MANGROVE CAPABILITY AS NATURAL COASTAL DEFENSE USING REMOTE SENSING AND GIS ASSESSMENT

AMIRUL AFIF BIN ABDUL AZIZ

CIVIL ENGINEERING
UNIVERSITI TEKNOLOGI PETRONAS

SEPTEMBER 2016

MANGROVE CAPABILITY AS NATURAL COASTAL DEFENSE USING REMOTE SENSING AND GIS ASSESSMENT

By

Amirul Afif Bin Abdul Aziz

17623

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
Civil Engineering

SEPTEMBER 2016

Universiti Teknologi PETRONAS

32610 Bandar Seri Iskandar

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

Mangrove Capability as Natural Coastal Defense Using Remote Sensing and GIS Assessment

By

Amirul Afif Bin Abdul Aziz
Student ID
17623

Project dissertation submitted to the
Civil Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(CIVIL ENGINEERING)

Approved by,

____

(Assoc Prof Ahmad Mustafa B Hashim)

UNIVERSITI TEKNOLOGI PETRONAS
BANDAR SERI ISKANDAR, PERAK
September 2016

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

____

(AMIRUL AFIF BIN ABDUL AZIZ)

ABSTRACT

Mangrove forest become a hot topic being discuss among research and being acknowledge as a natural costal protection after the Tsunami tragedy back in 2004. Mangrove not only able to decelerate wave before it hit coastline area to protect from hurricanes, typhoons and other ocean related. It also create a suitable habitat for fishes and other marine life which result in great value to coastal nations. Beside it is also being utilized economically by the local people. However, as year passed by the mangrove forest are declining much faster before the mangrove sapling are able to grow up due to inappropriate development and no sense of responsibility toward nature will reduce not only the population of the mangrove but also tourism potential. Thus, a lot of mitigation measure have been done to preserve the mangrove by replanting back the mangrove and building of breakwater to protect mangrove sapling against incoming wave which act as sheltering before the mangrove can survive on their own. To achieve this, coastal process need to understand that influence the growth of mangrove ecosystem. This can enhance in managing mangrove area more effectively and preserve it for a long period of time. By using the GIS (Geographical Information System) and remote sensing a map based on the mangrove characteristics and the result will be proven whether the study area are able to attenuate wave at least 90 % of the incoming wave towards the sea

ACKNOWLEDGEMENT

My deepest gratitude to Universiti Teknologi Petronas for all the facilities in providing software which for remote sensing and GIS assessment to complete my Final Year Project in time. Not to forget, UTP IRC have given lot of useful facilities that help a lot save time going in and out from IRC by providing the Inter Library Loan which allow you to access anything from your room.

I would like to thank Assoc Prof Ahmad Mustafa B Hashim, my Final Year Project supervisor for helping me in giving idea and analyzing the data. Plus, the most important things that I learn from you is to utilize all the resource that we have to become something useful that can contribute back to society. Not to forget, my colleague and senior who help me a lot in teaching me how to use GIS software and help me manage to get all the data needed on time.

Furthermore, I would like to thank Tanjung Piai mangrove reserve forest ranger for giving me an opportunity to go for a survey at Tanjung Piai to understand more on the mangrove and at the same time collecting data for my research project. Without these data, the project cannot be move to the next step as everything are related to each other.

Last but not least, I would say that this Final Year Project would not be a success without the help of all parties involved. I am truly grateful and I cherish every single moments here in doing my research especially during field work as lot of new experience. After I go through with this final year project, I have learned a lot of new things which cannot be learned in class as a student and I know that I still got a long way to go as there are a lot of other new things that I need to learn.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Mangrove are the dominant ecosystem along the sheltered shoreline of the Malaysia coast. These trees are tolerant to saline environments, which enables them to grow in the tidal zone. They are known for their often complex and impressive root system. These Mangroves play important roles the ecosystem especially in term of ecological, biological, medical and economical values. They are often located in the muddy, anoxic soils of estuaries, lagoons and river deltas, where their complex of aerial roots provide support and gas exchange, and their viviparous propagules confer an ability either to quickly establish under the parental tree, or to float away and colonize new areas. Mangroves forest are known as an erosion control. It is because mangrove can decelerate the wave current before it hit the coastline area. Mangrove biological systems are remarkable entirely unlike any physical or amphibian biological systems in that they straddle physical, freshwater and marine situations. They are frequently immersed by tides, flushed by freshwater and are waterlogged most of the time.

Besides coastal protection according to Awang et al. (1999) mangroves are important to maintain the quality of water by trapping the sediment and maintain the balance of natural equilibrium by preserve the scenic value of coastal region. Due to the high production of organic matter, mangrove forest are very suitable environments for large population of fish, breeding ground and nursery ground for many species. Mangrove also provide local economies and food supply as fish and shrimp can be found near mangrove forests.

Mangroves can endure with underwater biological communities such as sea grass and coral reef communities for waterfront protection, thus this will minimize the soil erosion and act as natural buffer. In short, if there are no mangrove forest, there will be either no fish or fewer fish in the sea.

The abrasion process occur in several coast, would leave impact on the shoreline as it started to eroded hastily causing the destruction of the local land and mangrove near the affected area. The loss of land at certain area would increase land in other places due to erosion process that occur on other place especially near the river mouth where the sedimentation process are quite heavy and would affect the quality of river water if there are no action taken. These are the reason why the shoreline change tend to increasingly toward the sea due to increase in the sedimentation process. Several of the previous studies mainly discussed the mangroves changes over the years and forecasting the shoreline changes including the depletion of mangrove vegetation. Many of the researchers nowadays use remote sensing and Geographic Information Systems (GIS) to deliver and monitor a lots range of system not only local but also globally since the last few decades (Hamzah et al., 2009). GIS software will be assess in this case studies to monitor and manage the mangrove forest as it is easier to be presented and show the changes of this ecosystem.

1.2 PROBLEM STATEMENT

After World War II, there was another tragedy in human history which is the Indian Ocean Tsunami tragedy back in 2004 or dark history of the mankind, has become a hot topic among the researcher and at the same time increase their awareness to study about the importance of mangrove as the natural shoreline protector. After the Tsunami tragedy, researchers have study the performance of mangrove between two villages where one villages is being protect by the mangrove while the other village are directly expose to Tsunami and the study prove the villages that are protect by mangroves experience no destruction (Science Daily, 2012). This study show and prove that, mangrove ability to protect coastline from the strong waves.

However, for the past 50 years mangrove forest have lost about quarter of the worldwide due to massive reclamation works and rapid urbanization (Alongi, 2002). It was reported that the changes of shoreline are due to several coastal development and human interferences. The erosion process occur are mainly because of coastal development such as manmade structure, reclamation activities, ship wake generated from heavy shipping activities that lead to declination of the existing mangrove (Nor Aslinda et al., 2014). Mangrove are known as a 'live seawalls' are very effective as compared to the concrete seawall to protect coastal erosion. Plus, the cost for planting of mangrove are a lot cheaper than the maintenance cost for concrete seawall and to add some more mangrove forest of 400 m width manage to protect village and forest for more than 50 years while manmade seawall protected the sea dyke for only 5 years (Kathiresan, K. 2012).

The loss of mangrove, have become an issue to government after knowing the importance of mangrove towards the costal defense. The government now urge to protect the coastal areas in order to prevent more mangrove losses in the future. The loss of mangrove to fish farm or other forms of development is a bad economic tradeoff both short and long term as it would leave a major negative environmental impacts. Thus we need to conduct a study on the behavior of mangroves in order to manage and protect the mangrove itself.

Technologies development in this 20th century, such as GIS and remote sensing are widely use among a group researchers to monitor and assess mangrove changes for their study. Many studies indicate that remote sensing has advantage over traditional field investigation methods in monitoring of wide-spread mangroves (Sader et al. 1995, Brian and Timothy 1996, Green et al. 1998, Kovacs et al. 1999, 2005, Akira et al. 2003, Hirano et al. 2003). The mangrove ecosystems are very unique and hard for surveying as the soil is very soft and muddy to walk by barefoot and during flood tide we may not able to survey the area. Thus, the easiest way to do is by using remote sensing technology which allow us to obtain information even in extreme environments. (Vaiphasa et al. 2006). Assessment of the existing mangrove forest is importance in order to obtain better understanding of the condition of mangrove forest as a guide in conserving and maintaining the resource.

1.3 OBJECTIVES

The objective of this study:

- To assess the mangrove forests capability against wave
- To identify and analyses the protection performance conditions of the mangrove along the coastline area represented by GIS software

1.4 SCOPE OF STUDY

After research a lot of location for study area, the study area that was chosen would be Tanjung Piai, Johor as there are not many studies that have been carried out around the Malacca and Singapore Straits in relation to the coastal hydrodynamic even though the area always affected by heavy shipping and a lot of developer interested in the industrial at that area as the location are strategic. The study area for Tanjung Piai, Johor is located at the southern-most tip of Peninsular Malaysia with a coordinate of 1°15'50.64" N and 103°30'36.57" E. Tanjung Piai are very unique place as there are 22 mangrove species which have their supporting role as a natural barrier to protect nearby villages in case if there are extreme wave events such as Tsunami.

Due to coastal issues and human interferences Tanjung Piai mangrove forest and mudflats have been eroded significantly over the years. Basically there will be two types of data, which are from satellite information and field observation. This study will be separated in two primary stages which is interpretation and analysis of satellite Landsat TM imagery. The outcome of the result were carried out will be based on the field observation data to prove the accuracy of classification mangrove type maps with the existing condition of the environment to avoid any misinformation on the study area. Both stages were connected to GIS processing for spatial analysis and digital map production. Then, a field observation will be carried out a selected locations along mangrove forests to verify the results produced from the image processing and to investigate the source of the problem and the changes that have been made.

This study will be categorized in three different parts to achieve the objective of the study starting from collecting data where the data will be collected using satellite images. The data will be collected from different types of satellite images with good high resolution and it will be analysed to choose the data that is suitable to be used in the project. After identifying the study area, several data from site survey need to be gathered. The data that will be collected for the mangroves are the type of species, age and density will be collected at the study area.

After the selection the best satellite images the data image will be process using GIS software. In this part, the author will be using GIS software to prove the mangrove study area are reliable and based on their performance condition. Lastly data analysis, the analysis will be made to represent the mangrove area based on the mangrove performance conditions that have been during the second part to produce a map. Hence after completion of this stages, then the assessment of the existing mangrove forests capability against prevailing wave attack can be done.

CHAPTER 2

LITERATURE REVIEW

The mangroves in Malaysia are the third largest mangrove forest in Asia-Pacific region after Indonesia and Australia. Mangrove forests develop best in sheltered muddy shorelines with a good supply of sediments and plenty of freshwater. The area of mangrove forests can vary from a narrow strip river bank to a forest of thousands hectares. The main characteristics of the land where the mangrove forest grow are land that continuously being eroded and build up by sediments, thus making it very difficult for the plant to have a secure footing. According to (Giesen et al. 2006) there are 268 plant species in the Southeast Asian mangroves.

