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# Assessment of Coastal Landscape Along Kelantan Coast Using Geospatial Techniques

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**Abstract.** The social and economic development from the coastal area benefits human life. However, growing human and environmental pressures at coastal areas also bring significant impacts on coastal erosion and coastline changes. Nowadays, geospatial technology which utilized remote sensing and GIS techniques has been widely used to detect coastal erosion for controlling the development and coastal region sustainability. Thus, this study was conducted to assess the coastal erosion and accretion for the potential risk zone based on the characteristics of the landscape and land use land cover (LULC) at the Kelantan Coast using land use classification and GIS spatial interpolation techniques. In this study, the vulnerability level of the coastal profile at the Kelantan coast was determined from the beach profile survey and the Inverse Distance Weighting (IDW) interpolation method. Then, the Land Use Land Cover (LULC) along a 1 km buffer zone were classified by performing a supervised classification method on Sentinel 2 satellite images year 2020. The effect of these parameters on coastal erosion was determined from separated five management units (MU 1, MU 2, MU 3, MU 4, MU 5) along the Kelantan Coast based on the Malaysian Department of Irrigation and Drainage (DID). It is found that MU 3 (0.8%) and MU 5 (0.6%) were the area with the lowest average slope profile percentages which is located at Pantai Sabak and Pantai Kemayang respectively. Thus, the infrastructure, LULC and coastal communities in Pantai Sabak and Pantai Kemayang were potentially vulnerable to erosion. This finding supports the significant use of geospatial techniques of important decision-making to protect and mitigate steps toward sustainable coastal management along the coastline.

**Keywords:** beach profile survey; Kelantan coast; LULC; sustainable; accretion



## 1. Introduction

The coastal regions is importance in human life as a residential, a source of employment and cultural practices. Thus, the sustainability of coastal regions are essentials in conjunction with the Sustainable Development Goals (SDGs)[1]. However, the changes of coastal regions always related to erosion and accretion, where the elevation of the beach profile causing the changes of the beach slope elevation either higher or lower [2]. To avoid erosion and accretion, the coastal regions needs to be controlled especially on the landscape of coastal regions. A coastal landscape is a coastline with several coastal characteristics, including some erosion and some deposition. It is distinguishable by dominant features that dominate the shape of the coastline there from neighbouring coastal landscapes. One of the main mechanisms that ensure global sustainability is the coastal areas [3]. The land-ocean interface is among the most complex regions upon this Earth's surface in which an ever-changing set of ecological factors continually rework unconsolidated sediments[4]. Coastal and nearshore marine areas are the most valuable and dynamic places on Earth. According to [5], with a mix of many physical processes, including tidal floods, a rise of the sea level (SLR), land reduction and erosion deposition, the climate is highly complex. Coastal erosion is known as the coastline's continuing erosion, including ecosystems.

Coastal areas are very complex, and it is critical for environmental conservation and sustainable coastal management to track shoreline changes [6]. The length of Malaysia coastline is about 4,809 km, which means that Malaysia's coastal resources are rich with natural biodiversity [7]. The critical problem is the rate of erosion increases dramatically especially in the east coast region of Malaysia [8]. Compared to the South China Sea, the Kelantan coastal area in Peninsular Malaysia provides heavy wind movement to the coastal area. The erosion and accretion of the coastal area are correlated with the high and low energy wave conditions. High energy waves erode the beach sand, while the supplies of low energy waves increase. Thus, it is very significant to identify the variables in the coastal landscape, especially on the coast of Kelantan beach. The monitoring of coastal changes and the recognition of vulnerable areas of erosion could be useful in planning and policy for sustainable coastal management, and the potential impact of coastal profile and land use cover (LULC) on the coast of Kelantan can be analysed. Hence, Comprehension of transitions in the LULC trend is important towards the region's urban growth over time for successful land use and self-sufficient urban planning. [9].

Various techniques can be utilized to monitor the erosion and accretion such as the statistical approaches aerial photography, and topographic surveys [10] or the estimation of erosion and accretion from historical data using the Geographic Information System (GIS) Technique by [11]. Another techniques to detect erosion and erosion involved the use of high spatial resolution satellite and unmanned aerial vehicles (UAV) images to determine on the beach profile changes using real-time kinetic (RTK-GPS) method such as carried out by [2]. Thus, the coastal changes and vulnerable areas of erosion is possible to be carried out with geospatial techniques by determining the coastal profile's vulnerability level and classifying the land use land cover (LULC) along buffer zone from water level. This study aims to integrate geospatial techniques such as satellite imagery and GIS technique to identify highly vulnerable coastal areas at Kelantan Coast with representative findings and valuable information.

## 2. Study Area

This study was conducted at the coastal area in Kelantan which is located between Kelantan river and Kemasin river. The coastal region is located between 6°13'2.11" to 6° 7'49.31" latitude and 102°14'23.43" to 102°22'9.32" longitude and faces the South China Sea. The distance of the shoreline is about 20 km approximately. It has characteristics of dynamic sedimentation and erosion at the mouth of the river. Local activities around the coast are also assisted by physical structures that can dramatically impact the coastline in an incorrect understanding of the coastal environment. Therefore, this is an important location that needs to be monitored as coastal erosion might occur in this area. To study the impact of parameters (i.e. beach profiles and LULC) on erosion and accretion of Kelantan Coast, the region then was separated into five management units (MUs) referring to the Malaysian Department of Irrigation and Drainage (DID). Table 1 listed the classification of MU and distance by location along the Kelantan Coast.

