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Extraction of shoreline changes in Selangor coastal area using GIS and remote sensing techniques

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Abstract. Nowadays, coastal zones are facing shoreline changes that stemming from natural and anthropogenic effect. The process of erosion and accretion will affect the physical environment of the shoreline. Therefore, the study of shoreline changes is important to identify the patterns of changes over time. The rapid growth of technology nowadays has facilitated the study of shoreline changes. Geographical Information System (GIS) alongside Remote Sensing (RS) technology is a useful tool to study these changes due to its ability to generate information, monitoring, analysis and prediction of the shoreline changes. Hence, the future projection of the trend for a specific coastal area can be done effectively. This study investigates the impact of shoreline changes to the community in Selangor area which mainly focus on the physical aspects. This study presents preliminary result using satellite image from SPOT 5 to identify the shoreline changes from the year 1984 to 2013 at Selangor coastal area. Extraction of shoreline from satellite image is vital to analyze the erosion and accretion along the shoreline area. This study shows that a shoreline change for the whole area is a categorized as a medium case. The total eroded and accretion of Selangor area from 1984 to 2013 is 2558 hectares and 2583 hectares respectively. As a result, Kapar, Jugra, Telok Panglima Garang and Kelanang are categorized as high risk erosion area. Shoreline changes analysis provides essential information to determine on the shoreline changes trends. Therefore, the results of this study can be used as essential information for conservation and preservation of coastal zone management.

1. Introduction

Phenomena of sea level rise (SLR) constitute as an effect of climate change. Based on the Intergovernmental Panel on Climate Change [1] envisaged that global mean SLR may increase between 0.26 m and 0.82m by the 2100 year. Predicted of climate change will greatly give high risk to coastal population [2]. One of the main factors that contribute towards the shoreline changes is sea level rise phenomena. According to National Hydraulic Research Institute of Malaysia (NAHRIM), sea level of Peninsular Malaysia will increase with the range of 0.253m to 0.517m by the year 2100 (from the year 2010 as a baseline) or 2.7mm to 7.0mm/ year. An increase of sea level rise has been recognized as one of the major threats to societies around the world [3].

Coastal zone is one of the most complex ecosystems that has a large number of non-living and living resources [4,5]. Many series of physical processes such as tidal flooding, sea level rise, land subsidence, erosion, and sedimentation, thus that area was categorized as a high impact of environment natural processes. According to [6], over 70% of the worlds coastal are experiencing

coastal erosion and this presents a serious hazard to many coastal regions. The coastal zone of the world exposed to danger due to several factors, among which is the development of industry, trade, tourism, migration and human population growth in coastal areas. [7]. Shoreline zone is considered as one of the zones that face the most dynamic processes in the coastal zone by [8,9]. Monitoring of shoreline is a significant task in environmental protection and national development [5], in which, extraction of shoreline is the fundamental study of necessity by [10]. Shoreline expert faced one of the obstacles to managing coastal environment changes due to the uncertainty of climate prediction [11,12]. Shoreline changes that stemming from natural and anthropogenic effect pose a threat to countries with high population and socio economic activities in coastal are such as Malaysia.

Nowadays, application of Geographical Information System (GIS) and satellite remote sensing data are being used in storing, extraction, analyze and mapped the shoreline changes. Application of GIS integrates the location of spatial information with its attribute information. GIS and remote sensing technology are able to calculate the historical rate of changes. Historic maps, aerial photographs, beach profiles, topographic and bathymetric surveys can be used to qualitatively and quantitatively evaluate the spatial and temporal changes in coastal areas [13]. Using updated technology of GIS and remote sensing, several techniques have been introduced to extract shoreline and detect shoreline changes from satellite imagery [14,15,16].

This study will be carried out analysis of satellite imagery SPOT 5 and topographic map to investigate the shoreline changes at several Selangor coastal area that clarify as erosion and accretion that has occurred. The main agenda of the study was to determine the shoreline changes in Selangor coastal area and the analysis of this study for these areas can be used for further investigation.