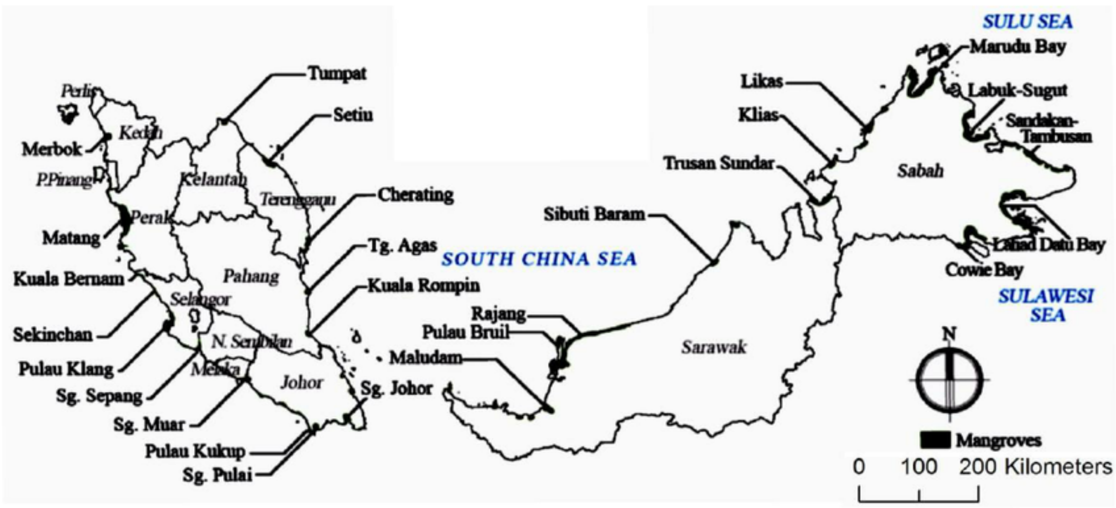


Figure 1: Mangrove forest Distribution source: Kasturi & Asfaneh (2015)

Mangrove species are differentiate based on their uniqueness. The easiest way to identify the species is based on their roots which can be found grown in the muddy area in the inter-tidal zone. It would be hard to identify type of mangrove solely based on the root some of the root may not be seen due to extreme environment conditions.

Thus, we can also identify through the type of leave of mangrove and type of fruits that it produce. The location of mangrove are very strategic place to protect against wave attack as it is situated in between the tidal zones, so wave will become calm as it started to reach mainland. The aerial root systems at mangrove tree help in to trap sediments and at the same time function as a land expanders as it help to accelerate sedimentation process based on Woodroffe (1992).

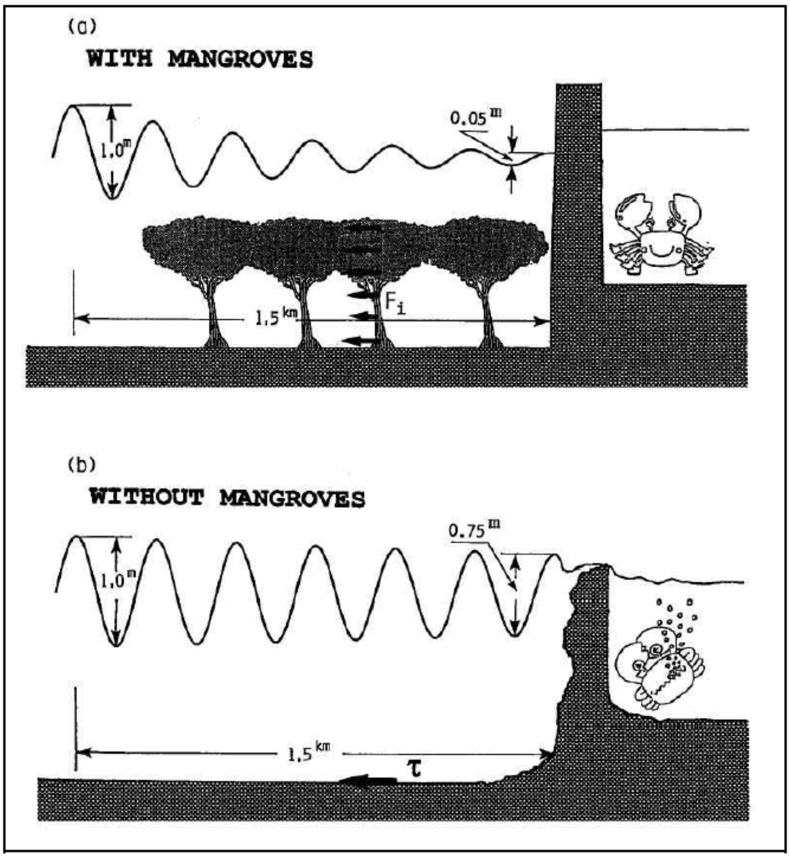


Figure 2: Wave current with and without mangrove (Source: Jan De Voz, 2004)

By observation, it has been realized that mangroves play a role in supporting marine habitats, stabilizing the coastal zone area and protecting the lives and properties of peoples. Based on the study that have been made by Hadi et al. (2003), the normal current speed carried by wave exceed 1m/s but, as the wave pass through mangrove swamp the current speed rarely reach 0.1 m/s. This show the effectiveness of mangrove in reducing the speed of wave current. There are many engineering solution in order to improve coastal area nowadays (breakwaters, seawall and groins) that play important role as a coastal protection but each of this structure can either solved coastal problem or worsen the situation if no detail study been carried. However, unlike mangrove they did not interfere with the equilibrium of the natural coastal process that may result in erosion in other part of area, destroy aquatic ecosystems and the quality of water. Plus, the cost to persevere and plant mangrove require less cost that any latest engineering solutions.

Furthermore, based on Hashim & Catherine (2013) has proved form their laboratory study where the properties of mangrove such as the species, density, band width and age can be a trigger factor that affect the wave reduction rate. The result of the experiment prove that the properties of mangroves clearly able to reduce the wave two times better than the area without mangroves. As we all aware, mangroves have different type of aerial roots such as stilt roots, pneumatophores, root knees and plank roots. These different type of root have the same characteristics which is to trap sediments. This give the coastal are more stability and indirectly lead to reduction of erosion. Furukawa and Wolanski (1996) observed that sediment brought by a wave allowed the sediment to settle as it pass through vegetation (mangrove forest) due to the calmness of water. This show that, mangrove are not vegetation that only colonize mud banks but actively participate to creation of mud banks.

Based on the Malaysian Nature Society, the loss of mangrove during 1950 and 1985 was over 50% and only 1.8% land areas that are covered by mangroves (Salina, 2009). This mangrove loss are mainly due to the human activities without any concern on surrounding area. The impact will be worsen in the future if no action or mitigation taken in the future which will affect the water quality, oxygen demand in the river and deterioration the habitat of aquatic organisms. Mangrove ecosystems need to be conserved and managed, thus in order to do so we need monitor the mangrove ecosystems and by doing so we can understand the vegetation structure that will help to restore mangrove for future generation.

The loss of mangrove will have negative impact not only to socio-economic value for eco-tourism and fisheries but also the environmental stability such as aquatic organisms and the biodiversity of flora and fauna. Thus, an effective monitoring are required to prevent further loss of mangrove. Traditionally the idea of using the ground surveying methods and field observations as a tool for mangrove is indeed precise and accurate for mapping purposes (cm to m), but it is rather time consuming, require a lot man power and costly. Moreover, unlike other forest mangrove forest have a harsh environment and hard to access (Kuenzer et al, 2011). Generally mangrove ecosystems have a good reputation investments ecologically and economically so it is and urgent demand for conservation and restoration measures. Therefore, the information must be up to date on the current condition of mangrove ecosystems for management and decision making process. There is a lots of new advance technology was invented in coastal area, one of the technology is remote sensing that help in monitoring and understand the changes in mangrove forest by using satellite image compare to traditional method that require a lot of time consuming and costly. Beside this method have been used by a lot researcher as the tool are proof to be very efficient in monitoring mangrove forest (Giri et al, 2011and Kuezner et al, 2011). Monitoring changes of mangrove areas of a huge extent require a more efficient tool which is satellite images that have been used by a lot of researcher for their study. One of the previous studies that have been used remote sensing would be (Wang et al, 2004) where they use the satellite images from IKONOS and QuickBird to map the mangrove ecosystems in their study.

In Malaysia, remote sensing have become one of the method that frequently used among the researchers using satellite data to analyze mangrove changes to keep an update on the current changes of the mangrove ecosystems. Plus there are also some lack of available data so in order to replace the lack of data remote sensing data are being used to represent as a tool for mapping mangroves where access for survey is limited and inconvenient.

Bands combination of Landsat image was used to identify mangrove area as it is hardly to recognize the difference between normal vegetation and mangrove vegetation. NDVI method was used to evaluate the forest density cover of mangroves according to Yuvaraj E., Dharanirajan K., Saravanan and Karpoorasundarapandian N. (2015). This is where the field work become important to point out or identify the location of the mangrove area. From there we can input all the data needed toward the location of interest. The bands combination was known as False Color Composite (FCC). FCC applied on Landsat image was composite of band 564, this band combination can make mangrove look different from other objects. Mangrove area were identified and delineated through visual interpretation by digitalizing on screen. The further step after identifying mangrove area was applying Normalized Difference Vegetation Index (NDVI) transformation to grouping mangrove density into three classes based on experiment that have been done by Hashim & Catherine (2013).

Basically green vegetation absorb solar radiation in the photosynthetically active radiation (PAR) which they use as a source of energy in the process of photosynthesis. From this, the NDVI is calculated from the visible and near infrared light reflected by vegetation. Healthy vegetation or dense plant absorbs most of the visible light that hits it and reflect a large portion of the infrared light. Whereas, unhealthy or sparse vegetation reflects more visible light and less near infrared light.

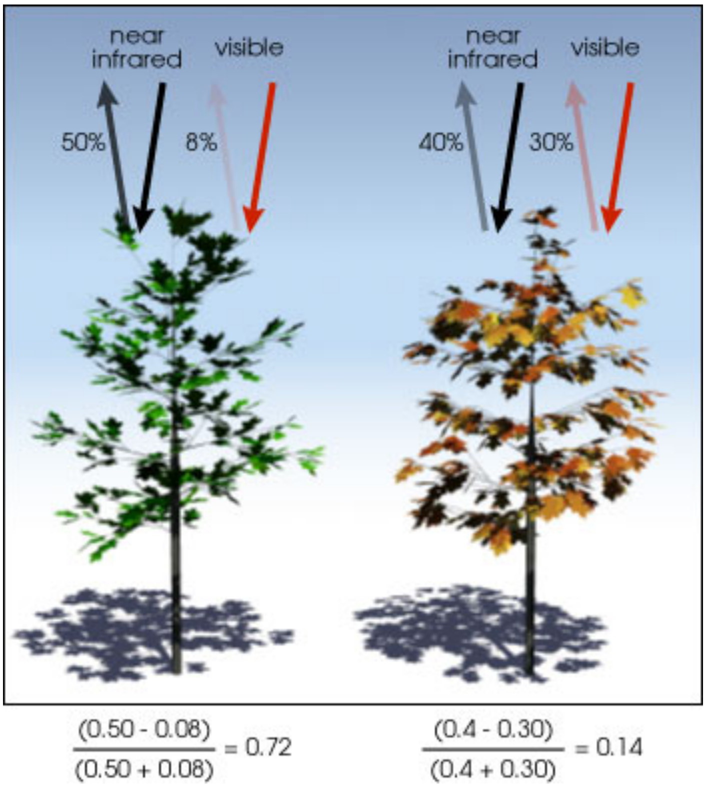


Figure 3: Vegetated mangrove (left side) and sparse mangrove (right side) (Source: Bhudiman S. et al, 2005).