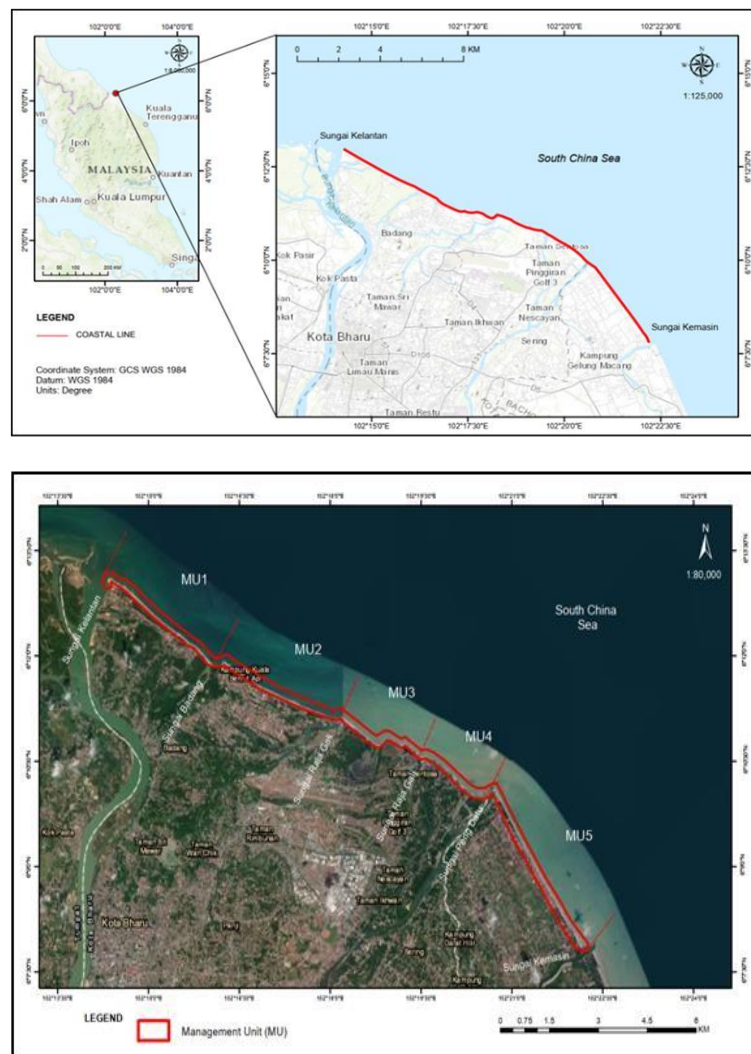


Figure 1: Study Area

Table 1: Management Units Classification

No.	Management Units	Sections	Distances
1	MU 1	Sungai Kelantan – Sungai Badang	4 km
2	MU 2	Sungai Badang – Sungai Raja Gali	4 km
3	MU 3	Sungai Raja Gali I – Sungai Raja Gali II	3 km
4	MU 4	Sungai Raja Gali II – Sungai Peng Datu	3 km
5	MU 5	Sungai Peng Datu – Sungai Kemasin	5 km

### 3. Research Methodology

There were three (3) phases involved in this study (Figure 2). The first phase was data collection from NAHRIM agency, google extraction and satellite images in 2020. For beach profile measurement data were extracted from Google Earth and Sentinel 2 image in the year 2020. The second phase is data processing were involves beach profile plotting and classification of LULC. The data from Google Earth were imported into the Profiler software to identify the profile and generate the volume of the long section and cross-section of the coastal. Then, 2D beach slopes were produced using Inverse Distance Weighting (IDW) interpolation tool in ArcGIS. LULC classification was carried out by using supervised classification by using the Sentinel 2 images and proceed with accuracy assessment. The final phase (Phase III) was the results and analysis. The analysis of the potentially impacted area was determined. The analysis involved producing all the data acquisition into the map which is to discover the area that has potential risk at the Kelantan Coast.