2. Material and method

Malaysia is a coastal nation rich with natural resources and biodiversity such as marine life and wildlife. Malaysia covers an area of 329, 750 square kilometers (km^2) with a coastal zone transverse along 4809 kilometers and the country is divided into two (2) landmasses which are being separated by the South China Sea. Peninsular Malaysia is located in the west covers an area of 131, 590 km^2. Whereas, the island of Borneo Sabah and Sarawak each covering an area of 73.711 km^2 and 124.449 km^2 [17]. Figure 1 shows the shoreline of the Malaysia coastal area. Malaysia coastal zone consists of broad sandy beaches such as those on the East Coast of Peninsular and muddy coastal areas in the west.

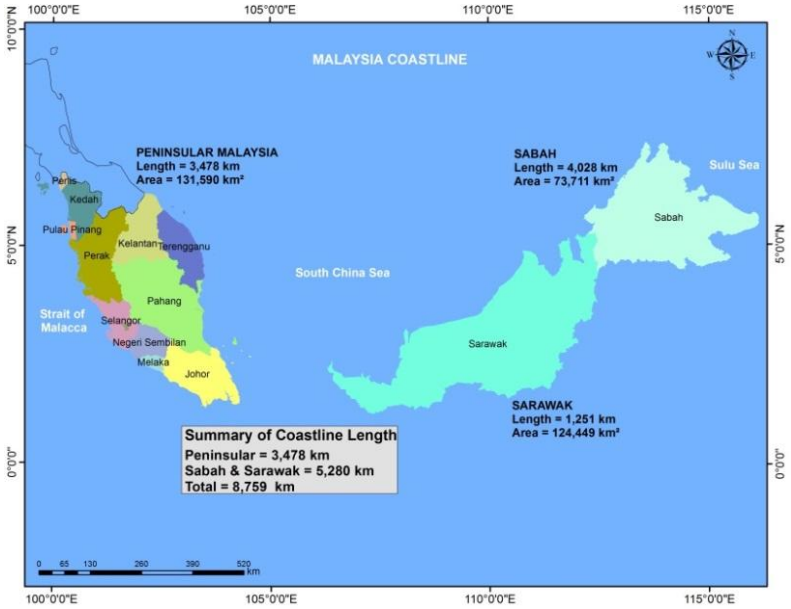

Figure 1. The shoreline of Malaysia area

As shown in the figure, most of Malaysia shoreline is occupied by important industries, agricultural, construction, fisheries, tourism and major city/ports are coast which contributes significantly to Malaysia's economic growth. The study area is located along the Selangor coastal area. This area is located on the west coastal of Peninsular Malaysia. Selangor's coastal is one area that located at the west coast of Peninsular Malaysia. Selangor coastal area covers the shoreline along Kuala Langat toward Sabak Bernam. The coastal areas along 276 km which are from Kuala Langat and Sabak Bernam exposed to potentially catastrophic hazards such as coastal erosion, flooding and technological hazards. According to *Rancangan Fizikal Zon Persisiran National* (RFZPPN), the boundary of shoreline in Malaysia is divided into management units, which peninsular coastal zone consist of 17 management units. Every management unit is being determined by the administration, use of land, and ecological characteristic. The study area and three management units are shown in Figure 2.