NDVI is calculated as below:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Determination of mangrove conducted with field work and delineation object showing the existence of the mangrove. Mangrove can be identify from the combination of color red, green and blue where the band IR (infrared) presented as red layer, band NIR (Near infrared) presented as green layer and Red band presented as blue layer according to Bhudiman S. et al, (2005). Theoretically, NDVI value range would be between -1 and +1 where increasing positive value represent the area are densely vegetated and negative values represent non-vegetated surface such as water, land, structure or clouds according to Yacouba D et al, (2009). The combination of red and infrared bands along with vegetation indices help in distinguish mangroves, swamps and other wetland vegetation.

CRITICAL ANALYSIS

Table 1: Previous studies of application GIS for coastal area

SOURCE	**LOCATION FOR REMOTE SENSING**	**METHOD USED FOR SATELITTE IMAGE**
Kasturi & Asfaneh, (2015)	Southern coast of Johor - Iskandar Malaysia Landsat TM, ETM+ and OLI	The used of Maximum Likelihood Classifier (MLC) and Support Vector Machine (SVM) techniques to classify mangrove and land cover using Landsat Thematic Mapper (TM), Enhanced Mapper (ETM+) and Operational Land Imager (OLI) data. Then they detect the land cover for a period of 25 years (1989-2014).
Kai Liu et al., (2008)	China Pear River Estuary Landsat TM	The study is about the applicability of the decision tree learning method in detecting rapid changes in the mangrove forest based on the temporal Landsat TM data starting from 2002 to 1988.
Ramachandaran, (1993)	Andaman Islands Landsat TM, Landsat MSS, SPOT and SAR	The research involve broad classification of the general land cover including mangrove and detect mangrove changes by using SPOT and airborne SAR X-band imagery data for mapping mangrove and estimation of mangrove biomass. Then the area covered by mangroves are calculated using SPOT 1993 and IRS-1D LISS 2003 imageries.
Tien Dat P. & Yushino K. (2015)	Hai Phong City, Vietnam Landsat TM, OLI and ETM+	This study are to map mangrove forest and analyze mangrove changes using LANDSAT imagery from 1989 to 2013. They used different Landsat sensor: TM, ETM+ and OLI.

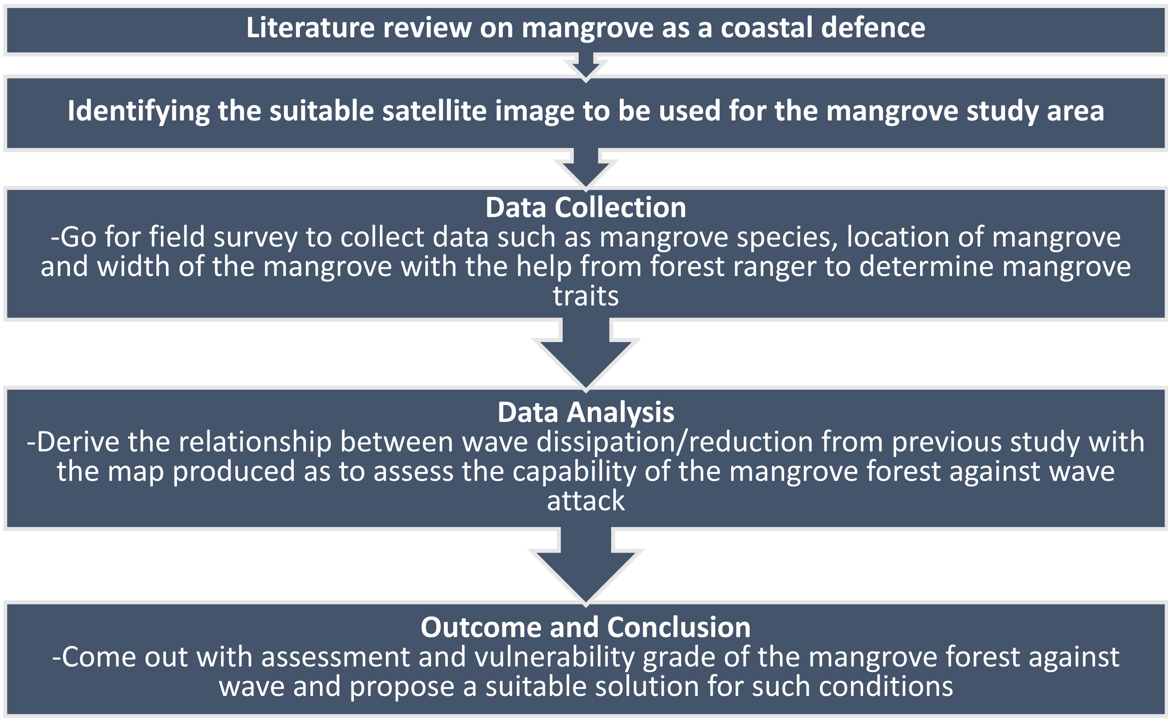
CHAPTER 3

METHODOLOGY

The research is about deriving the capability of the existing mangrove as a natural buffer in protecting coastline against the prevailing wave attack. Based on several literature review and journal, in order to identify which aspects that need to take note in understanding the capability of mangrove. Thus, with the use of GIS application we can identify the mangrove areas based on their properties. From these result, we can analyse the capability of mangroves forest as a natural buff.

The research will start with field survey on the study area. The study area will be chosen based on the accessibility of the area and also the information provided by the local authority. My study area for this project are located at Tanjung Piai, Johor the southern tip of Peninsular Malaysia. Several site visit to the study area will be conducted to gather all the information regarding the mangrove tree data and the surrounding for study area as an input later on for the GIS analysis. Lastly, the data that have been collected will be compared with the previous study. The comparative analysis will be compared with satellite images of recent years. Below are the research methodology:

3.1 THE FLOW OF THE PROJECT



Field survey data or ground truth

Before this there are 3 possible location for my study area which is Tanjung Bin, Kuala Sepetang and Tanjung Piai. However, after several investigation between these three places Tanjung Piai have been chosen Tanjung Piai as it can easily access and it has their own management so that it would be easier to get the information needed for my study. The other reason Tanjung Piai choose as a location for my study area is because the mudflats and mangrove forests have been significantly eroded over the years due to coastal issues and human interferences so it become an interesting places to study as this area are protected by the government.

The site visit will involve to gather all the information needed as the input for the GIS analysis later on. For this part I have to identify the type of mangroves at Tanjung Piai. It would be hard for me to identify alone so I will be need some help from the expert or the forest ranger who work there as they have more experience in determining the mangrove species. Plus at the same time, I can use this change to ask the local about the reason why the mangrove are destroy as some of the local may experience itself or know the reason why the mangrove deteriorate.

Figure 4: Discussion on the mangrove age and species

GIS Analysis

The satellite image are selected and will be analyses the result with the comparative analysis done with the previous study. There are several satellite image such as IKONOS and Quick Bird but most of the researcher from previous study chose USGS (U.S. Geological Survey) website as the site is free and easy to access. The input that we collect from the field survey data will be transfer into GIS software. Hence, the input will be classified based on the parameter of the mangrove such as mangrove ages, density and species of the mangrove.

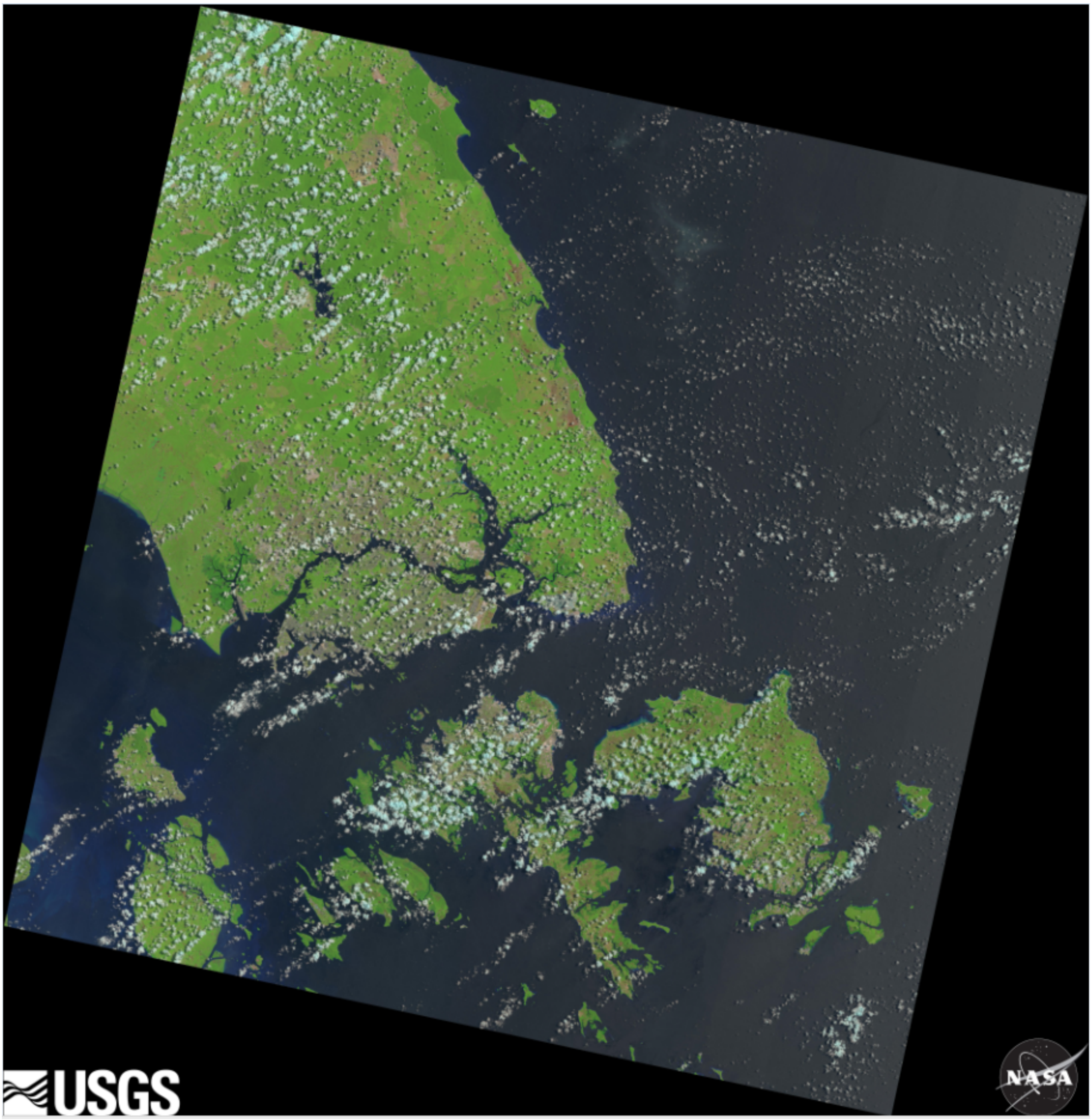


Figure 5: Natural color Landsat 8 image

Image processing

Data of Landsat Imagery date acquisitions September 21st 2015 were used in this study. Landsat image was processed using software ArcGIS 10.2.2. This software were needed to analyze the data that have been collected from the study area. The data of Landsat image was projected to Universal Transverse Mercator (UTM) coordinate system, Datum WGS 1984, zone 48 South, Path/Row: 125/059. The image chosen based on less cloud at the study area as this would effect NDVI value and it would affect the originality of the result.

