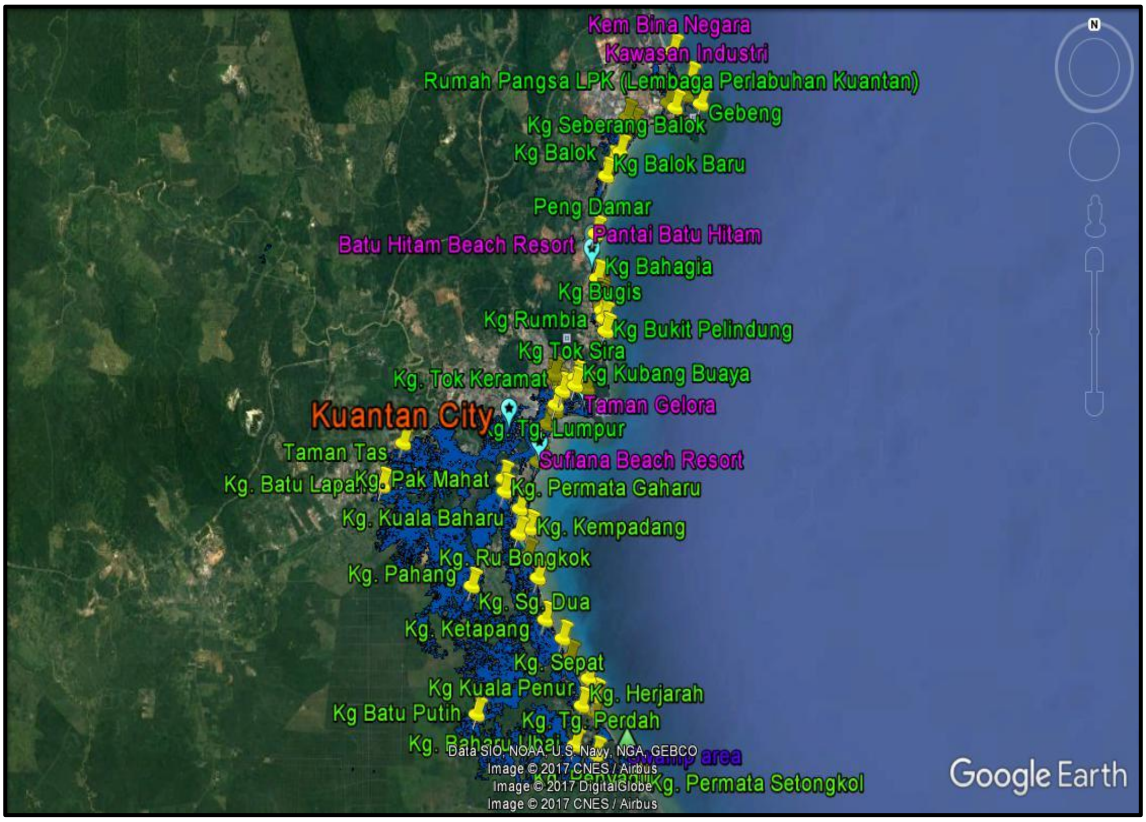

Figure 4.2 The Projection of Coastal Flood in Year 2100

Source: Geographical Information System (GIS), Presented in Google Earth

4.4 The Projection In 5 Meter

Projection of coastal flood within 5 meters height has been made to show the difference elevation areas between projection in year 2050 (8.46 meters) and projection in year 2100 (8.72 meters). From the comparison that has been made, height of areas in the Kuantan mostly in the range between 6 to 8 meters. This statement could be proved in the figure 4.1, figure 4.2 and figure 4.3. The yellow colour show that the result in 5 meters height, only thirteen of villages which located in coastlines were affected with the coastal flood. The seawater flow into the Kuantan River but not spill over and not caused the deluge at surrounded areas. So that in the projection 5 meter, Kuantan City saved from coastal flood.