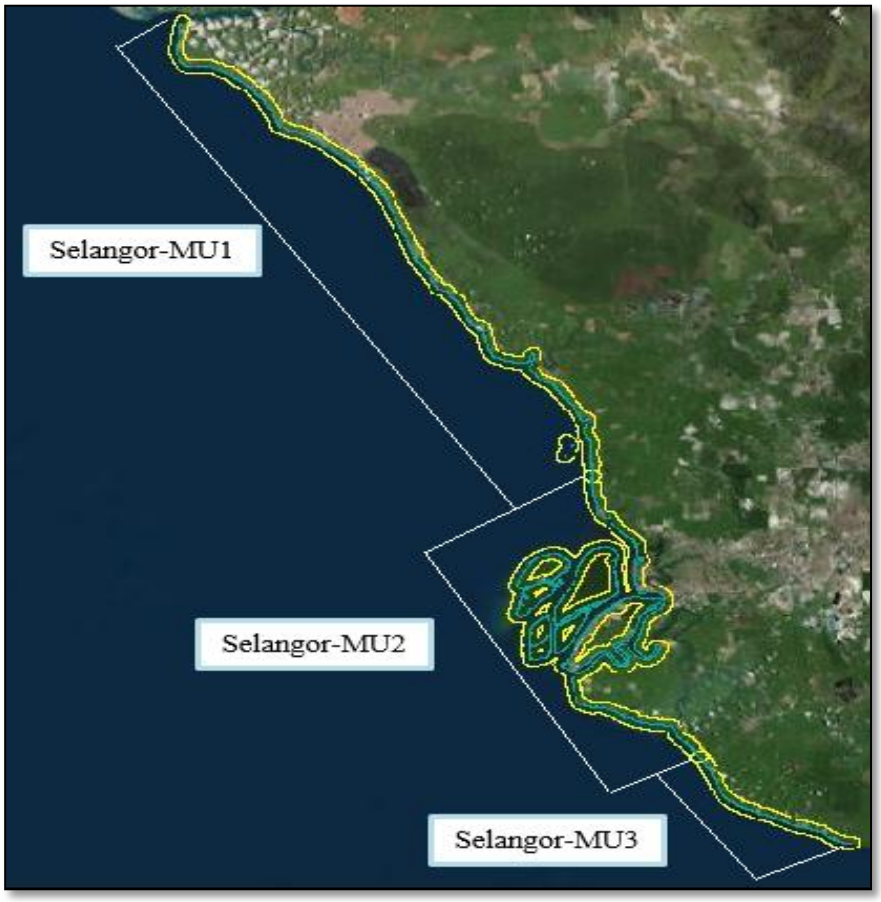

Figure 2. Study area and management units from Kuala Langat to Sabak Bernam [18]

Every management units consist of their own shoreline area where the shoreline is divided by district. According to RFZPPN, part of the management unit covers the southern of Perak and the northern of Negeri Sembilan. Management Unit 1 (MU1) is starting from Sungai Perak at Perak to northern border sub-district of Kapar, Management Unit 2 (MU2) starting from northern border sub-district of Kapar to southern border sub-district of Kelanang, and Management Unit 3 (MU3) along the coastal zone from southern border sub-district of Kelanang to southern border sub-district of Jimah at Negeri Sembilan. Table 1 shows the details of sub-district which include the management units.

Table 1. Management unit area according to RFZPPN 2012

Management Unit (MU)	Shoreline area	District	Sub-district
MU1	Sungai Bernam-Northern border sub-district of Kapar	Sabak Bernam Kuala Selangor	Bagan Nakhoda Omar, Panchang Bedena, Pasir Panjang, Tanjong Karang, Hujong Permatang, Kuala Selangor, Pasangan, Api-Api and Jeram.
MU2	Northern border sub-district of Kapar-Southern border sub-district of Kelanang	Kuala Selangor Kelang	Kapar, kelang, jugra, telok panglima garang and kelanang.
MU3	Southern border sub-district of Kelanang - Southern border district of Kuala Langat	Kuala Langat	Jugra, Telok Paglima Garang, Bandar, Morib, and Batu.

In this study, SPOT 5 satellite imagery and Topographic map acquired from 1984 to 2013 are used to extract the shoreline changes along the Selangor coastal area. Table 2 indicates the data sources used for the shoreline extraction. Projection system that used in this study is Rectified Skew Orthomorphic (RSO) projection system.