3.2 GANTT CHART

Table 2: Gantt chart FYP I

Activities	Academic weeks													
	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	WK 9	WK 10	WK 11	WK 12	WK 13	WK 14
Selection of project topic														
Preliminary research work														
Understand the elements in research topic														
Field survey														
Understand the usage of GIS software in defining mangrove properties														
Proposal Defense														
Consultation with Supervisor														
Submission of Interim Report														
Interim Report														

Table 3: Gantt chart FYP II

Activities	Academic weeks													
	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	WK 9	WK 10	WK 11	WK 12	WK 13	WK 14
Identification of problem statement	■													
Resource gathering and research		■	■	★										
Satellite image			■	■	★									
Interpretation of image						■	■	★						
Digitation and analysis of GIS								■	■	■	★			
Map and analysis result									■	■	■	★		
Project Documentati on												■	■	
Report Submission													★	
Project presentation and evaluation														★

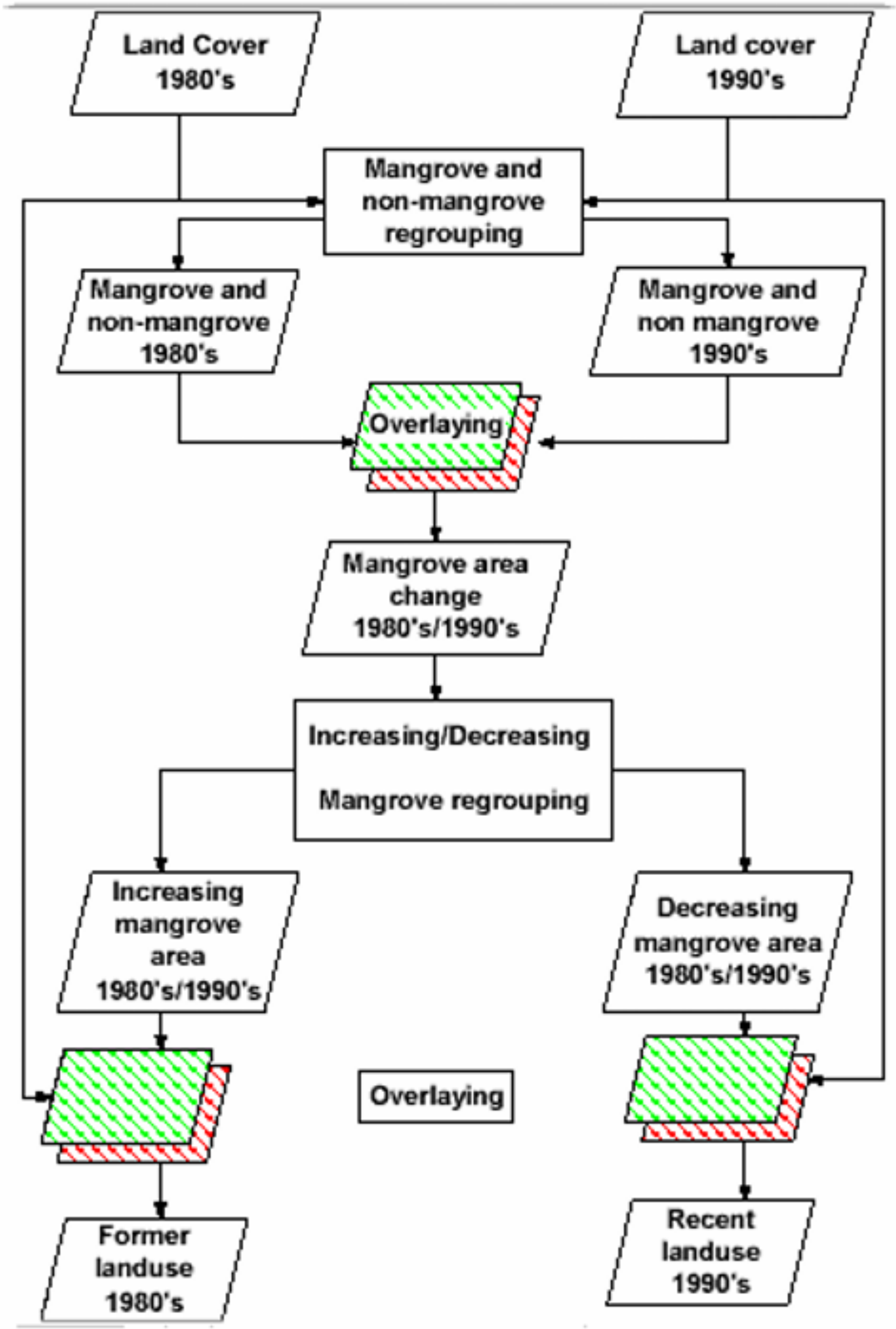


Figure 6: Mangrove area changes detection procedure (Hussin et al., 1999)

CHAPTER 4

RESULTS AND DISCUSSION

As stated by Ramachandran (1993) many of the researcher in recent years has proved that remote sensing is a reliable technique or method in acquiring a data for their research and also be used in coastal environment monitoring and management. Having to know these, remote sensing is the easiest way to monitor and manage the mangrove by using the satellite image as it gives more accurate information and it also crucially needed in classifying and delineating mangrove forest in order to determine functional forest classes into management zones.

Figure 7: Tanjung Piai mangrove data station

The first visit have been made at Tanjung Piai and the mangrove data are taken from four station as shown in figure 5. The mangrove height and species of the mangrove are taken within the 20 m x 10 m area for each station with the help of the forest ranger. The boundary have been mark with a red tape within the area of the station so people can recognize the limitation for mangrove survey and for each station location have been recorded for future use.

Table 4: Location of mangrove station

Station	Location
T1	(1°15'58.44"N, 103°30'37.20"E)
T2	(1°15'58.92"N, 103°30'39.41"E)
T3	(1°16'0.19"N, 103°30'41.13"E)
T4	(1°16'2.31"N, 103°30'40.15"E)
T5	(1°16'19.28"N, 103°30'9.23"E)
T6	(1°16'32.14"N, 103°30'38.73"E)

In order for me to understand more on Tanjung Piai, interview have been made to identify the reason mangrove at that area erode faster than the mangrove can regenerate. The ranger at the reserve forest told that one of the major reason is heavy shipping activity at Port of Tanjung Pelepas near Tanjung Piai. The ship wake generate a higher energy wave which disturbed the growth of existing mangrove. The rate of erosion start to increase proportionally with the increase a number of ship that went through Johor Strait to Port of Tanjung Pelepas.

Table 5: Number of ship berthed in PTP (Source: PTP website)

Year	Number of Ships
2010	4163
2011	5301
2012	5013
2013	4762
2014	4839
2015	5191
2016	4267 (till August)

Plus, there also a case where oil spill back in 2012 which lead to closed of Tanjung Piai National Park.in order to clean up the oil spill. One of the personnel at Tanjung Piai said the oil spill occurred during fuel transfer from vessels off Tanjung Piai and wash up onto a 600 m coastal stretch in the park. This oil spill not only endanger fishes but also the mangrove tree as the oil covered the mangrove root and it will eventually lead to withering of mangrove tree. The oil spill lead to the failure of mangroves and eventually increased the erosion process.

Water level data was obtained from the Royal Malaysian navy, Malaysia Tide Tables 2016. Water levels from four different tidal stations near Tanjung Piai. Characteristic water levels in the study area are presented in table below. As you can see typical tidal range is just above 3 m whereas HAT is approximately 3.75 m CD.

Table 6: Tidal Levels at standard ports

Levels	**Tanjung Pelepas (m CD)**	**Kukup (m CD)**	**Pulau Pisang (m CD)**	**Batu pahat (m CD)**
Highest Astronomical Tide (HAT)	3.75	3.68	3.79	3.37
Mean High Water Spring (MHWS)	3.03	3.04	3.12	2.75
Mean High Water Neap (MHWN)	2.16	2.20	2.28	2.03
Mean Sea Level (MSL)	1.66	1.70	1.77	1.59
Mean Low Water Neap (MLWN)	1.17	1.21	1.26	1.15
Mean Low Water Spring (MLWS)	0.30	0.37	0.42	0.43
Lowest Astronomical Tide/ Chart Datum	0.00	0.00	0.00	0.00

The tidal levels can be characterized by a form number that is described based on the different tidal harmonic components in the area from the formula below:

$$N_f = \frac{K1 + O1}{M2 + S2}$$

Based on these formula, we can used the harmonic constant from tide table to determine tidal conditions.

Table 7: Harmonic Constants from Tide Table

Tidal Stations	**Harmonic Constant**				N_f
	M_2	S_2	K_1	O_1	
Tanjung Pelepas	0.93	0.43	0.27	0.24	0.375
Pulau Pisang	0.93	0.42	0.24	0.26	0.370
Kukup	0.92	0.42	0.26	0.25	0.381
Batu Pahat	0.8	0.36	0.19	0.26	0.388

Based on the data calculated above, we can determine the tidal conditions as shown below:

a) $N_f < 0.25$ (Semidiurnal Tide)
b) $0.25 < N_f < 1.25$ (Mixed Tide)
c) $N_f > 1.25$ (Diurnal Tide)

As shown above, from the calculated harmonic constant the tidal conditions for four tidal stations are corresponds to predominantly mix tidal conditions. An illustration of measured water levels in the study area are presented in table 4.