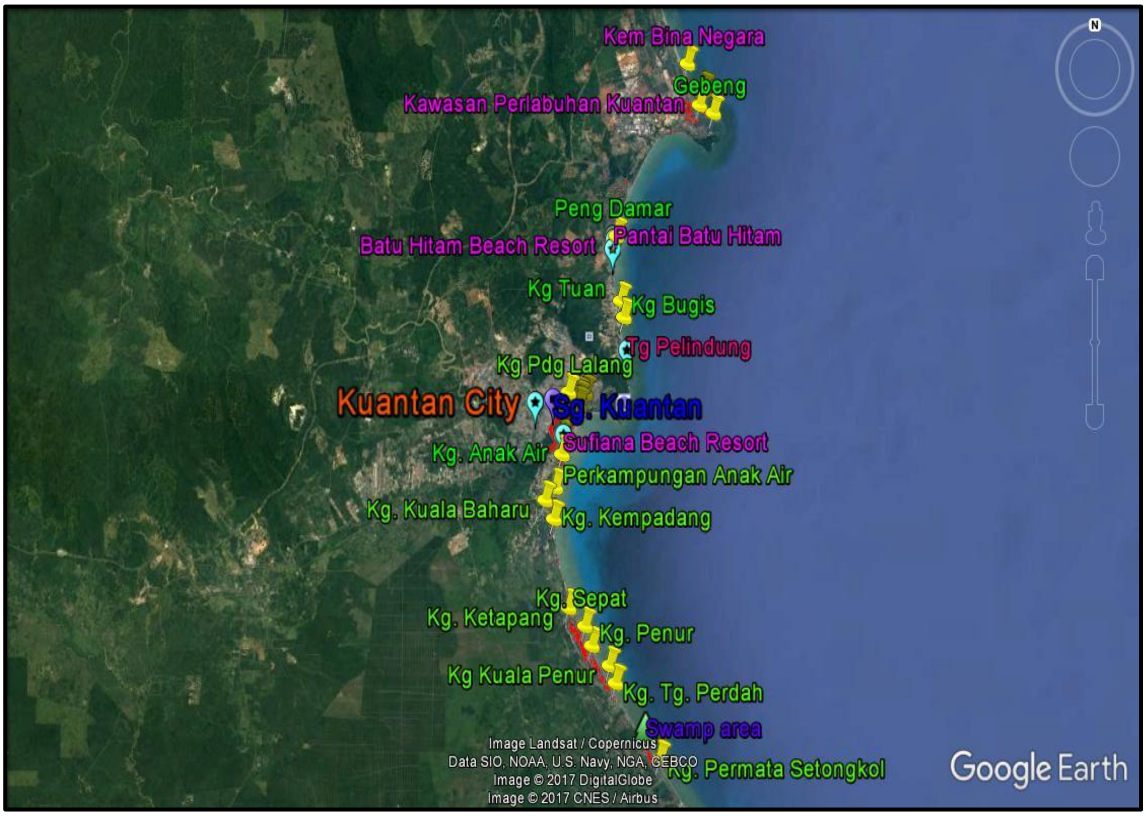

Figure 4.3 The Projection of Coastal Flood in 5 Meter
Source: Geographical Information System (GIS), Presented in Google Earth

4.5 The Total Area Affected by the Coastal Flood

Arc Map also could directly calculate the areas were influence by the coastal flood. The specific value of total areas were inundated by the coastal flood for year 2050 was in 130.5296774 square kilometer. The specific value of total areas for year 2100 was in 130.5296777 square kilometer. From these results, the difference of total area only 0.0000003 square kilometer for year 2050 up to 2100. The total area affected for both projection in year 2050 and year 2100 could be concluded as 131 square kilometer. The total area for projection of coastal flood in 5 meters was in 5 square kilometer. All these values could be found in the data Attribute Table in the Arc Map.

Table 1.3 Total Area Affected by Coastal Flood

Year Projection	2050 (8.46 m)	2100 (8.72 m)	5 m
Square Kilometer (km^2)	130.5296774 km^2	130.5296777 km^2	5 km^2

Source: Attribute Table, Arc Map

From the figure in 4.4, figure 4.5, and figure 4.6 below, show the biggest location that were affected by coastal flood for this study. In figure 4.4, the pink colour with a turquoise lines shown that the biggest area was submerged by the coastal flood for projection in year 2050 (8.46 meter) has 111 km^2 area affected. In figure 4.5, the purple colour with a turquoise lines shown that half from the whole area in Kuantan Boundary was influenced by the coastal flood and also has the same value with projection in year 2050; (111 km^2) for the biggest area affected. From figure 4.6 state that the biggest area value was in 2 km^2 that would affected by coastal flood in 5 meters projection and the location that influenced by this flood was located in around Perkampungan Peramu and Kuantan River only. In the 5 meter projection, Kuantan City was saved from coastal flood.