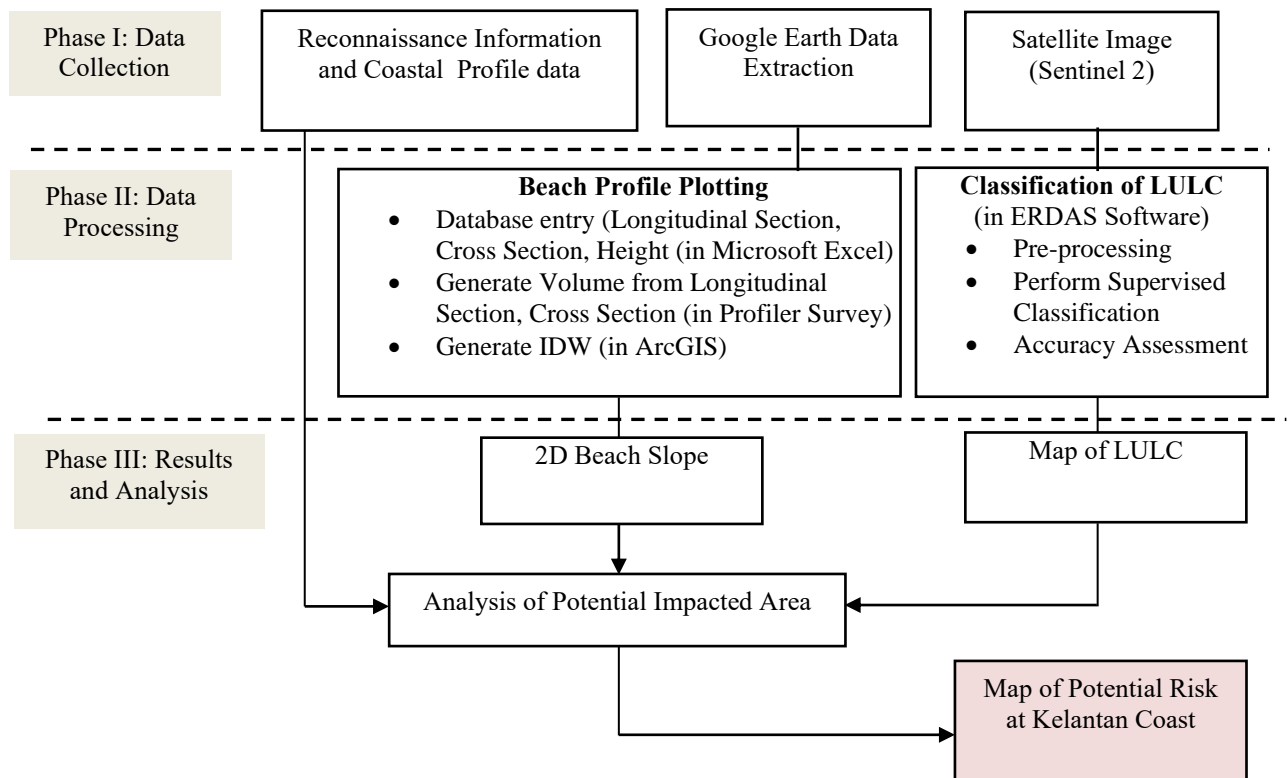


Figure 2: Research Methodology

### 3.1. Data Collection

The first data were reconnaissance information and coastal profile on the year 2020 along the Kelantan coast acquired from NAHRIM agency. These data were carried out using survey method which consist of GPS survey for distance and elevation in 15 locations along MU 1 until MU5. These data were used to verify the results of this study. Meanwhile, the second data for the beach profile data from Google Earth software on the actual in-situ places were calculated using beach profile formula based on distance, and elevation data of points. Based on the data, the beach slope at the study area was extracted to analyse which area have a low average slope that can bed expose to erosion. A variety of chainages then were plotted along the shoreline on the site's reclaimed ground. For the beach profiling survey, the chainage is then utilised to determine the distance between the low mark of each chain. The beach profile were used to determine the form of the shoreline and the shape of the coastline. This profile were also used to detect the real basis on the recovery site. But this survey is only appropriate during the low tide was. The major characteristics are the placement of the low mark on the sea. This type of survey is commonly employed during coastal construction to ensure that the curve is correctly plotted during processing.

The third data used in this study was Sentinel 2 satellite image. The data was downloaded from the USGS website in June year 2020. Basically, the Sentinel 2 data complemented with 13 spectral bands; 4 bands at 10 meters from blue-green, red, and near-infrared(NIR) wavelengths, 6 bands at 20 meters with 4 narrow bands for vegetation characterization and 2 larger shortwave infrared (SWIR) bands and 3 bands at 60 meter (NASA, 2020). In this study, only the Sentinel spectral bands with 10m spatial resolutions were used, since the purpose is only to determine the land use land cover (LULC) classification at Kelantan coastal. Then, the land use land cover (LULC) along the 1 km buffer zone from the water level can be classified.

### 3.2 Beach profiles from Google Earth Software.

The beach slope data that have been extracted from Google Earth Application will be tabulated in Microsoft Excel according to the chainages for the longitudinal section and cross-section at the Kelantan coast. There were 76 chainages in total for longitudinal section and cross-section. The data used in this processing method is the length of chainages and elevation of the chainages. Then tabulated data from Excel were imported into the ArcMap software by adding the X, Y and Z data. The spatial interpolation technique of Inverse Distance Weighting (IDW) being processed in ArcGIS Software to plot the coastline profile, including its surface. By this method, any known point shall be weighted inversely proportional to its distance from the estimated point.

The process of interpolating or estimating the unknown value for specific locations based on the known data values for other points is the spatial interpolation technique. The spatial interpolation technique of Inverse Distance Weighting (IDW) was used to plot the coastline's profile, including its surface. It can be hypothesized that local values contribute a huge interpolated value compared to distant observations[6]. By using Inverse Distance Weighting (IDW) method, any known point shall be weighted indirectly relative to its distance from the predicted points. Inverse Distance Weighting (IDW) techniques were used to map the profile and surface of the coastline, apparently that local values are more significant than long-distance measurements for interpolated values[5]. The technique or method of interpolation can be divided into two main global and local groups. The global interpolation technique, as the name suggests, uses all available data to provide estimates for points with unknown values, while local interpolation techniques use only information near the estimated point. The analysis data that can be performed for the two-dimension (2D) profile is the data need to

be calculated by calculating the beach gradients and morphology. It also includes estimating the lost or gained volumes of the sand [12]. The weight of every identified point in this IDW system is inversely proportional to its distance from the projected point. This method is one of the simplest and most readily available methods.

$$\hat{v} = \frac{\sum_{i=1}^n \frac{1}{d_i} v_i}{\sum_{i=1}^n \frac{1}{d_i}} \quad (1)$$

From this IDW formula in (1) by [6], it shows where is the value to be estimated,  $V_i$  is the known value while  $d_i$  is the distances from the  $n$  data points to the point estimated  $n$ ,  $d_i = (x,y)$  are the coordinates of the interpolation point and  $(x_i,y_i)$  are the coordinates of each dispersion point. The weight function varies with a value of unity at the dispersion point to a value close to zero as the distance to the dispersion point increase.

### 3.3 Land Use Land Cover (LULC) from Sentinel 2

According to [13], land cover classification is a crucial application of remote sensing in order to classify characteristics such as land use through the common use of multispectral satellite imagery. Land use is broadly defined as a series of land operations carried out by humans to use land resources to obtain commodities or benefits. Land cover is usually described as the vegetation that exists on the earth's surface, whether it is natural or plant or man-made structures, such as buildings. Land use and land cover have some central contrasts. [14]

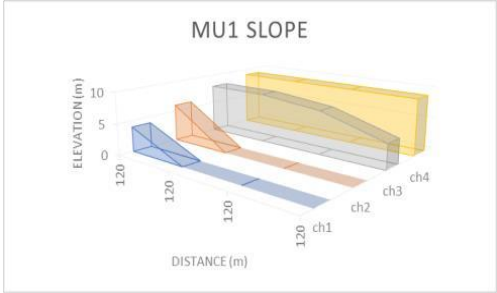
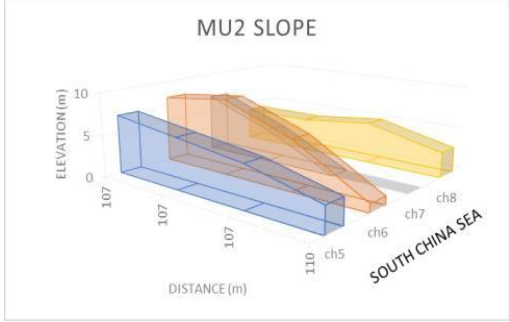
In this study, the main processing involved to generate LULC from Sentinel 2 were pre-processing, supervised classification and accuracy assessment using ERDAS Software. The initial steps in pre-processing like layer stacking and image subset were carried out before the image can be classified. The supervised classification was performed using Maximum Likelihood Classification (MLC) decision rule. Then, the accuracy of the supervised classification were assessed via Google Earth and reconnaissance information from NAHRIM at Kelantan Coast. The LULC map and detail accuracy assessment were explained in Section 4.4 and 4.5 respectively.