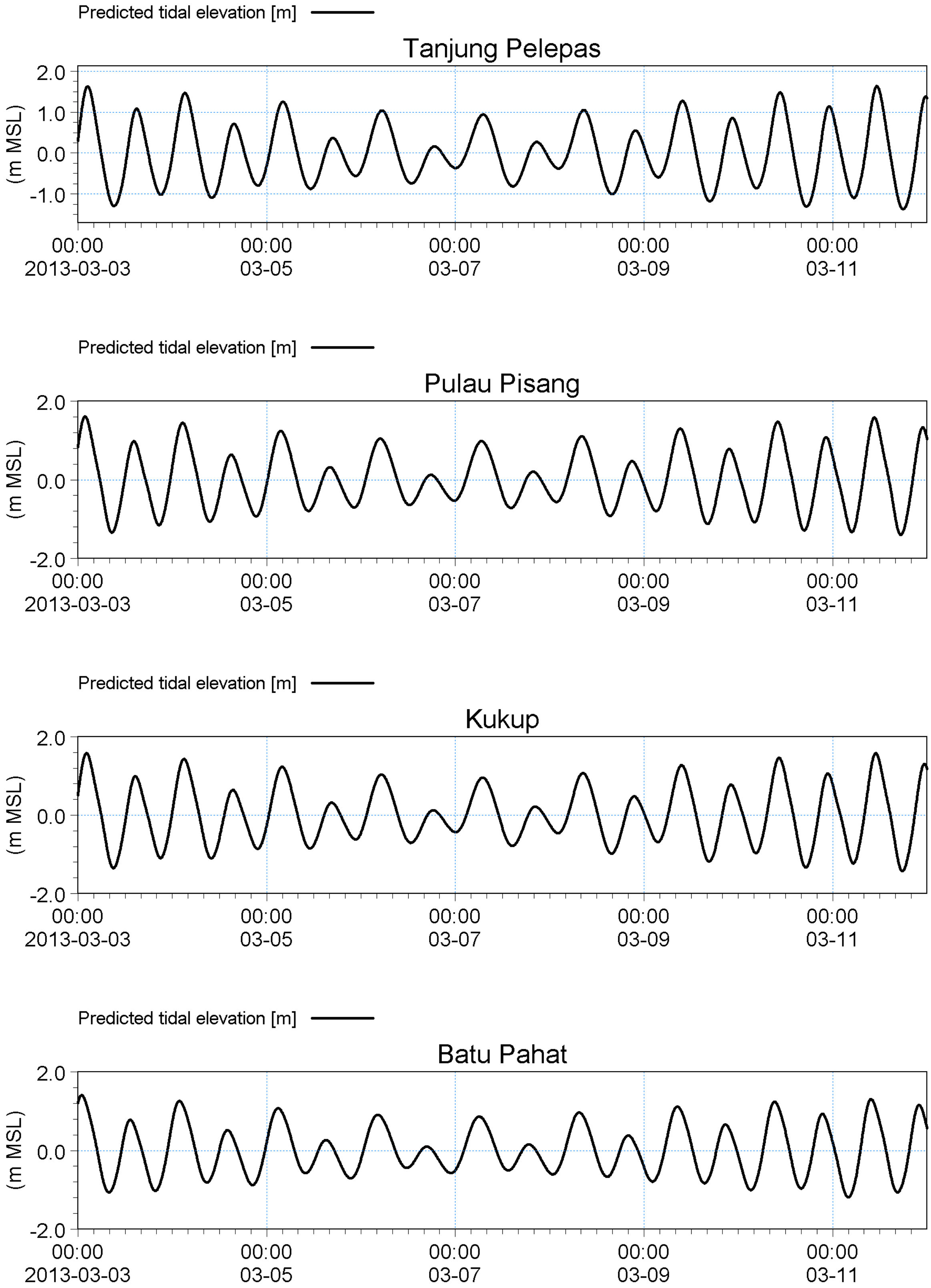


Figure 8: Predicted water levels at different locations

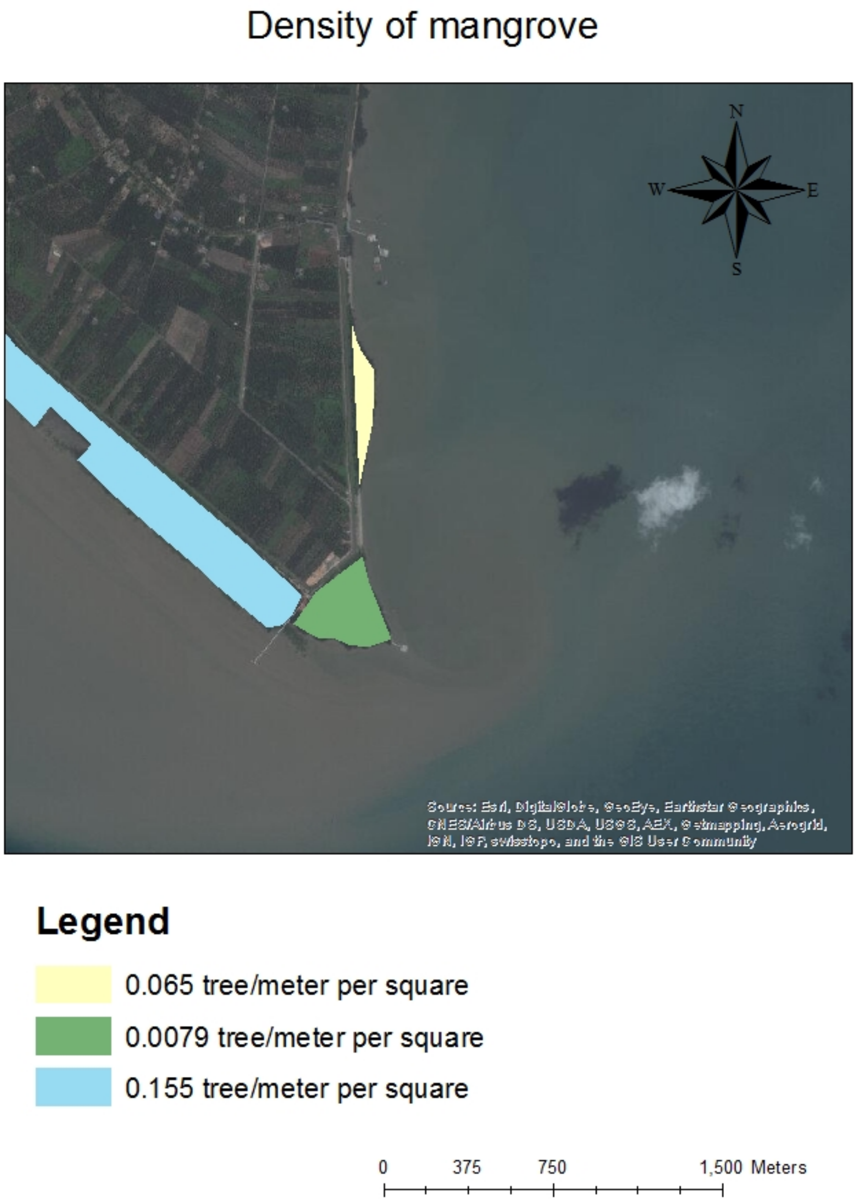


Figure 9: Distribution of mangrove according to their density

The density of mangrove forest at Tanjung Piai can be classify at three different places where the density are calculated based on the how many tree within the area of the field work. The average density of 0.0996 tree/ meter^2. Based on the comparative analysis, the blue area show dense area followed by the green and yellow the lowest vegetation. The difference on the area of the mangrove vegetation are also one of the reason why the mangrove at certain are denser than other area. The vegetation are plant with a spacing 1.2 meters and 1.8 meters respectively because if the spacing are too close the mangrove would need to compete among each other to receive sunlight for their essential need.

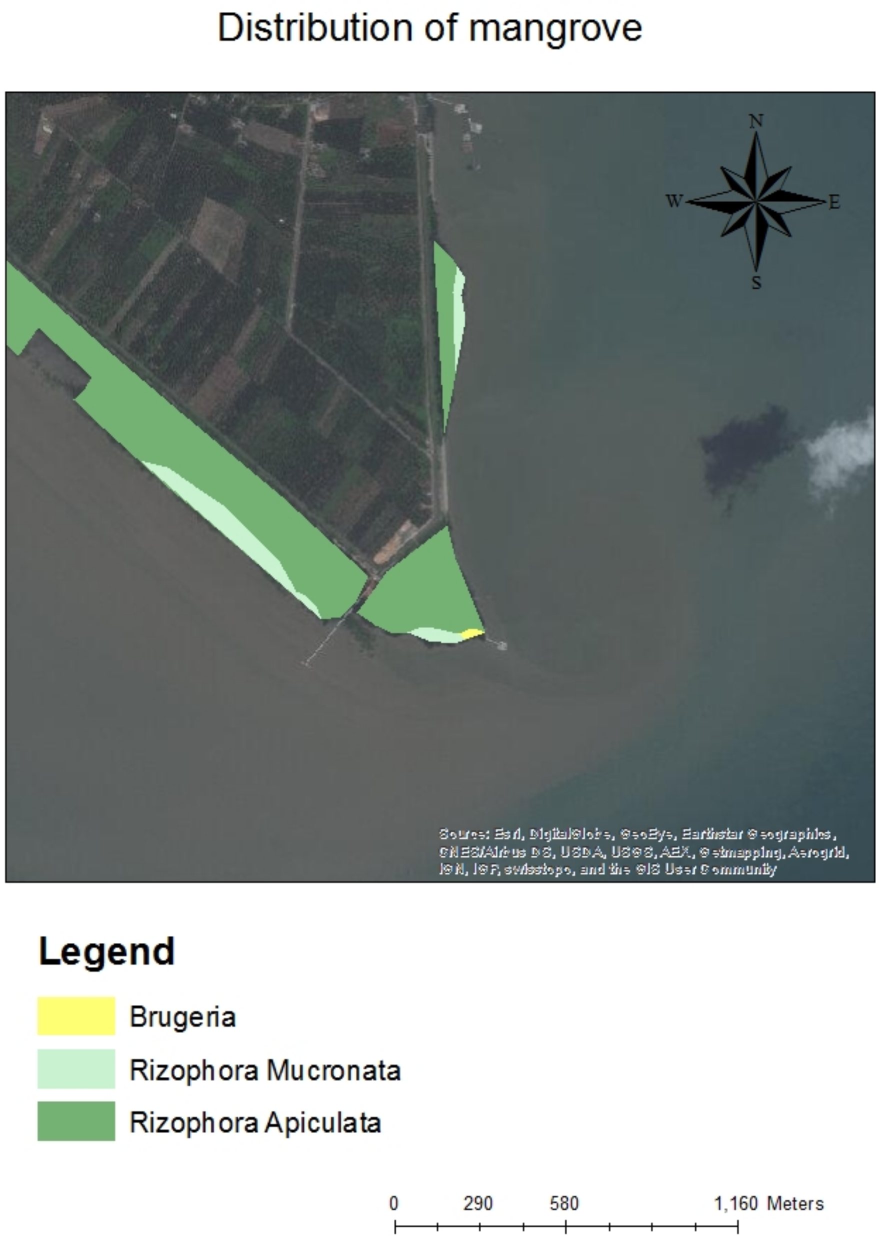


Figure 10: Distribution of mangrove species

Based on the map, Tanjung Piai are predominantly covered with *Rizophora sp.* while another 5% is covered with *Brugeria sp.* The ranger at Tanjung Piai said the original species at Tanjung Piai would be *Rizophora sp.* whereas *Brugeria sp.* are carried from other place through other medium such as ocean. Previously, in the literature review it has been proved that *Rizophora sp.* is one of the best attenuator among other species. Based on the experiment by Hashim and Catherine (2013) stated that 80 m wide for

Rizophora sp. is good enough to reduce wave height by 80%. The study are dominantly with Rizophora sp. with a large area of such species help in reducing wave as it reach mainland.