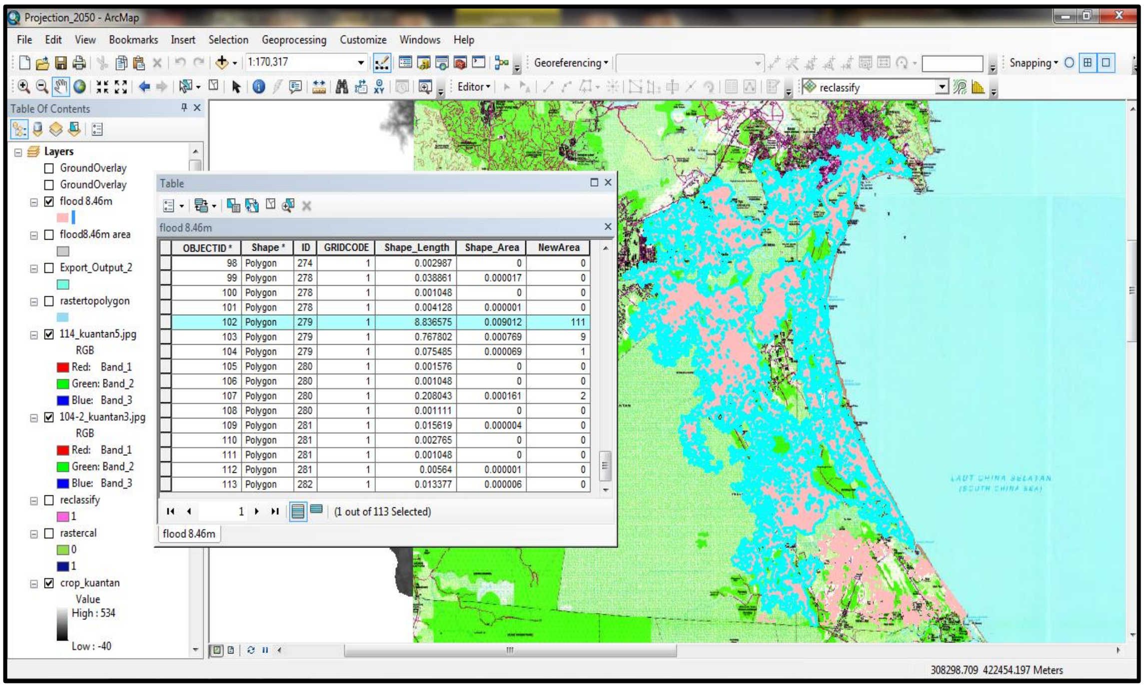

Figure 4.4 The Biggest Area Submerged by Coastal Flood in 8.46 Meter (2050)

Source: Geographical Information System (GIS), Arc Map

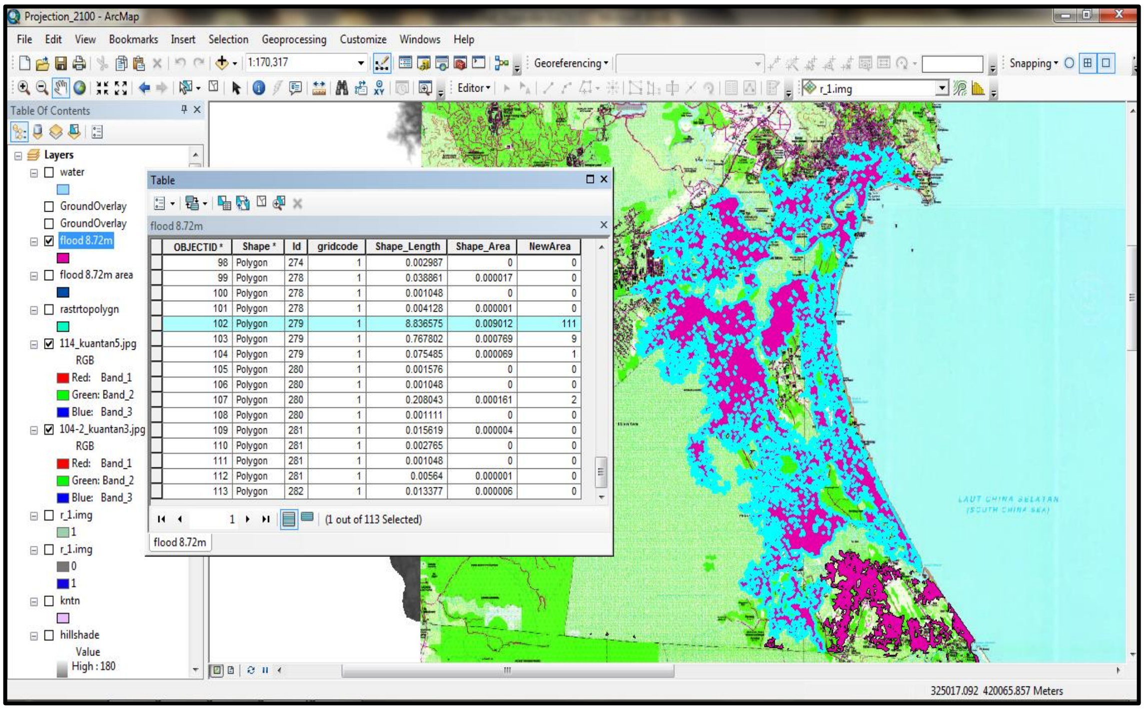

Figure 4.5 The Biggest Area Influenced by Coastal Flood in 8.72 Meter (2100)