## 4. Results and Analysis

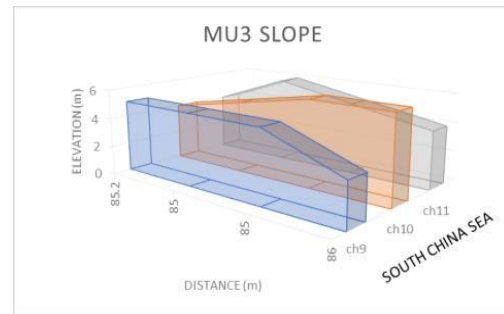
### 4.1 Beach Profile at Kelantan Coast

Based on Malaysia National Coastal Erosion Study in 2015, Kelantan has a higher percentage for the eroded coastal than other states. The beach profiles of separated five (5) Management Units at Kelantan Coast were shown in Table 2. The profile section topographic of the Kelantan coast covers from Kelantan river to Kemasin river. Topographic data has been transferred and visualised in the form of height graphs obtained in Google Earth Pro. Five MUs in this study area were MU1, MU2, MU3, MU4 and MU5 at Pantai Mek Mas Pantai, Cahaya Bulan Pantai Sabak, Pantai Senok and Pantai Kemayang respectively. These five locations were selected due to the major erosion and accretion. Based on the interpretation from Google Earth, the coastal at the Kelantan can be identified as a sandy beach area and facing the South China Sea. Pantai Mek Mas had a beach known as a sandhill or dunes, while Pantai Cahaya Bulan had a long and wide sandy beach along the shoreline. Pantai Sabak was known as fine golden sands, and the coastlines were far and wide. Pantai Senok had a beach known as sandy and picturesque meanwhile, the sand texture at Pantai Kemayang was also sandy. MU 1 and MU 2 have about four chainages along the coastline with an interval of 1 km from one chainage to another chainage. MU 3 and MU 4 have about three (3) chainages along the coastline with intervals of one (1) km from one chainage to another. MU 5 have about five (5) chainages along the coastline with interval of one (1) km from chainage to another chainage.

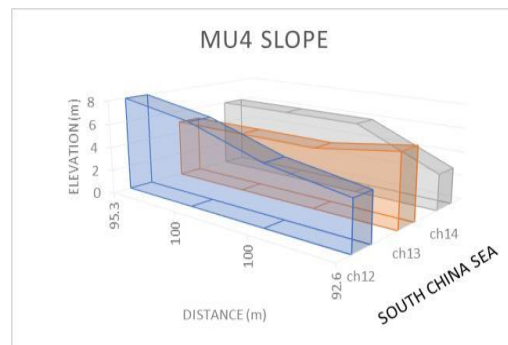
Table 2: Beach Profile at Kelantan Coast

Stations	Beach profiles
Pantai Mek Mas	
Pantai Cahaya Bulan	

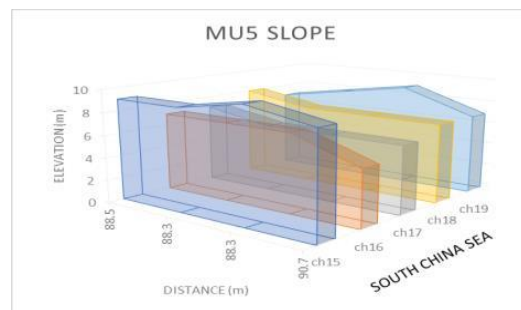
Pantai Sabak



Pantai Senok



Pantai Kemayang



Based on Table 3 and Table 4, five (5) MUs average slope percentages have been obtained. From the five management units of the study area, Pantai Sabak (MU 3) and Pantai Kemayang (MU 5) have the lowest average slope percentage with the value of 0.8% and 0.6%. Meanwhile, the coastal of Pantai Mek Mas (MU 1), Pantai Cahaya Bulan (MU 2), and Pantai Senok (MU 4) are shows that these locations have higher coastal slope compare to MU 3 and MU 5 with 1.5%, 1.7% and 1.2% respectively. MU 3 and MU 5 areas are risky toward coastal erosion based on their coastal slope percentage.

Table 3: Management Unit Average Slope

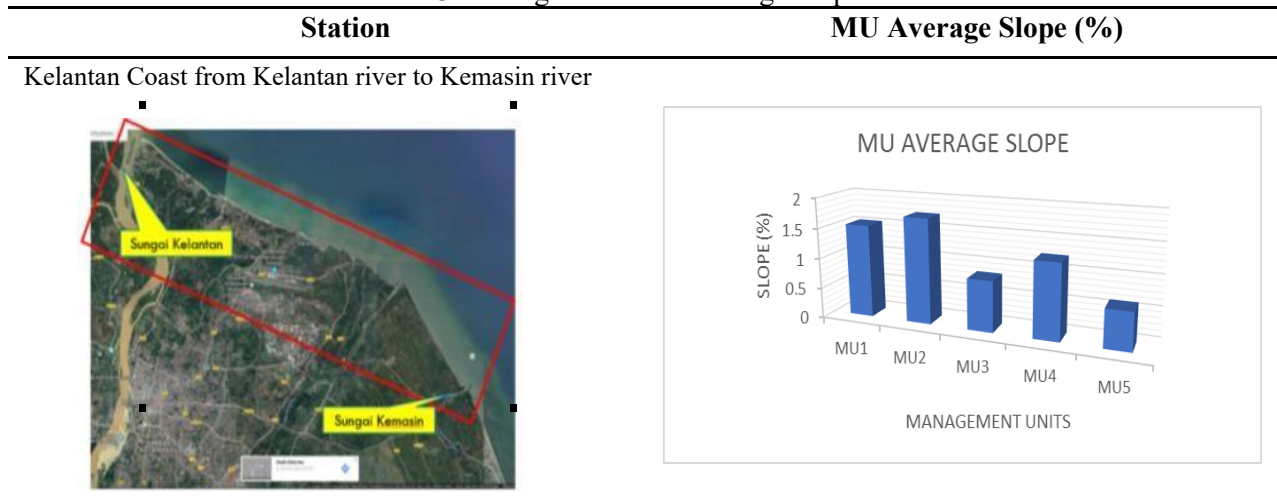


Table 4: Average Slope Percentage

Management Units	Slope (%)
MU 1	1.5
MU 2	1.7
MU 3	0.8
MU 4	1.2
MU 5	0.6

4.2 Variation of Slope Values Along Kelantan Coast by IDW

Figure 3 shows the whole profile of the beach produced in 3D, which is about 20 kilometers along the Kelantan shoreline from Kelantan river to Kemasin river. There are five (5) Management Units (MU) divided to cover the whole area along the shoreline. There are about 76 chainage plots in Google Earth, including longitudinal section and cross-section. The interval distance of every chainage for the longitudinal section in the Management Unit is about one (1) kilometer. For cross-section, the interval distance for every chainage is equally. Thus, this makes five (5) management units along the 20 km coastline based on river meets to another river.