Table 2. Data acquisition

Type of data	Year	Scale/Resolution
Topographic map	1984	1: 50 000
SPOT 5	2013	2.5 meter
SPOT 5	2013	2.5 meter
SPOT 5	2013	2.5 meter

Figure 3 illustrate spatial model process generated by using ArcGIS software to extract the eroding and accreting shoreline changes. In this study, shoreline topographic map on year 1984 is used as a baseline whilst the extraction of shoreline on year 2013 from SPOT 5 satellite imagery as an investigation analysis. Thus, based on the overly of baseline and satellite imagery data it is able to identify the erosion and accretion changes.

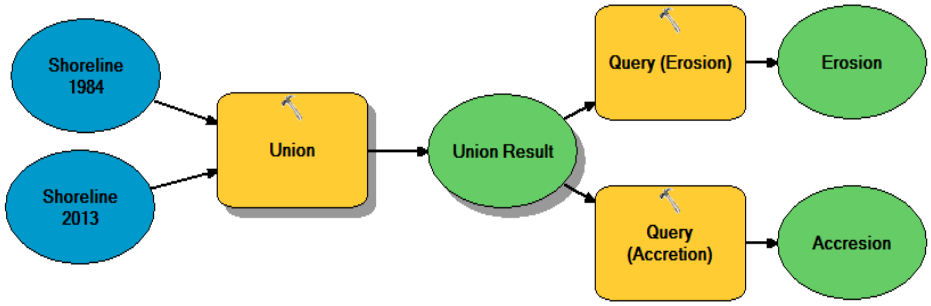

Figure 3. Spatial Model to classify the coastal change

3. Result and Discussion

The shoreline changes phenomena will occur as a two events either erosion or accretion. Erosion phenomena is a process that describe the condition of coastal area that destruction effect from

activities of sea water, while accretion is an additional material caused by the removal of material from river. The focus of this research is extraction of shoreline changes at Selangor coastal area with the total length is 276 km from Kuala Langat to Sabak Bernam. Figure 4 shows the map of erosion and accretion area at management unit 1 (MU1) which is from Sungai Bernam to northern border sub-district of Kapar.

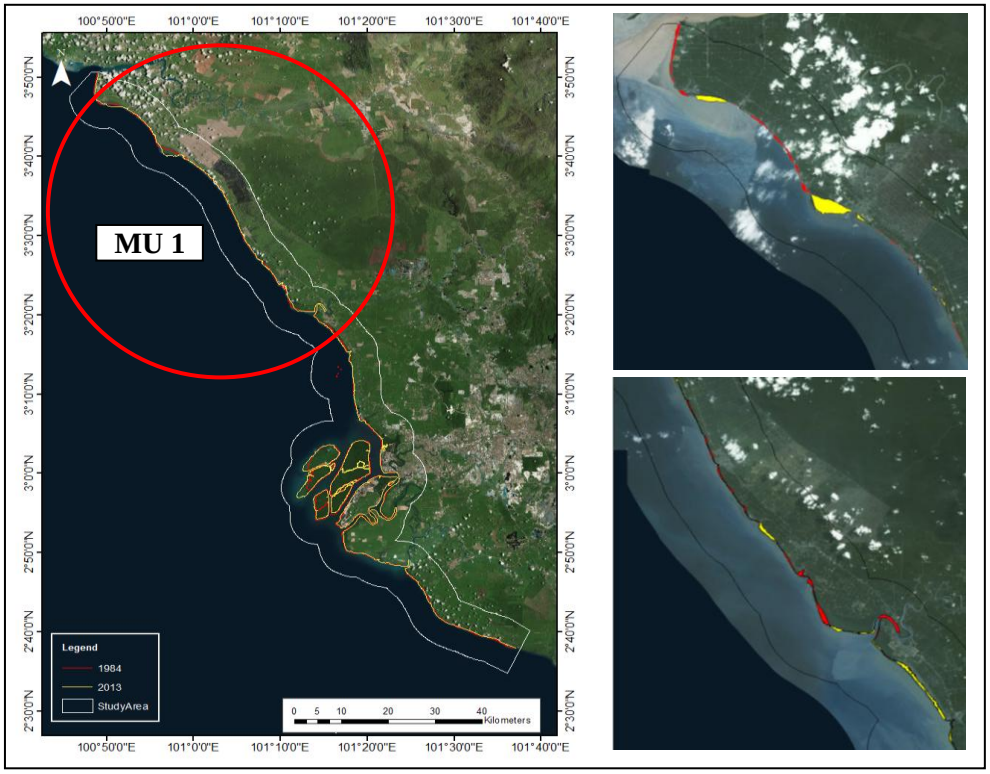

Figure 4. Map of erosion and accretion along Management Unit 1 (MU1)