Source: Geographical Information System (GIS), Arc Map

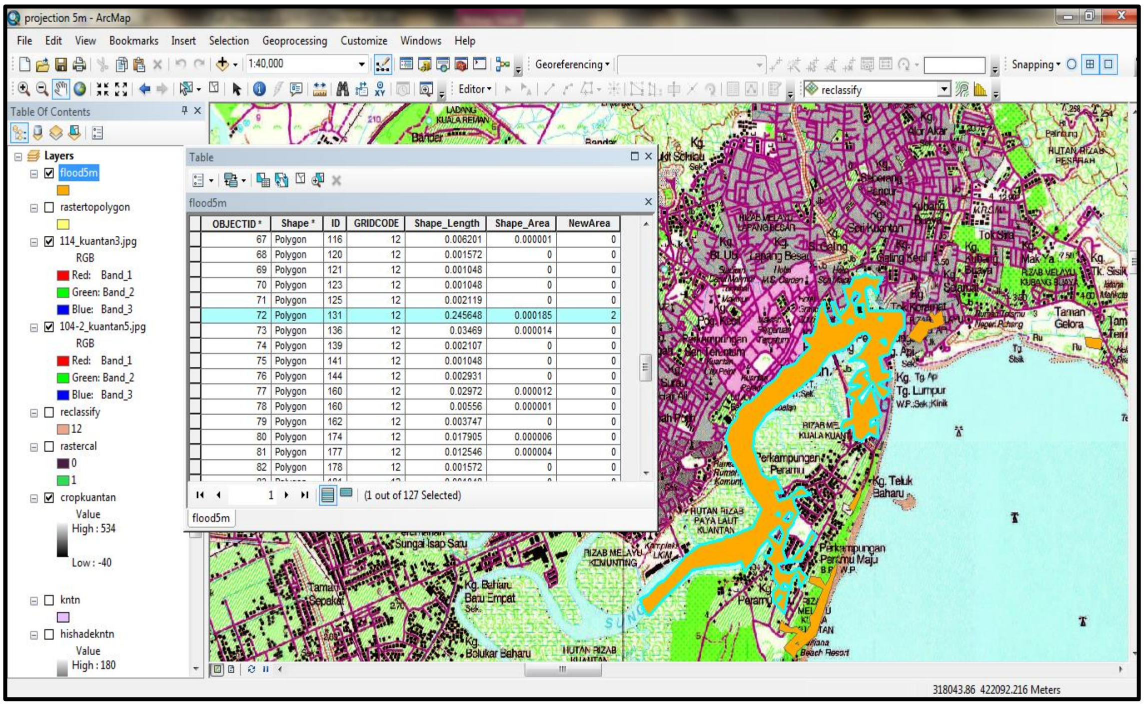

Figure 4.6 The Biggest Area Affected by Coastal Flood in 5 Meter Projection

Source: Geographical Information System (GIS), Arc Map

4.6 Result in 3D Presentation by ArcScene

Data of coastal flood also could be used in the ArcScene. ArcScene provide a results in a three dimension. This software would show clearly the initial flow of seawater from coastlines area until to the farthest affected area. This software also would show the seawater flow from the main stream to its sub-streams. Because of this software indicate in a three dimension, the coastal flood would flow by following its elevation from the coastline first up to the lowest area which was nearby with the streams or rivers.

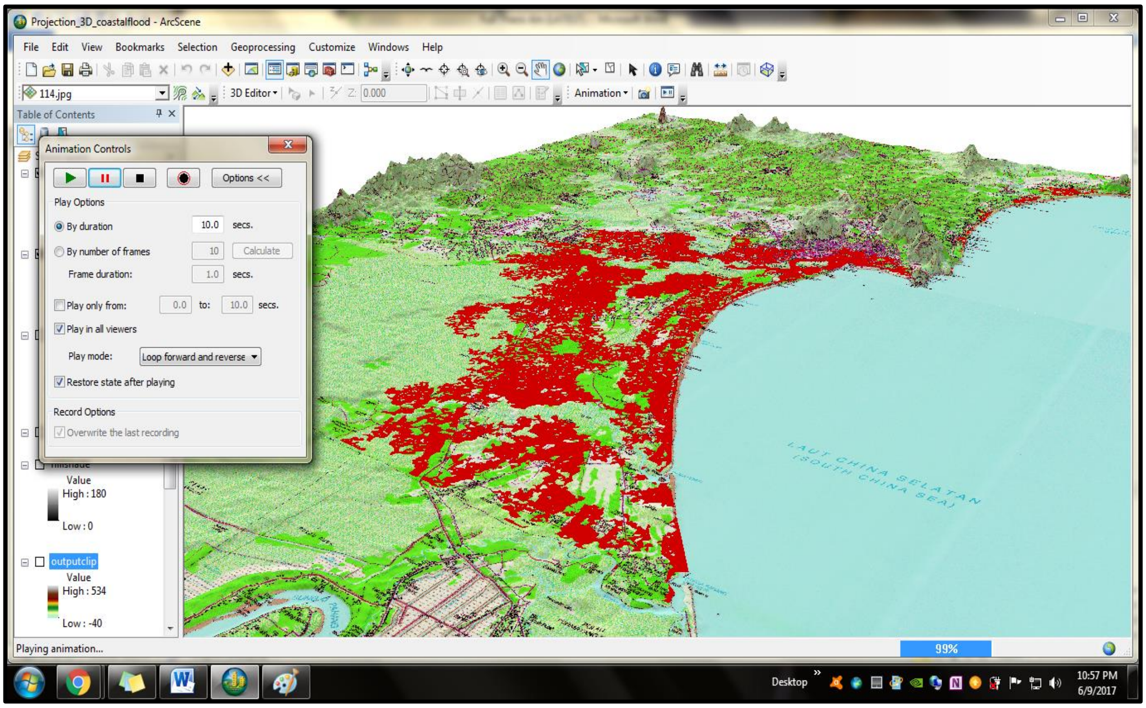

Figure 4.7 Result of Coastal Flood in ArcScene

Source: Geographical Information System (GIS), ArcScene

4.7 The Mitigation Plans

Mitigation was an elimination or reduces the damage that could be done to existing or proposed development or to the coastal environment when natural hazards impact a property or when humans take action in response to that event. Mitigation measures could be either non-structural measures or structural measures. Non-structural measures include changes a community or person could undertake to make property less susceptible to flooding, erosion, or other hazards, such as elevating buildings, using buffers and vegetation, and avoiding development of hazardous areas. Structural measures include levees, floodwalls, seawalls, rip-rap, diversions, groins, jetties, and beach nourishment. In this study, the mitigation plans action were proposed by using curved seawall, wave breaker and wave energy converter.