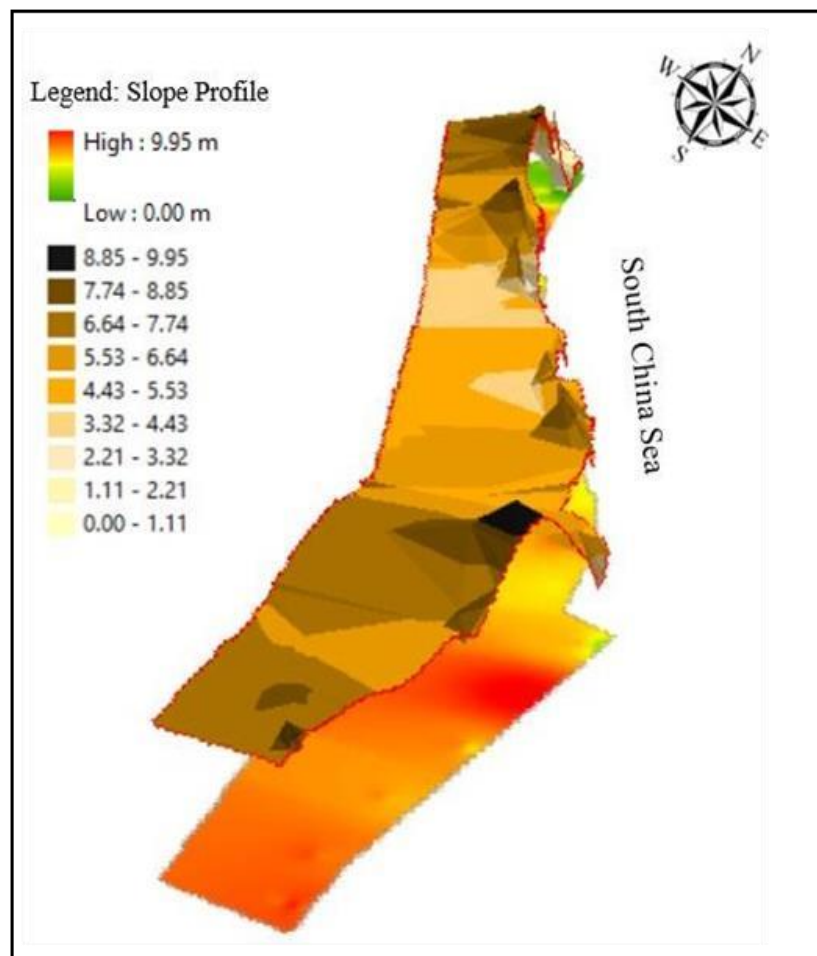
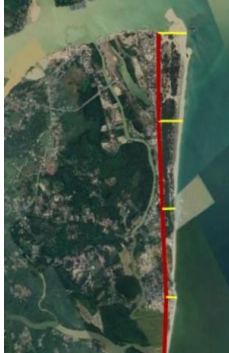
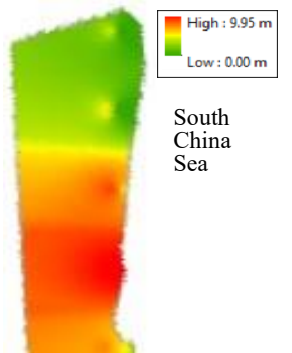

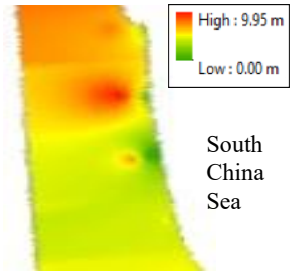

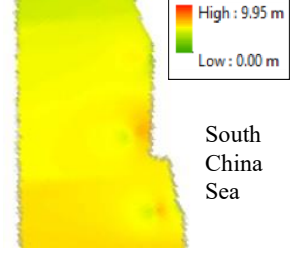

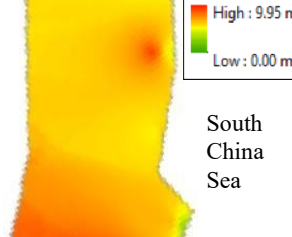

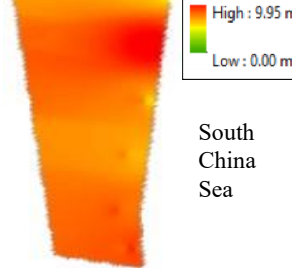


Figure 3: Beach Slopes Along Kelantan Coast

Table 5 depicts the topographical profile section of the coast of Kelantan from Kelantan river to Kemasin river. The lowest to highest elevation profiles have been analyzed by using the IDW method which the concentration of colour has been divided by the total elevation of the beach profile. Thus, the colour concentration for high to low elevation is from 9.95 m to 0.00 m. From five of the Management Unit study area, Pantai Kemayang (MU 5) has the lowest elevation profile, and Pantai Sabak (MU 3) is the second-lowest elevation profile overall. Based on the colour concentration in every Management Unit, two (2) concentrations of colour in MU 3 is Green and Yellow, and MU 5 is Red and Yellow, which means these two Management units (MU) has a low average slope. According to Tilmans, (1991) this area had the fiver outlets mostly blocked by sand bar formation due to littoral drift. This hampered free river discharge, especially during the wet season, and often flooded the lower coastal areas before sand bar breaching due to excess river run-off. Meanwhile, the coastal area at Pantai Mek Mas (MU 1), Pantai Cahaya Bulan (MU 2) and Pantai Senok (MU 4) are shows that the area around here is quite high compared to the two (2) areas earlier which are in MU 5 and MU 3. In addition, these three Management Units have three (3) type colour concentrations which means the average slope is higher compare to MU 3 and MU 5. MU 3 and MU 5 areas are risky toward coastal erosion based on their coastal slope percentage. This may be due to certain factors that cause differences between the beach profiles.