Mangrove species can easily be distinguish by looking at the shape of leaf or propagule. For example *Rizophora Mucronata* have a wider surface of leaf and with small corky spots underneath the leaf whereas *Rizophora Apiculata* have a smaller surface of sharp leaf and without small corky spots underneath the leaf. However some of the leaf hard to distinguish due weather and the age of the tree so we can also identify the species through the propagule where for *Rizophora Murconata* have a longer propagule compared to *Rizophora Apiculata.*

As for *Brugeria sp.* there are some of the mangrove produce red color on top of the propagule. Plus there are no other same *Brugeria sp.* so it is really easy to distinguish. There are mangrove guide to distinguish between the species of the mangrove at APPENDIX 5.

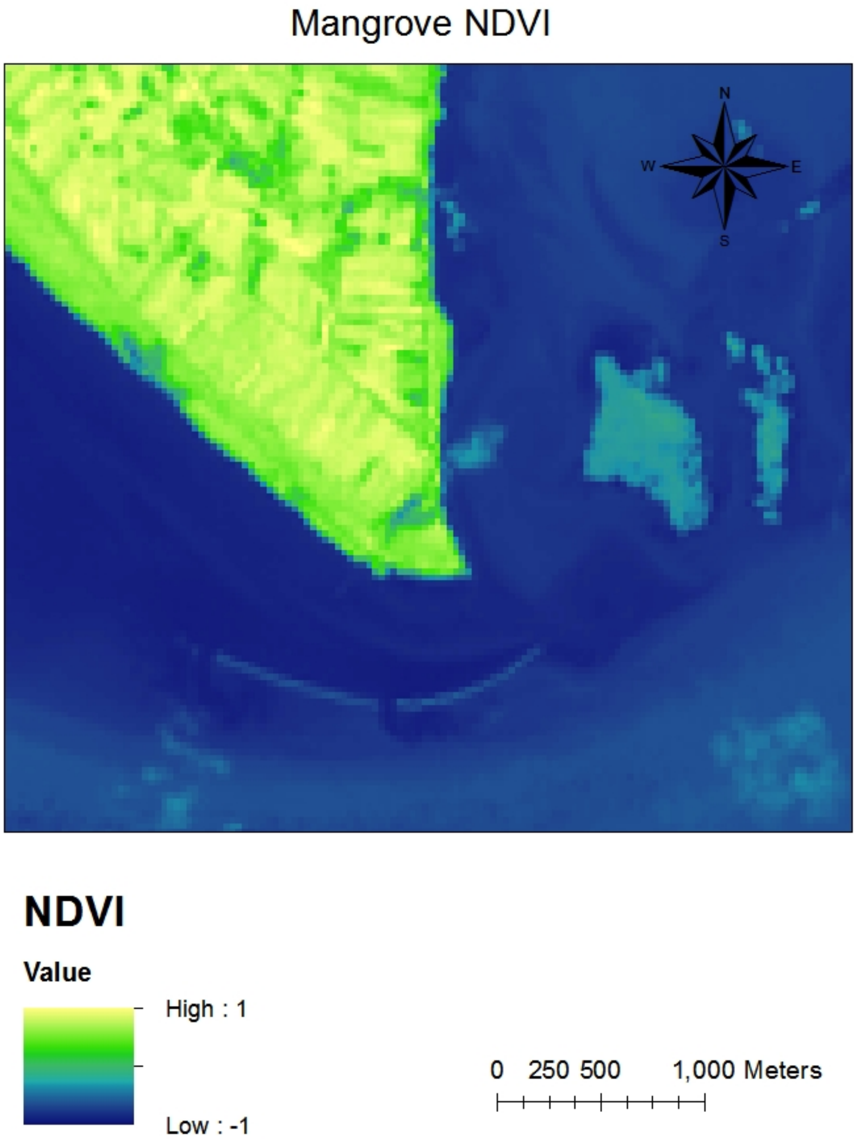


Figure 11: NDVI

Image processing from Landsat 8 divided mangrove into three classes based on NDVI range from Ministry of forestry. Density classes are Density classes are divided into three classes which is sparse, moderate and denser the study area. Each of this classes have different with respect to the number of tree per hectare. The pixel in the map that have been produced by GIS will show the properties for the selected area and it will be analyze and map will produce through classification of the NDVI value from the density classess

However, some of the pixel will show negative NDVI value where in this case it will represent water and cloud within the study area. The negative value help in distinguishing the vegetated and non-vegetated area. The mangrove vegetated mangrove area can be differentiate with the non-mangrove with the relationship from the field data done during project activities. Higher vegetated area tend to absorb more light thus giving out less light color based on the map whereas for less vegetated area it absorb less light due resulting green color based on the map that have been produced.

Table 8: Density from NDVI source: to Umroh, Wahyu Adi, & Suci, S. P. (2016)

NDVI Range	**Density Classes**
-1 – 0.33 equal with <1,000 Trees/Ha	Sparse
0.33 – 0.42 equal with ≥ 1,000 to <1,500 Trees/Ha	Moderate
0.42 – 1 equal with ≥ 1,500 Trees/Ha	Dense

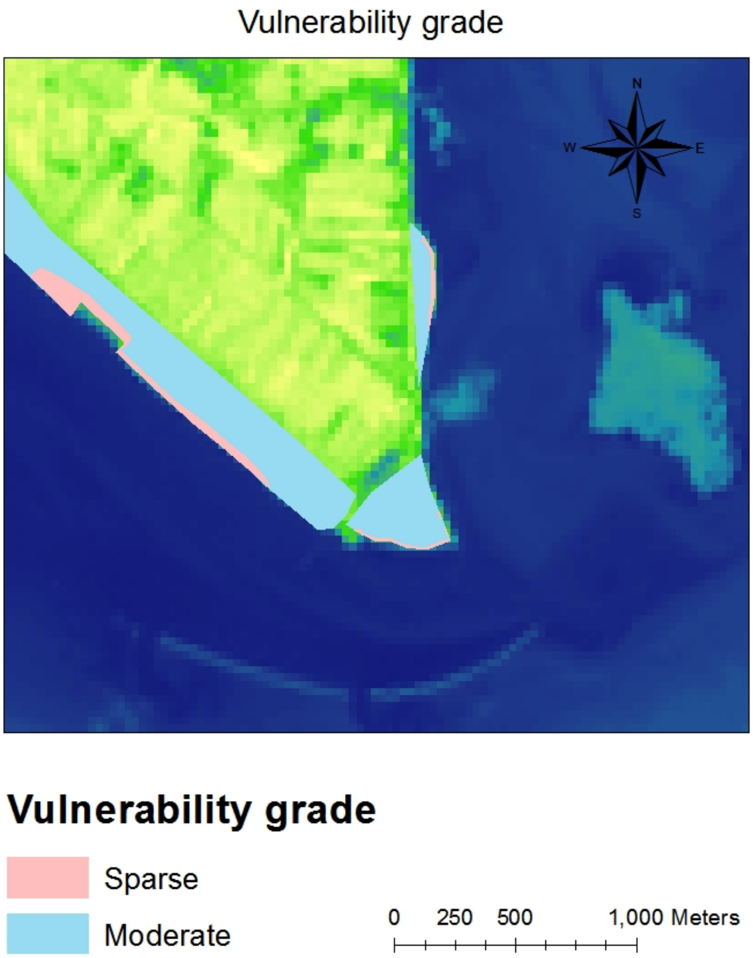


Figure 12: Vulnerability grade

Classification of mangrove have been made at the study area, it show the density of mangrove are thicker as it reach near the mainland and less density of mangrove in front of mangrove. The reason why mangrove at the front are less density than at the back because front mangrove attenuate more wave or receive more damage causing the mangrove to be less density. High waves that combine with strong the tidal currents which occur during spring with the average of 3m mean high water spring

Table 9: Wave height reduction table (R – Rizophora, B - Brugeria), max H (.west – 0.56 m, east – 0.32 m, tip – 1 m)

Location	Species	Width of mangrove (m)	Density of mangrove	Percentage wave reduction (%)	Wave height reduction (m)
A-1	*Rizophora sp.*	175	Moderate	97	0.0135
A-2	*Rizophora sp.*	164	Moderate but sparse at the tip	94	0.027
A-3	*Rizophora sp.*	170	Moderate but sparse at the tip	95	0.0225
A-4	*Rizophora sp.*	105	Partially sparse and moderate	70	0.135
A-5	*Rizophora sp.*	94	Partially sparse and moderate	67	0.1485
A-6	*Rizophora sp.*	182	Moderate	98	0.009
A-7	*Rizophora sp.*	227	Moderate	100	0
B-1	*Rizophora sp Brugeria sp.*	283	Moderate but sparse at the tip	100	0
C-1	*Rizophora sp.*	90	Moderate but sparse at the tip	82	0.081
C-2	*Rizophora sp.*	78	Moderate but sparse at the tip	75	0.1125