4.7.1 Curved Seawall

Seawall was used to protect the coastlines, areas of human habitation, conservation, and leisure activities from the strong waves, tides and tsunamis. Seawall is one of the coastal defence was constructed at the sea. Seawalls are massive structures designed to protect the land behind them from direct wave attack (Herrington,. 2003). Seawall was built along the shore to protect it from the action of the sea on the shoreline.

The curved concrete seawall was selected for the first mitigation plans in this study because its advantages very convenient with the coast areas in Kuantan. The main advantage was the curved surface function to reflect the wave back to the sea. The curved seawall aim to re-direct most of incident energy, resulting in low reflected wave and much reduced the turbulence. The second advantages were the seawall could create a promenade for people to walk on it. Kuantan was already known as a tourism country, with presence of this seawall would allowed the tourists walk on the seawall to experience the beautiful scenery in the Kuantan's beach. In figure 4.8, the orange lines show the proposed location of curved seawall.

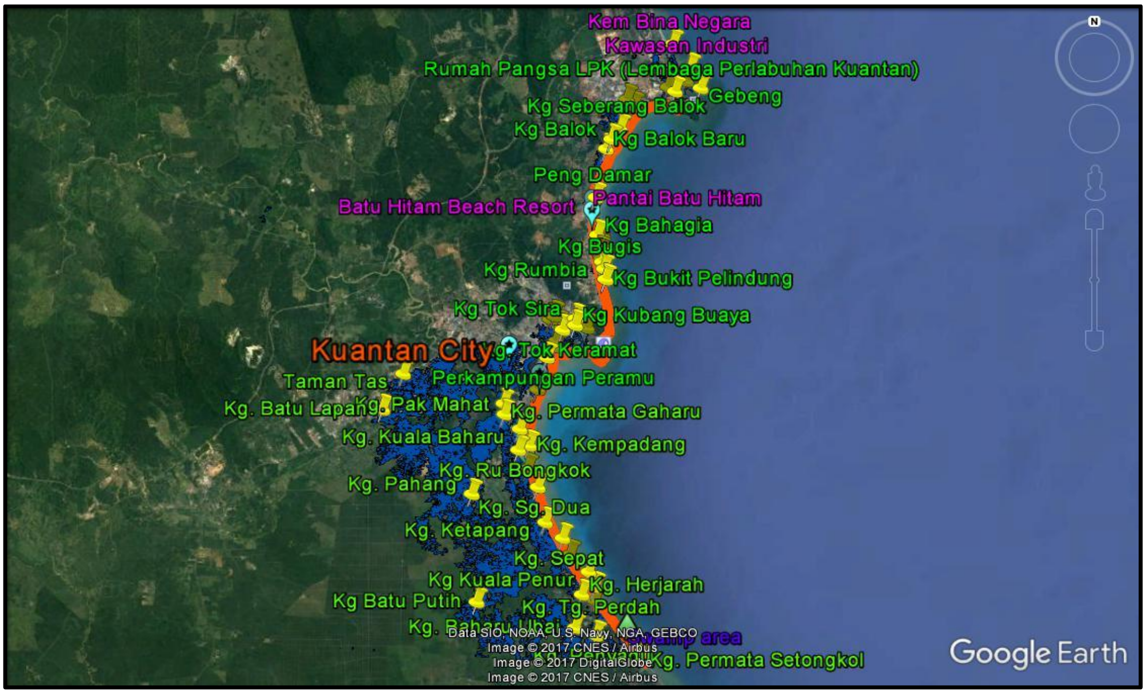

Figure 4.8 The Proposed Seawall Location at Kuantan Coastlines

Source: Geographical Information System (GIS), Presented in Google Earth

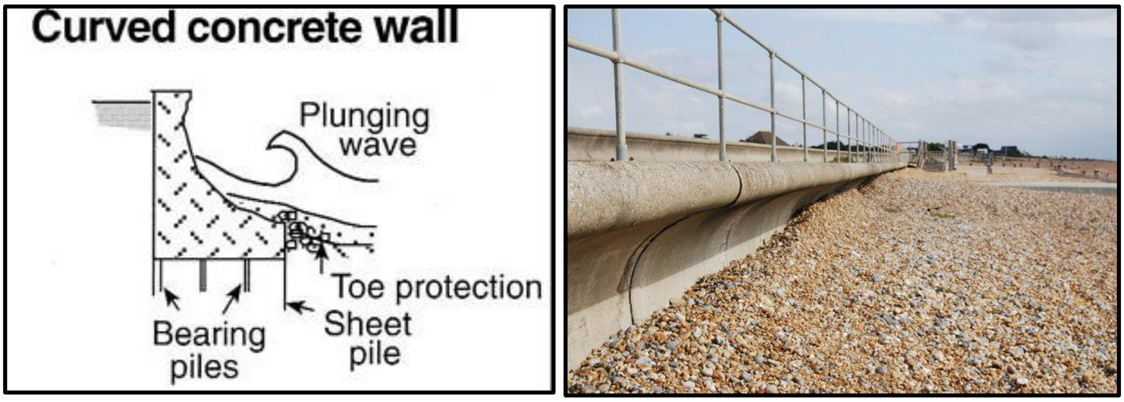

Figure 4.9 Example of Design for Curved Seawall at England
Source: Wikipedia

4.7.2 Wave Breaker

Wave breaker was selected as a second option to mitigate the coastal flood. Wave breaker function as a breaker for flow of water. Wave breaker was built out into the water to improve the harbour by blocking the flows of wave or current. The breakwaters was served to reduce the incoming wave energy in protecting certain coastal areas from wave attack (Thaha et al,. 2015).

The wave breaker was chosen as a second mitigation plans because it could reduce the intensity of wave action in inshore water hence could reduce the coastal erosion. In this study, rubble mound breakwater was selected to lessen the effect of coastal flood towards coast areas. The rubble mound type of the breakwater is the one of the famous and mostly used in the world as a coastal defence structures (Thaha et al,. 2015). The long-term of its stability, and the intermittent storm damage to rubble-mound breakwaters are of consideration interest to the designers, builders, and authorities responsible for their maintenance and for keeping the ports functioning (Tulsi and Phelp,. 2009). In the figure 4.10 below show the proposed location of wave breaker.