The purposed of this study is to investigate the shoreline changes between different years. The shoreline change in different parts of the coastal area is determined by the process of swash and backwash of sediments due to seasonal current movements [19]. Therefore, the changes rate is differences based on their specific area and the shoreline change process is due to dynamic process (see Table 3).

Table 3. Eroding and accretion shoreline in Selangor coastal area on 1984 to 2013

Management Unit (MU)	Location	Shoreline Length (km)	Eroding (Ha)	Accreting (Ha)
MU1	Sungai Bernam - Northern border sub-district of Kapar.	114.727	813	960
MU2	Northern border sub-district of Kapar– Sothern border sub-district of Kelanang	293.675	1,549	1,523
MU3	Southern border sub-district of Kelanang - Southern border district of Kuala Langat	29.858	196	100
	Total	438,260	2,558	2,583

During year 1984 to 2013 about 2558 hectra was eroded from the area, and the value of accrating is 2583 hectra. Table 2 illustrate the rate of eroding at Selangor coastal area from year 1984 to 2013. Based on the table below, the highest erosion area occurred at MU2 compare to the MU1 and MU3, meanwhile erosion in MU1 is more than MU3. Figure 5 shows the map for management unit 2 (MU2) which from which is from northern border sub-district of Kapar to southern border border sub-district of Kelanang, while Figure 6 represent the changes for management unit 3 (MU3) which from Southern border sub-district of Kelanang to Southern border district of Kuala Langat respectively.

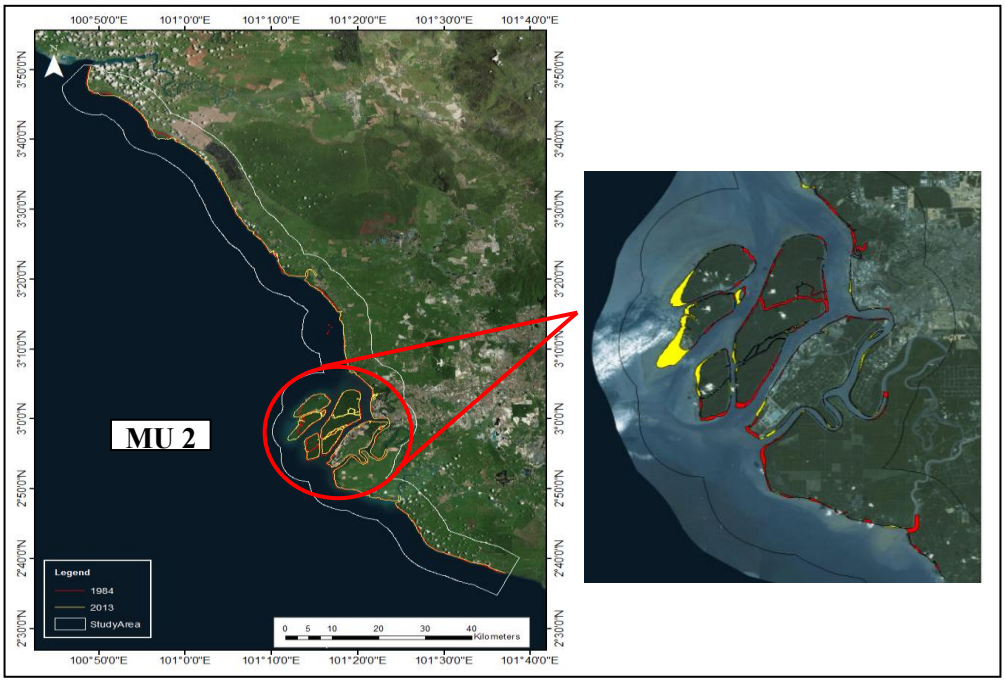

Figure 5. Map of erosion and accretion along Management Unit 2 (MU2)