Table 5: Beach Slopes by IDW

Station	Beach Profile
<p>Pantai Mek Mas</p> 	<p>MU 1</p> 
<p>Pantai Cahaya Bulan</p> 	<p>MU 2</p> 
<p>Pantai Sak</p> 	<p>MU 3</p> 
<p>Pantai Senok</p> 	<p>MU 4</p> 
<p>Pantai Kemayang</p> 	<p>MU 5</p> 

### 4.3 Land Use Land Cover (LULC) Classification at Kelantan Coast

Land Use Land Cover classification is performed for planning, management and monitoring programs at local, regional and national levels. Figure 4 shows land use classification maps of 6 classes, which consist of water bodies, sandy area, forest, urban area, agriculture, and bare soil. Table 6 lists the areas based on the classified land use. The total area of LULC is 17240.28 ha. It is found that water bodies had the largest area, which is 11323.9 hectares, with the highest percentage, 65.7%, while the sandy area shows as the smallest area which is 228.07 hectares with the lowest percentage is 1.3%. The water bodies show as the largest area because the Kelantan coastal is located at the South China Sea.

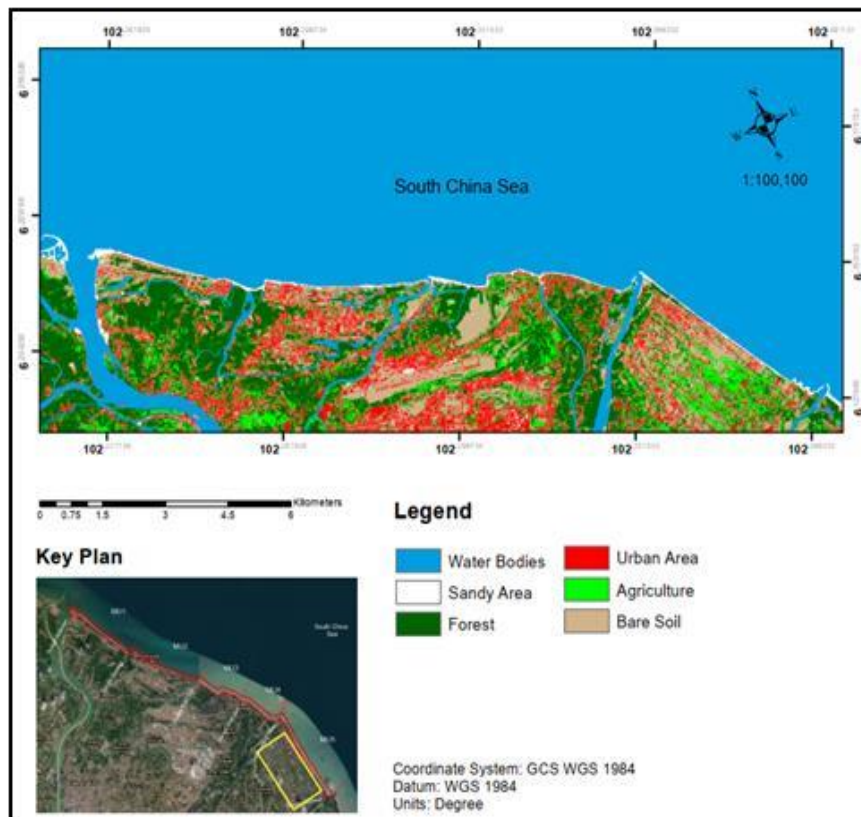


Figure 4: Map of Land Use Land Cover Classification by Supervised Classification

Table 6: Attribute Table of Land Use Land Cover

ID	Class Name	Color	Area (ha)	Percentage (%)
1	Water Bodies	Blue	11323.9	65.7
2	Sandy Area	White	228.07	1.3
3	Forest	Green	2152.09	12.5
4	Urban Area	Red	1258.27	7.3
5	Agriculture	Yellow-Green	850.35	4.9
6	Bare Soil	Brown	1427.6	8.3

#### 4.4 Accuracy Assessment for Land Use Land Cover (LULC) Classification

The required accuracy to be achieved is above 85%. The results of applied MLC (and the producer and user accuracies are presented in Table 7 for each class. It is found that the highest producer accuracy was Water Bodies with a value of 100.00%, while the lowest was Urban Area with a value of 57.14%. Meanwhile, the highest user accuracies were Urban Area and Agriculture with a value of 100.00%, while the lowest was Forest with a value of 62.50%. For water bodies, the producer's accuracy was 100.00%, while the user's accuracy was 96.97%. Meaning that, only 96.97% of the areas identified as "Water Bodies" in the classification even though 100.00% of the reference Water Bodies areas have been correctly identified as "Water Bodies". Both user's and producer's accuracy for any given class typically are not the same. The overall accuracy was 89.29%. Since the overall classification accuracy exceeded 85%, the result was acceptable for this classification.

Table 7: Accuracy Totals

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Water Bodies	32	33	32	100.00%	96.97%
Sandy Area	0	0	0	-	-
Forest	6	8	5	83.33%	62.50%
Urban Area	7	4	4	57.14%	100.00%
Agriculture	4	3	3	75.00%	100.00%
Bare Soil	7	8	6	85.71%	75.00%
Totals	56	56	50		
Overall Classification Accuracy = 89.29%					

The Kappa Coefficient is generated from a statistical test to evaluate the accuracy of classification. This is a discrete multivariate technique that produces a K, which is an estimate of Kappa. Table 8 shows the overall Kappa Statistics, which is 0.8264. Strong agreement occurs if K is greater than 0.8 – 0.85. Thus, the overall Kappa Statistics is acceptable.