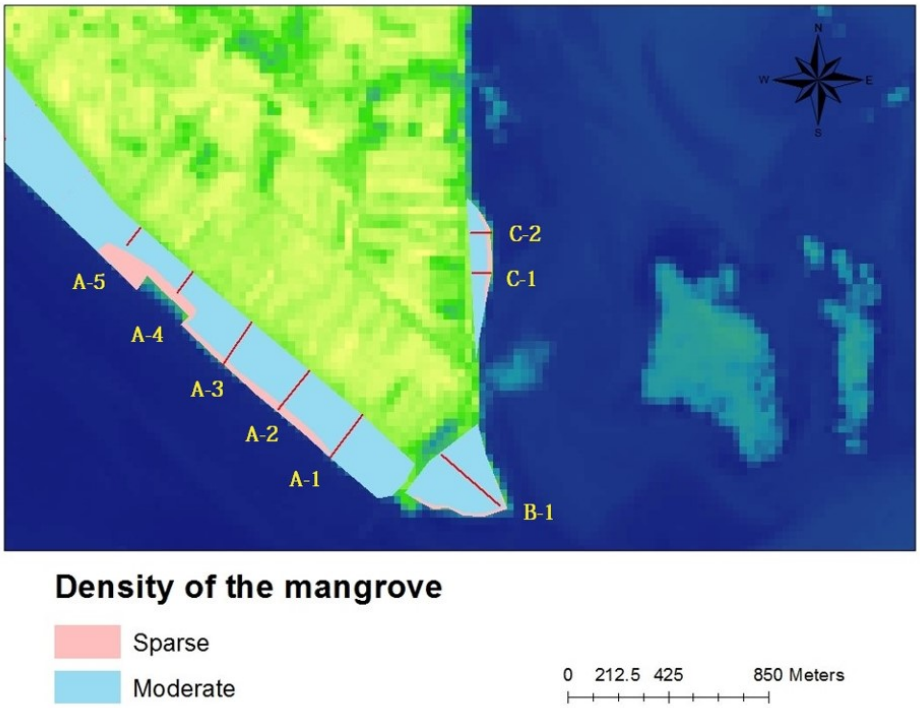


Figure 13: Width of Mangrove

The dominant waves came from Singapore (south) and Malacca Straits (northeast) with amplitudes of over 1.5 m, reducing their heights to less than 0.8 m as they propagate towards Tanjung Piai. Since the bed sediment at Tanjung Piai is very soft, these high waves, combined with the strong tidal currents, which occur during spring tide and storm events, will dislodge and transport the sediment away. This is devastating to the existing mangroves growing in Tanjung Piai, because the mangrove roots are also regularly subjected to the wakes of the passing ships which will loosen their grip on the soft mud, causing them to fall and eventually die. The maximum wave height in the study area coming from west is in the range of 0.56 m, 0.32 m coming from east while the maximum wave can reach up to 1.0 m particularly at the tip area. Note that the monsoon for this study area are during Northeast Monsoon where the rainfall are heavier compared to Southwest Monsoon.

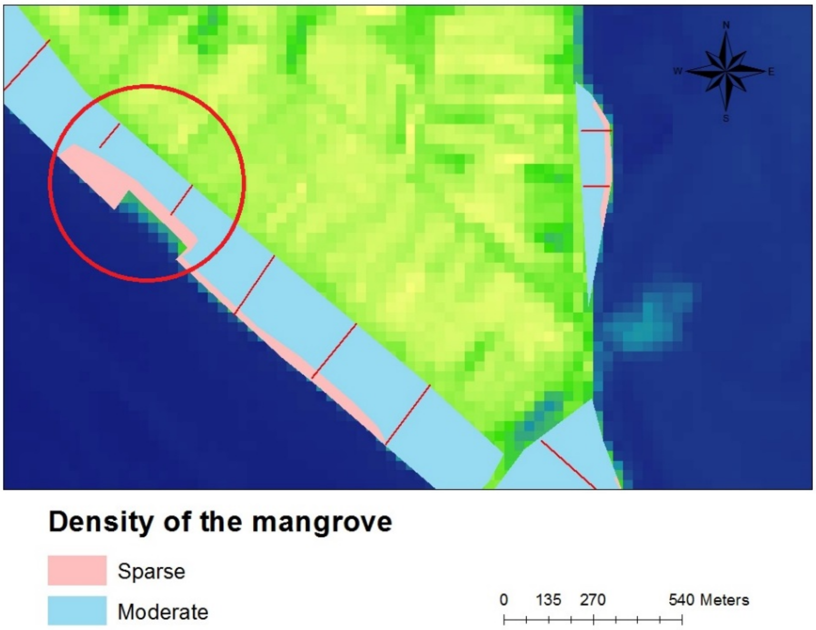


Figure 14: Mangrove replanting needed at that area

Table 10: Vulnerability grade table

Vulnerability grade	Percentage of wave reduction (%)
None	80
Low	70
Moderate	60
High	< 50

The map is produced by deriving the relationship between the wave dissipation and wave attenuate from previous study done by Hashim and Catherine (2013) with the field data from the ground truthing done during the project activities. The vulnerability grade is characterized based on the percentage of wave reduction from the graph in APPENDIX 6. Most of the area have a good characteristic as the coastal protection as it can attenuate almost more than 80% of the incoming wave except locations A-4 and A-5 as replanting of mangrove are needed to prevent the area become more sever. The width of mangrove for that area are 105 m and 94 m which is quite is quite small number of mangrove to attenuate wave because mangrove attenuate wave based on a group of mangrove.

Plus, less number of mangrove require will have to attenuate more wave and the worst case would be if the incoming wave that are too strong would eventually destroy the mangrove as year pass by. The setback limit according to Department of Irrigation and Drainage are 400 m for muddy coast measured from seaward edge of mangrove vegetation and no development should be allowed in areas where mangrove vegetation have been gazette as permanent forest reserve under the National Forestry Act 1984. However this setback limit are not entirely depend on the current stability of the coastline erosion as this are considered as good engineering practices for shoreline development. Most of the village at Tanjung Piai followed the setback limit that have been proposed by the Department of Irrigation and Drainage.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Mangroves are known as a natural buffer in protecting the coastal area thus understanding the mangrove forest is needed to preserve this forest in the future. The location of mangrove itself are very strategic against wave attack as it is situated between the tidal zones, so wave will become calm as it started to reach mainland. The surrounding of Tanjung Piai are the reason why the mangrove are starting to demolished one by one due to human interference and recent development. At the same time, it disturb the coastal equilibrium lead to erosion at the other area. In this study, as showed in the map the area are good enough in protecting coastal area. Mangrove ages, types, density and mangrove coverage area play important role in attenuating the waves. Vulnerability and the assessment of the mangrove forest against the wave are done by this simplified approach. In Tanjung Piai, almost 90% of the total study area can attenuate incoming wave. Mitigation measures should be considered in securing the future of the mangrove ecosystems.

REFERENCES

Akira, H., M. Marguerite, and W. Roy. 2003. Hyperspectral image data for mapping wetland vegetation. Wetlands 23:436–48

Alongi, D. M. 2002. Present state and future of the world's mangrove forests. Environmental Conservation 29:331–49.

Nor Aslinda, A.; Wan Hasliza, W.J., and Mohd Radzi, A.H., 2014. Coastal erosion at Tanjong Piai, Johor, Malaysia. In: Silva, R., and Strusińska-Correia, A. (eds.), Coastal Erosion and Management along Developing Coasts: Selected Cases. Journal of Coastal Research, Special Issue, No. 71, pp. 122–130

Awang, N. A., Adam, K. A. & Mamad, S. (1999). Coastal Zone Stabilisation, Restoration and Enhancement through Mangrove Forest Establishment

Brian, G. L. and S. D. Timothy. 1996. A technique for mapping mangroves with Landsat TM satellite data and Geographic Information System. Estuarine, Coastal and Shelf Science 43:373–81.

Budhiman S, Hasyim B. Pemetaan sebaran mangrove, padang lamun dan terumbu karang menggunakan data penginderaan jauh di wilayah Pesisir Laut Arafura. Pertemuan Ilmiah Tahunan MAPIN XIV. 14 – 15 September 2005. In Bahasa.

Furukawa, K. and Wolanski, E. 1996. Sedimentation in mangrove forests. Mangroves and Salt Marshes.

Faridah-Hanum, I., Latiff, A., Khalid Rehman, H., & Munir, O. (2014). Mangrove Ecosystems of Asia Status, Challenges and Management Strategies.

Giri, C.; Ochieng, E.; Tieszen, L.L.; Zhu, Z.; Singh, A.; Loveland, T.; Masek, J.; Duke, N. Status and distribution of mangrove forests of the world using earth observation satellite data. Glob. Ecol. Biogeogr. 2011, 20, 154–159.

Green, E. P., C. D. Clark, P. J. Mumby, A. J. Edwards, and A. C. Ellis. 1998. Remote sensing techniques for mangrove mapping. International Journal of Remoter Sensing 19:935–56

Hadi, S., Latief, H., & Muliddin 2003. Analysis of Surface Wave Attenuation in Mangrove Forests

Hamzah, K. A., Omar, H., Ibrahim, S., & Harun, I. (2009). Digital change detection of mangrove forest in Selangor using remote sensing and geographic information system (GIS). The Malaysian Forester, 72(1), 61-69.

Hashim, A. M., & Catherine, S. M. P. (2013). A Laboratory Study on Wave Reduction by Mangrove Forests. APCBEE Procedia, 5(0), 27-32. doi: http://dx.doi.org/10.1016/j.apcbee.2013.05.006

Hirano, A., M. Madden, and R. Welch. 2003. Hyperspectral image data for mapping wetland vegetation. WETLANDS 23:436–48.

Hussin. Y.A, Mahfud, M. and Zuhair Michael Weir (1999). Monitoring Mangrove F orests using Remote Sensing and GIS. GIS development proceedings, ACRS.

Kathiresan, K. 2012. Importance of Mangrove Ecosystem

Kovacs, J. M. 1999. Assessing mangrove use at the local scale. Landscape and Urban Planning 43:201–08.

Kovacs, J. M., J. Wang, and F. F. Verdugo. 2005. Mapping mangrove leaf area index at the species level using IKONOS and LAI-2000 sensor for the Agua Brava Lagoon, Mexican Pacific. Estuarine Coastal and Shelf Science 62:377–84.

Kuenzer, C.; Bluemel, A.; Gebhardt, S.; Quoc, T.V.; Dech, S. Remote sensing of mangrove ecosystems: A review. Remote Sens. 2011, 3, 878–928.

Nor Aslinda, A., Wan Haslizah, W. J., & Mohd Radzi, A. H. 2014. Coastal Erosion at Tanjung Piai, Johor, Malaysia

Ramachandran. S. (1993). Coastal Zone Information System – Pilot project for Rame swaram area. Report submitted to Department of Ocean Development. Govt. of Indi a, 40 pp.

Salina, K. 2009. Move to Restore Mangrove Forests. The Star. 3 November

Sader, S. A., A. Douglas, and W. S. Liou. 1995. Accuracy of Landsat-TM and GIS rule-based methods for forest wetland classification in Maine. Remote Sensing of Environment 53:133–44.

ScienceDaily. Mangroves Shielded Communities against Tsunami. Retrieved in August 2012 from http://www.sciencedaily.com/releases/2005/10/051028141252.htm

Umroh, Wahyu Adi, & Suci, S. P. (2016). Detection of mangrove distribution in Pongok Island. Science Direct, Procedia Environmental Sciences 33 (2016) 253-257.

Vaiphasa, C., S. K. Andrew, and F. B. Willem. 2006. A postclassifier for mangrove mapping using ecological data. Photogrammetry and Remote Sensing 61:1–10.

Wang, L. Sousa, W.P., Gong. P., Biging G.S., (2004) Comparison of IKONOS and QuickBird images for mapping mangrove species on the Caribbean coast of Panama. Remote Sens. Environ. 91 (3), 432-440.