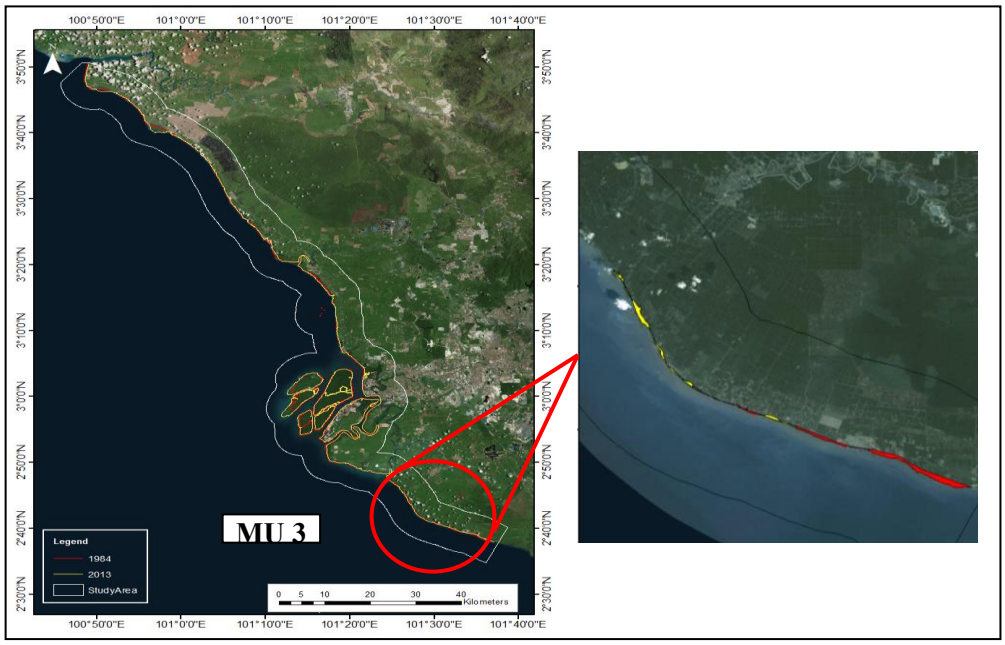

Figure 6. Map of erosion and accretion along Management Unit 3 (MU3)

Based on the Table 3, shoreline in MU2 is the highest erosion compare with MU1 and MU3, meanwhile erosion in MU1 is more than MU3. The persentage of eroding and accrating is shown in Figure 7. Based on the result, the higher eroding area occurred at MU2 and the lower eroding area occurred at MU3 which is 60% and the 8 % respectively. Where as, the higher accration area occurred at MU2 and the lower accration occurred at MU3 in 59% and 4% respectively. As a result, MU2 indicates facing the higher erosion rate and clasify as the high risk erosion area.