Table 8: Kappa Statistics for each category

Class Name	Kappa
Water Bodies	0.9293
Sandy Area	0.0000
Forest	0.5800
Urban Area	1.0000
Agriculture	1.0000
Bare Soil	0.7143
<b>Overall kappa Statistics = 0.8264</b>	

4.5 Potential Impacted Area of Erosion based on Coastal Profile and LULC

Map of potential impacted areas at the coastal profile and LULC along the Kelantan shoreline were shown in Figure 5. The maps of potential impacted areas in MU3 and MU5 were shown in Figure 6 and Figure 7 respectively. It can be concluded that there were many infrastructures and LULC along the Kelantan coast. If there is erosion occurs in any area at this shoreline, the coastal profile, infrastructure, and LULC near the shoreline might be affected. [15] had revealed that the natural delta erosion rate of about two m/year along the Sabak village shorefront has more or less doubled to about 3-4 m/year as a result of the defence works, and an erosion rate of up to 9 m/year would result if the sediment supply from the Pengkalan Datu river is cut off. According to [16], it is unavoidable that Kemayang Beach would experience soil erosion.

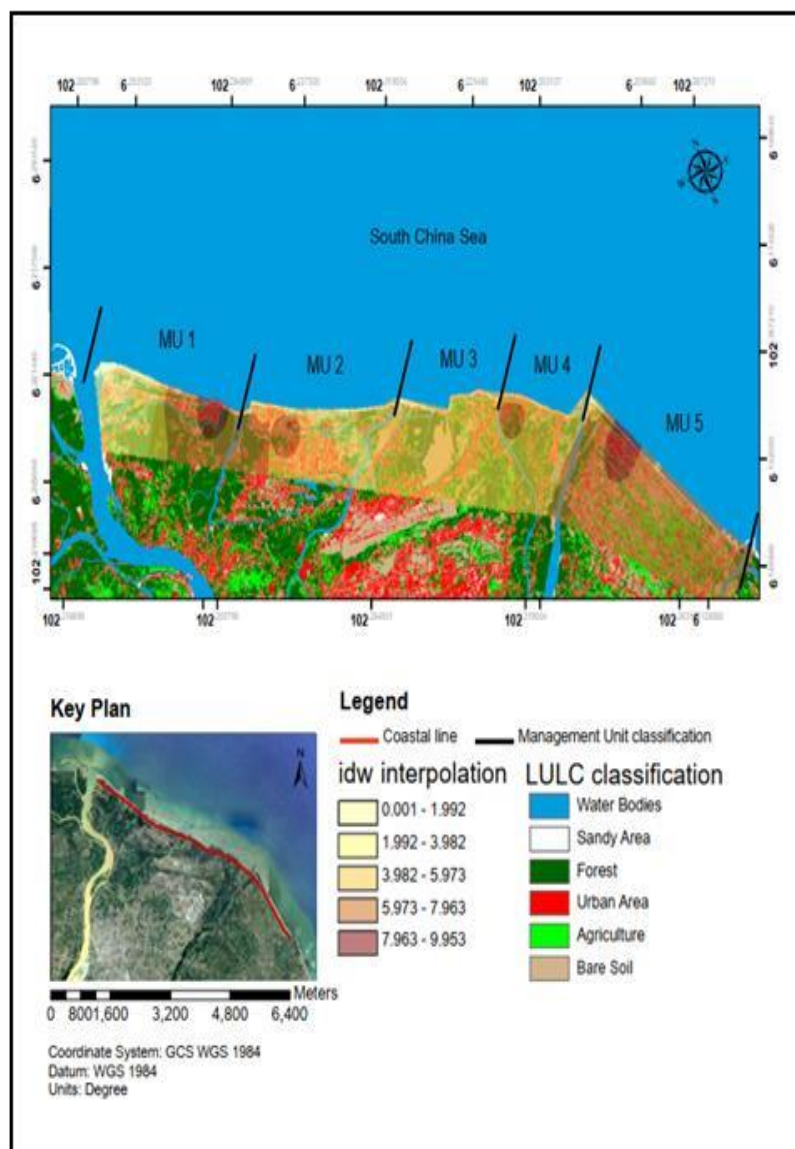


Figure 5: Map of Potential Impacted Area along Kelantan Coast

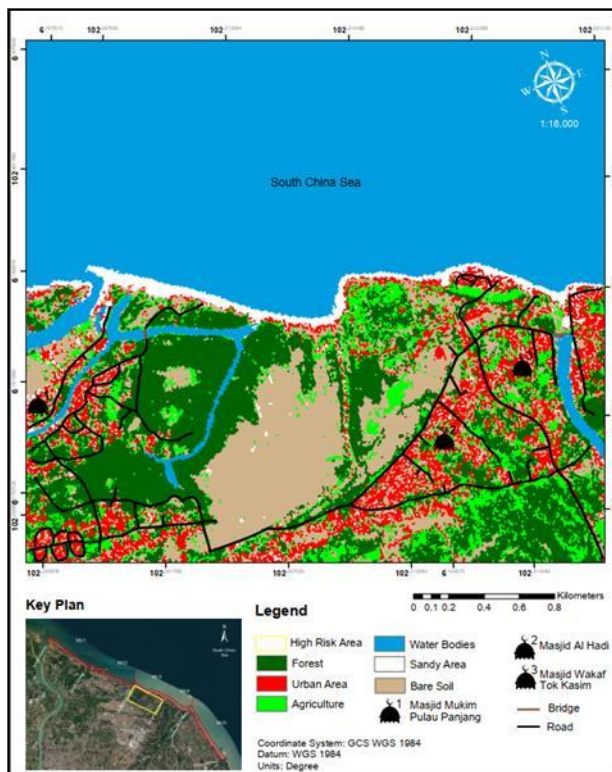


Figure 6: Map of Potential Impacted Area at MU 3

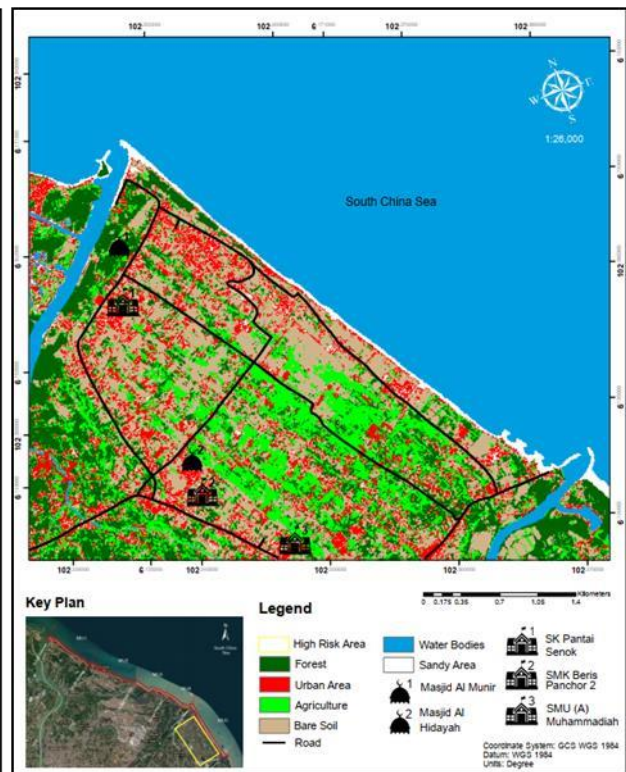


Figure 7: Map of Potential Impacted Area at MU 5

Based on Table 9, the infrastructure in that two areas have been shown along one (1) km buffer zone from the water level. Based on the result, the potentially impacted area is located at MU 3, and MU 5 can be identified as a high-risk area. The infrastructure that have been included in MU 3 were Masjid Mukim Pulau Panjang, Masjid Al Hadi, Masjid Wakaf Tok Kasim, Bridge and Road while at MU 5, there were Masjid Al Munir, Masjid Al Hidayah, SK Pantai Senok, SMK Beris Banchor 2, SMU (A) Muhammadiyah and Road. Many LULC might also be affected in that two areas in MU 3 and MU 5. The LULC at these two Management units is risky toward erosion. Thus, the coastal community in these two areas need to be aware. Table 9 reveals that MU 5 area at Pantai Kemayang had a very low sloping coastal area, causing a very high coastal vulnerability level in this area, while coastal vulnerability at the MU 3 Pantai Sabak was high. Besides, there was a mouth river in both areas, which means the area exposes the wind that might cause erosion level increase in the future. Furthermore, Kelantan is also one of the areas that occur in Northeast Monsoon. According to [17], tidal hydrodynamics transition during the increase in sea levels can affect shipping, ecological ecosystems, amenities and coastline geomorphology. Another source of erosion that occurred for these locations is affected by wind movement on fine to medium coastline during the monsoon of the South China Sea.

Table 9: Classification of Potential Impacted Area Along MU

Management Unit (MU)	LULC Features	Infrastructure	Prediction of the Impacted Area from Coastline to Infrastructural Features	Average Slope (%)	Vulnerability Level
MU 3 (Pantai Sabak)	-Water Bodies	-Masjid Mukim Pulau Panjang	1.40 km	0.8	High
	-Sandy Area	-Masjid Al Hadi	0.82 km		
	-Forest	-Masjid Wakaf Tok Kasim	0.36 km		
	-Urban Area	-Bridge	0.25 km		
	-Agriculture	-Road	0.04 km		
MU 5 (Pantai Kemayang)	-Water Bodies	-Masjid Al Munir	0.87 km	0.6	Very High
	-Sandy Area	-Masjid Al Hidayah	1.89 km		
	-Forest	-SK Pantai Senok	1.27 km		
	-Urban Area	-SMK Beris	1.95 km		
	-Agriculture	Banchor 2			