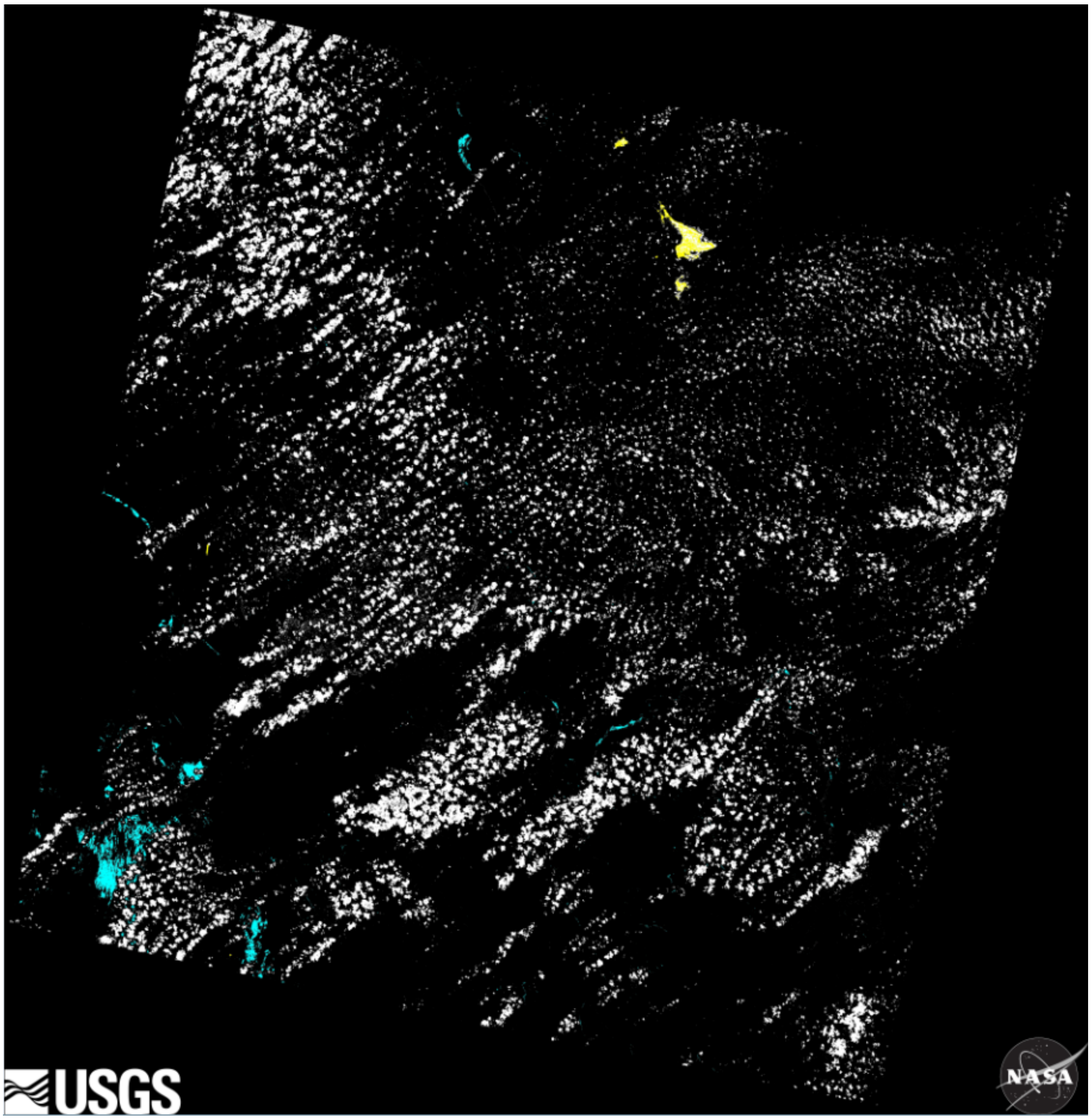
Woodroffe, C. (1992). Mangrove sediments and geomorphology. In: A.I. Robertso n and D.M. Alongi (Eds.), “Coastal and Estuarine Studies: Tropical Mangrove Ecos ystem”. American Geophysical Union, Washington DC., USA, pp. 7-41.

Yacouba D, Guangdao H, Xingping W. Assessment of land use cover changes using NDVI and Dem an Puer and Simao Counties, Yunnan Province, China. World Rural Observations 2009;1(2):1-11.

Yuvaraj E., Dharanirajan K., Saravanan and Karpoorasundarapandian N. Evaluation of Vegetation density of the Mangrove forest in South Andaman Island using Remote Sensing and GIS techniques. Int. Res. J. Environment Sci 2014; 3(8):19–25.

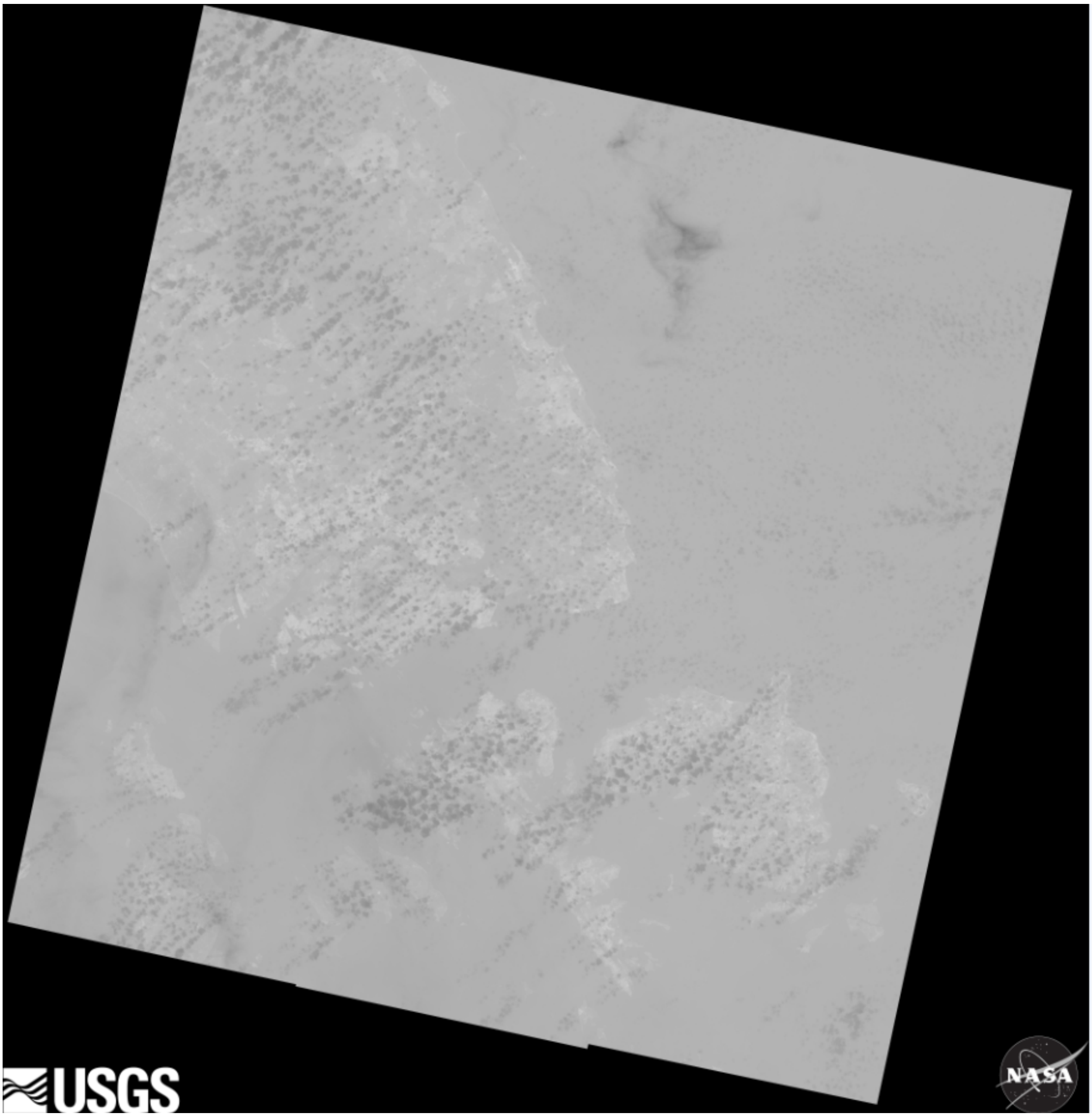
APPENDICIES

APPENDIX 1



Landsat Quality image

APPENDIX 2



Landsat thermal image

APPENDIX 3

Table: Metadata of satellite image used in the project.

Data set attribute	**Attribute value**
Landsat Scene Identifier	LC81250592015264LGN00
WRS Path	125
WRS Row	059
Target WRS Path	125
Target WRS Row	059
Full or Partial Scene	FULL
Nadir/Off Nadir	NADIR
Data Category	NOMINAL
TIRS SSM Model	N/A
Bias Parameter File Name OLI	LO8BPF20150921025452_20150921043409.01
Bias Parameter File Name TIRS	LT8BPF20150921025058_20150921033749.01
Calibration Parameter File	L8CPF20150701_20150930.02
RLUT File Name	L8RLUT20150303_20431231v11.h5
Roll Angle	0
Station Identifier	LGN
Day/Night	DAY
Data Type Level 1	L1T
Sensor Identifier	OLI_TIRS
Date Acquired	2015/09/21
Start Time	2015:264:03:16:20.6323490

Stop Time	2015:264:03:16:52.4023450
Date L1 Generated	2015/09/21
Image Quality	9
Scene Cloud Cover	20.06
Sun Elevation	64.96465489
Sun Azimuth	91.06442141
Geometric RMSE Model X	7.233
Geometric RMSE Model Y	5.656
Ground Control Points Model	80
Ground Control Points Version	-1
Browse Exists	Y
Processing Software Version	LPGS_2.5.1
Center Latitude	1°26'47.98"N
Center Longitude	104°08'23.71"E
NW Corner Lat	2°29'39.19"N
NW Corner Long	103°29'14.06"E
NE Corner Lat	2°08'05.96"N
NE Corner Long	105°09'41.94"E
SE Corner Lat	0°23'30.84"N
SE Corner Long	104°47'26.88"E
SW Corner Lat	0°45'15.44"N
SW Corner Long	103°07'03.94"E
Center Latitude dec	1.44666

Center Longitude dec	104.13992
NW Corner Lat dec	2.49422
NW Corner Long dec	103.48724
NE Corner Lat dec	2.13499
NE Corner Long dec	105.16165
SE Corner Lat dec	.3919
SE Corner Long dec	104.7908
SW Corner Lat dec	.75429
SW Corner Long dec	103.11776

APPENDIX 4

Tanjung Piai mangrove

i. Rizophora sp.

ii. Tools that being used for mangrove survey

APPENDIX 5

Comparative guide to mangroves

APPENDIX 6

Figure used to derive the relationship between wave dissipation from the previous study by (Hashim & Catherine, 2013) and (Hashim & Noraini) with the map produced.