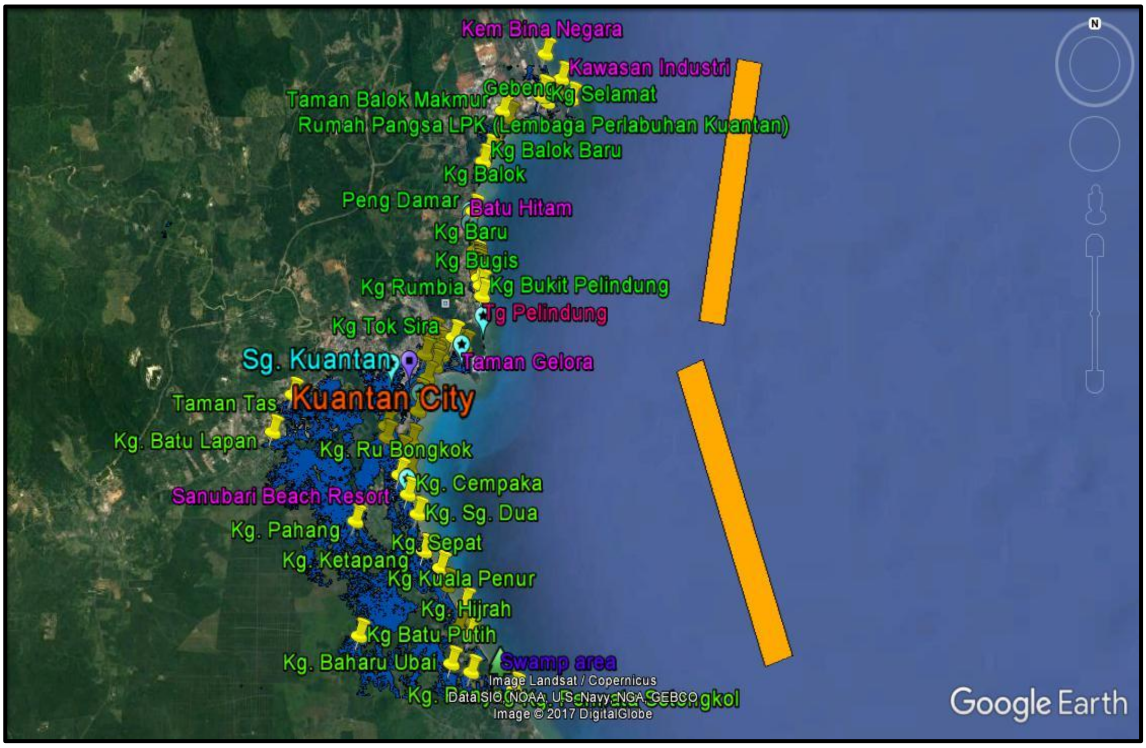

Figure 4.10 The Proposed Location of Wave Breaker

Source: Geographical Information System (GIS), Presented in Google Earth

Figure 4.11 Wave Breaker at Maldives

Source: FramePool, UN Global Compact

4.7.3 Pelamis Wave Energy Converter

The third option, to mitigate the coastal flood for this study was using Wave Energy Converter. There were many types of wave energy converter but the best was The Pelamis Wave Energy Converter. Pelamis Wave Energy Converter was developed by Scottish company and its function act as to break the flow of wave while could generate the electricity. According to the THESEUS (Innovative technologies for safer Europeans coast in a changing climate), this machine useable to be as coastal mitigation because able to absorb a significant of the wave energy even during the extreme storms. Waves that have passed through a WEC have reduced energy levels and this is beneficial for coastal protection. WEC's have the potential to produce blue energy while at the same time protecting the coasts from wave attacks. This machine consist of a series of a semi-submerged cylindrical section linked by hinged joints. Wave-induced motion of the sections was resisted by hydraulic cylinders which pump high pressure oil through hydraulic motors via smoothing hydraulic accumulators. The hydraulic motors drive electrical generator to produce electricity. The Pelamis machine was an offshore wave energy converter, operating in water depths greater than 50 m. The ocean waves was a source of energy that has great potential. Waves that propagate from the deep sea to the shore actually not transported the water but there propagate the energy (Thaha et al,. 2015). Alternatively WEC's could be integrated into coastal defence structures such as breakwaters. Such WEC's could either function by harvesting the impact energy of the waves or by guiding water rolling in with incoming waves into a hydro turbine. In conclusion, this wave energy converter was very environmental and could help to reduce the risk of coastal flood. In the figure 4.14 below show the proposed location of Pelamis wave energy converter in the Google Earth.