	-Bare Soil	-SMU (A) Muhammadiyah	1.96 km		
		-Road	0.05 km		

## 5.0 Conclusions

Nutshell, all objectives of this study were successfully achieved. All of the results obtained is answering the objectives of the study. The first objective is to determine the vulnerability level of coastal profile by using the Inverse Distance Weighting (IDW) method and Google Earth measurement along management units. Based on the first objective, the vulnerability level of the coastal profile has been determined. The result obtained are MU 3, and MU 5 have the lowest average slope, about 0.8% and 0.6%. In addition, the result obtained from variation of beach slope by IDW method along Kelantan coast in 2D also tallied with the result from Google Earth measurement. The result obtained from the IDW method showed that MU 3 and MU 5 had a lower average slope for the concentration of colour percentage.

The second objective was to classify the land use land cover (LULC) along 1 km buffer zone from water level had been achieved. The area shows that water bodies had the largest area with the highest percentage with a value of 65.7%, while the sandy area shows as the smallest area with the lowest percentage, which is 1.3%. The water bodies show the largest area because the Kelantan coastal is located at the South China Sea. Since the overall classification accuracy (89.29%) and Kappa statistics (0.8264) were within allowable tolerance, the supervised classification was acceptable.

The last objective was to assess the potentially impacted area of the coastal profile and land use land cover (LULC) at the Kelantan coast. Map of the potentially impacted area was shown by identifying the risky area towards LULC, infrastructures and coastal profile along of Kelantan coast. The results related to objective 1 and objective 2 would be overlaid and then formed into a map to identify which areas were high-likely exposed to the risk of erosion.

This study provide five (5) management units to identify which areas were high-likely exposed to the risk of erosion. The simplest expression of the coastal profile was the beach cross-section where it is an easy measurement tool that Google Earth and IDW method can perform. The classification of land use land cover (LULC) was performed by supervised classification using Sentinel 2 image in 2020. Besides, the previous study indicated that using a low-resolution satellite, the produced coastal profile was not clear enough, but it produced a better result by using a high-resolution satellite. This is a significant differentiation from other approaches. Based on the result, the potentially impacted area is located at MU 3, and MU 5 can be identified as a high-risk area. The infrastructure in that two areas has been shown along one (1) km buffer zone from the water level. Based on the overall NCES, Kelantan coastal shows that the erosion rate is at a high level. Therefore, Coastal Management should be given high care to face natural disasters such as causing coastal erosion and estuaries, ecosystem disruption, pollution and declining water quality, and rising sea levels in the long term. Using temporal data to integrate geospatial techniques such as satellite imagery and GIS technique provides representative findings and valuable information to identify highly vulnerable coastal areas, which might be useful in policy and decision making for protective and mitigation measures towards sustainable coastal management.

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