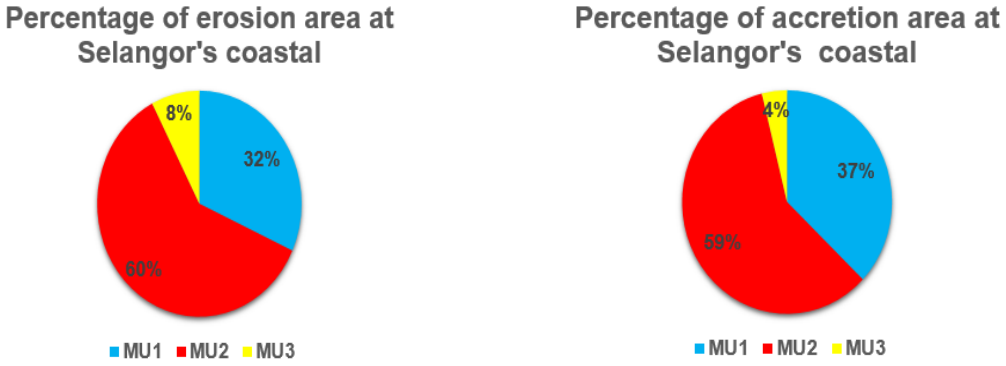

Figure 7. Percentage of erosion and accretion area at Selangor coastal

Table 4 shows the rate of erosion and accretion for MU1, MU2 and MU3. The erosion and accretion rate have calculated in meter unit and per year. The erosion rate for this study varies between 2.0 to 18.00 per year, while the accretion rate fluctuated between 3.0 to 100 meters per year. Shoreline in MU2 is the highest erosion rates compare with MU1 and MU3, meanwhile rate of erosion in MU1 is more than MU3. MU2 get the highest erosion rate where applicable 17.79 meters per year compare with the highest erosion at MU2 is 14.41 meter and MU3 only 10.28 meter per year.

Table 4. The rate of erosion and accretion per year

Management Unit (MU)	Location	Erosion (m)	Accretion (m)	Rate per year	
				Erosion	Accretion
MU1	Sg.Selangor	289		9.97	
	Sg.Beting Kepah	159		5.48	
	Bagan Sg Burong	418		14.41	
	Sg. Panchang Bedena		1548		53.38
	Bagan Sg Tengkorak		313		10.79
MU2	Sg.Ular	516		17.79	
	Sg. Langat	493		17.00	
	Sg.Tiram Besar	287		9.90	
	Sg.Labu Lemak		240		8.28
	Pulau Tengah		2896		99.86
MU3	Sg.Gaping	149		5.14	
	Sg. Kudang	109		3.76	
	Sg.Pulai	298		10.28	
	Sg. Kanchong		206		7.10
	Sg.Tengkah		108		3.72

The highest rate of accretion also in MU2 compared with MU1 and MU3. MU2 get the highest accretion rate where applicable 99.8 meters per year compare with the highest accretion at MU2 is 53.38 meter and MU3 only 7.10 meter per year. Pulau Tengah located at MU2 is constituted the highest rate of accretion area where the island is a mangrove swamp that helps increase the rate of accretion per year.

4. Conclusion

This study focused on the extraction of shoreline changes using GIS and remote sensing technique to determine the impact of shoreline changes due to the physical environment. The analysis of shoreline change assessment using SPOT 5 satellite imagery exposes that the study area has experienced the high rate of erosion and accretion along the different coastal zone during 1984 to 2013. Monitoring and management of the coastal zone are very complex because it needs to focus on all aspects that influence to the disaster of the coastal zone. Therefore, Coastal zone management has been divided into sub-sections that call as a management unit and it was divided into small units according to natural coastal processes and land use activity. Every development that planned at coastal areas must comply with the policies and negotiations as *Konvensyen Antarabangsa berkaitan Tanah Lembap Berkepentingan Antarabangsa atau Konvensyen Ramsar, Rancangan Fizikal Negara 2, Rancangan Fizikal Zon Persisiran pantai Negara (RFZPPN),* and International Union for Conservation of Nature (IUCN). Each policies and negotiation have their own aspects because different soil type and different physical activities contributed the different impact of the coastal zone**.** The coastal development plan must comply with the conditions that have been stated and each application should be accompanied by an Environment Impact Assessment (EIA) report that represents preliminary report on the activities to be carried out on water quality. Consequently, development planning at coastal zone is important to ensure that area is not threatened. This study denotes as a preliminary study to investigate the shoreline changes in Selangor coastal area. As a recommendation, further research should be conducted by using the statistical technique for other critical location throughout Malaysia due to its effectiveness for prediction of shoreline changes.

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