Figure 4.12 Pelamis Wave Energy Converter

Source: The Renewable Energy Website

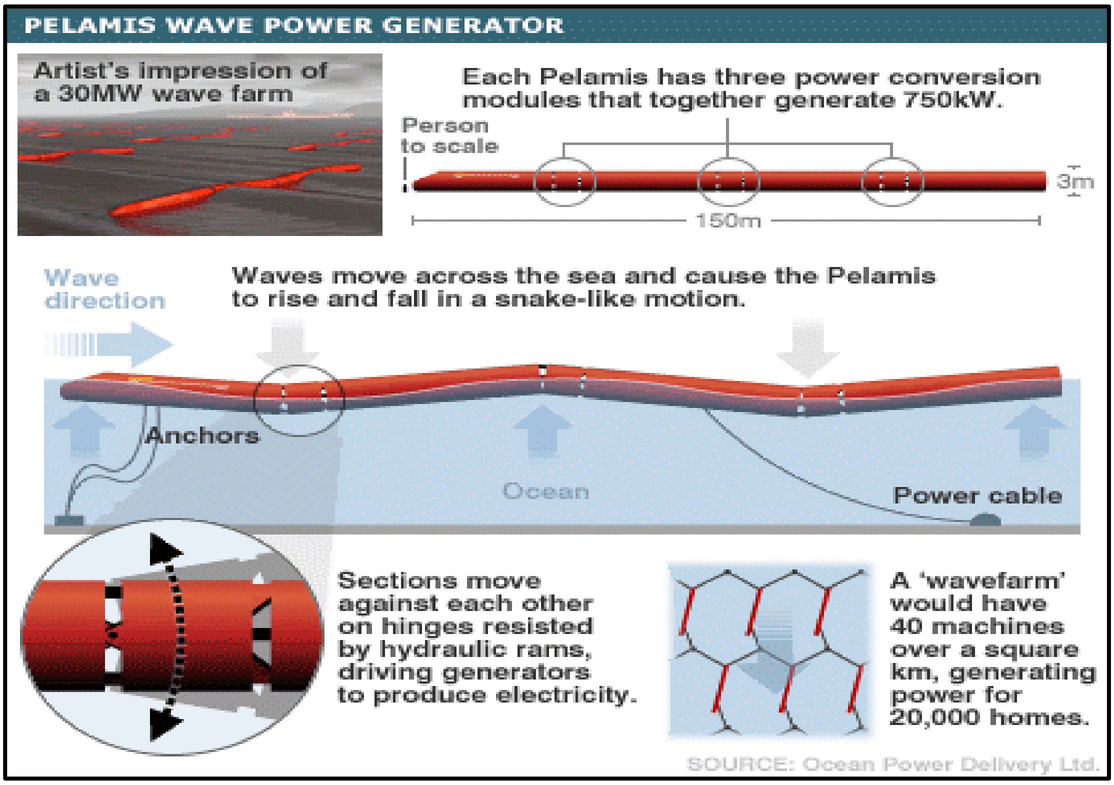

Figure 4.13 Description about Pelamis Wave Energy Converter

Source: Ocean Power Delivery

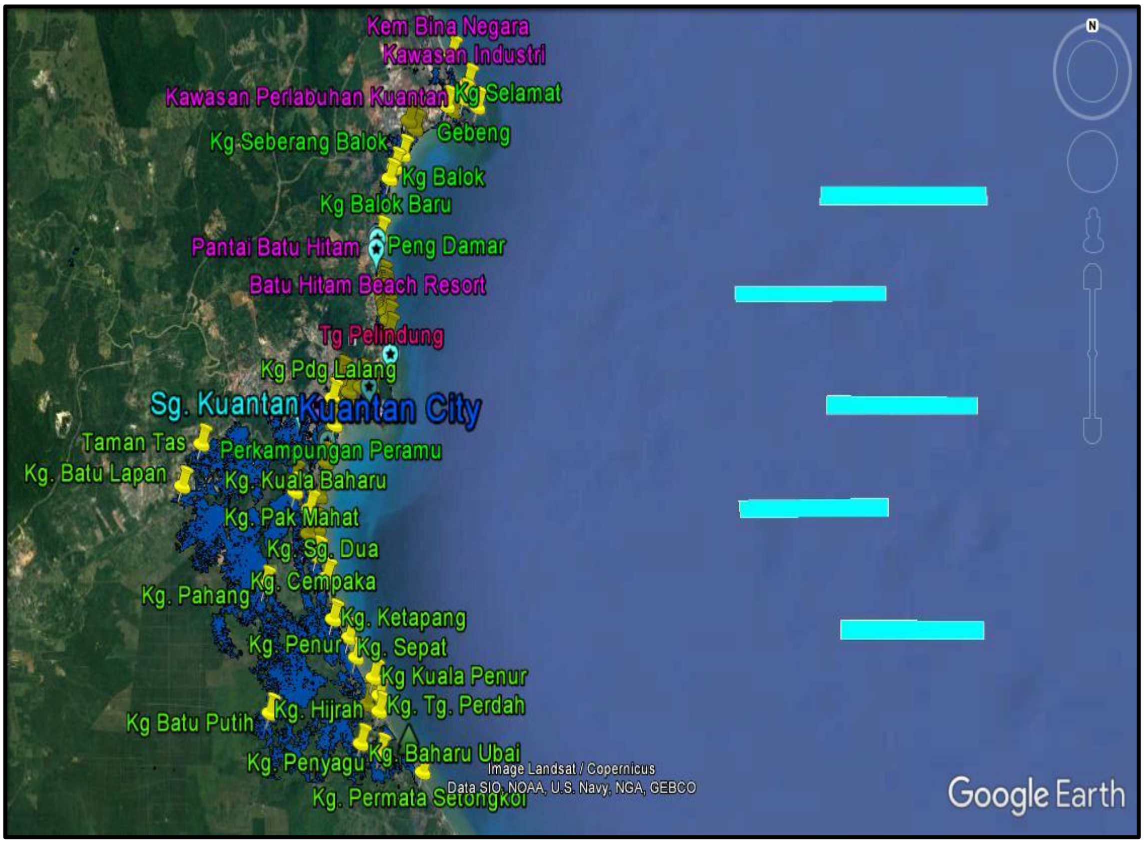

Figure 4.14 The Proposed Location of Pelamis Wave Energy Converter
Source: Geographical Information System (GIS), Presented in Google Earth

CHAPTER 5

CONCLUSION

5.1 Introduction

Kuantan was a major contributor to the economy in Pahang, particularly in eco-tourism. Its location also strategic which was located close to the coast. With the presence of coastal flood map, tourism activities in Kuantan areas would not affected at all. This is because, coastal flood map would show the areas affected by the coastal flood. Hence, the authorities would plan to evacuate the population around the coast to the safe areas.

Geographical Information System (GIS) was used as a method to develop coastal flood map. Coastal flood map was needed for every country especially for the areas close to the coast. This is because the natural disaster cannot be handled without proper action and pithy ideas. With coastal flood map, government and authorities could create any acts or safety plans that could be followed by the population if coastal flood happen.

Until now, none of specific software in Malaysia was used to detect or forecast the coastal flood. Therefore, the result from this study could be applied in Malaysia to reduce the percentage of losses when coastal flood occur.

5.2 Conclusion

Eventually, there were several factors that causes the coastal flood happen which was due to the high rise of mean sea level, global warming and lack of awareness among the public. These factors would change population's life dramatically if coastal flood happen such as loss of property, loss of life and paralyze the economy around the Kuantan mainly tourism areas.

This study successfully to identify the risky location in Kuantan that would be affected by coastal flood for next 50 and 100 years. All the risky location could be found in the coastal flood map in the figure 4.1 and figure 4.2. The risky locations that affected by the coastal flood were recorded from the coastlines area up to the Taman Tas and Batu Lapan, Kuantan. This study also provide the areas that inundated by the coastal flood. The total areas were inundated by the coastal flood for year 2050 was in 130.5296774 square kilometer and the total areas for year 2100 was in 130.5296777 square kilometer. From this area, local authorities could determine what the biggest area flooded in this severe flood and some action could be taken.

This study also has been successful to answer the second objectives that need to proposed the mitigation plans. There were three mitigation plans that had been proposed from this study, the first one was the curved seawall, the second options was the wave breaker and the third was the Pelamis wave energy converter. Each of this mitigation options have its own advantages and its really useful to prevent from coastal flood especially at Kuantan area.

As a solution, result in the coastal flood map that was developed from Geographical Information System (GIS) for this study could prevent the risk of coastal flood event in the future and this map also was really helpful to local authorities to manage or propose the mitigation plans.

5.3 Recommendation

From this study, the recommendations that had been suggested were all the affected areas that highlight in the coastal flood map could get more attention from the local agencies. The local agencies or the government would arrange some another plans such as used the mitigation plans to avert from the coastal flood.

The second recommendation was this study also could be used to predict a Tsunami. Tsunami modelling could be done due to the capability of the software. This is because, this software was designed to work with GPS that ease the modellers to produce maps and the consumers to understand the location of map.

Nowadays, many software and application could be provided easily. Geographical Information System (GIS) was highly recommended for this study because its superiority to analyse the data precisely. Besides, this system was easy to be managed and could produce the result quickly.

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