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ANALYSIS OF RATE OF SHORELINE CHANGES ALONG THE COASTLINE OF KUALA TERENGGANU

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ABSTRACT

The coastal zone is home to a substantial portion of the population (approximately 70%) and the hub of economic activity, including urbanisation, agriculture, and fisheries. Coastal erosion has led to the destruction of property and loss of land due to the corrosion of the shoreline. This research aims to identify the coastal erosion using the shoreline changes rate in Kuala Terengganu, Malaysia. The objectives of this study are i) to identify the location with the highest and lowest rate of shoreline changes in Kuala Terengganu and ii) to analyse the rate of changes along Kuala Terengganu shorelines. This study calculated net changes of shoreline position using the Linear Regression Rate (LRR) statistical method. Six (6) images are chosen between 2000 and 2019. The main findings show that the severe coastal erosion areas are Pantai Tok Jembal and Pantai Cendering, with 5.88 metres/year and 6.11 metres/year of the rate of change, respectively. The coastal erosion in Kuala Terengganu is due to the close development that intrudes the natural habitat. The extinction of vegetation are due to human activity and harsh weather conditions at the coastline area during monsoon season in the winter months. It is essential to prevent coastal areas because coastal erosions will destroy the property nearby and displace land as the coastline recedes. The best mitigation action for coastal erosion is monitoring the coastline.

Keywords: *Digital Shoreline Analysis System, linear regression, coastal erosion, changes rate*

INTRODUCTION

Coastal erosion is the process of material being removed from the coast by wave action, tidal currents, and human activities, resulting in a landward retreat of the coastline (British Geological Survey, 2012). Several causes leading to coastal erosion are due to human activities. Historically, some parts of the development do not adhere to any guidelines and have caused an intrusion of natural habitat.

Natural factors (adverse effects of climate change and sea-level rise) have been widely reported as the leading causes of coastal erosion. In addition, human activities are also recognised as significant contributors to coastal erosion and mangrove degradation, for example, poor

aquaculture, pond construction, mangrove cutting for commercial and domestic uses, construction of local boating channels, and the interaction of anthropogenic activities.

In the case study of Malaysia, the Department of Irrigation and Drainage (DID) has revealed that 29 percent of 4,809 km of shoreline in Malaysia were subjected to erosion of varying degrees of severity (Keizrul Abdullah, 2000). Studies using DSAS, such as Rasha (2021) and Kankara (2015), assessed the coastline changes in the respective study areas. These studies suggested monitoring the shoreline changes to develop a sustainable shoreline management plan. It assessed coastline changes along the coast of the Nile Delta, Egypt, and found that 44.2 percent was under erosion and 45 percent under accretion. In a local study, Ibrahim (2017) analysed Klang coastal areas and showed that the average rate of shoreline change was 5 m/year. This study can be used to translate a policy for future environmental mitigation.

According to Bagheri (2019), Kuala Terengganu will face a rise in sea level and coastal erosion so action is taken in the current state of the coastline. The incline rate that has been shown in his research is about 25.3 mm/year from 2013 until 2020. According to Aidy M Muslim (2011), Pantai Tok Jembal is facing coastal erosion with about 46 metres moving towards the land due to the development of Sultan Mahmud Shah Airport. Shwarzer (2010) explained that man-made structures are one of the major causes of coastal erosion despite natural tidal inundation and mineral resource mining. It is also aligned with the statement by Bagheri (2019) that Pantai Tok Jembal showed the highest deterioration for the construction. The mitigation has been implemented in a particular area by using beach nourishment.

This research paper aims to identify and locate the coastal erosion in Kuala Terengganu by calculating the rate of shoreline changes from 1995 until 2019. The research proposes the objectives; i) to identify the location with the highest and lowest rate of shoreline changes in Kuala Terengganu, ii) to analyse the rate of changes in Kuala Terengganu shorelines, and iii) to propose mitigation off coastal erosion in Kuala Terengganu. The importance of analysis on the shoreline changes rate and predict the upcoming events that will strike the shorelines caused by several reasons. One cause of shoreline changes is the heavy weather hitting the shoreline creating waves from the sea that beat the shoreline sedimentation, causing coastal erosion. Monitoring and predicting the shoreline changes rate will help the agency and the local authorities produce program and mitigation relevant to the future projection relevant to the future projections. Coastal erosion is one of the disasters that can cause significant economic damage, as it strikes a location, it can destroy infrastructure and property such as a house.

STUDY AREA

Kuala Terengganu covers an area of 210.21 square kilometers and had a population of 343,284 at the 2010 Census. the According to Bagheri (2019), Kuala Terengganu is one of the East Coast Economic Region (ECER) districts, which upholds the importance of boosting the economy by emphasizing the tourism site. Thus, Kuala Terengganu need to upgrade its urban place to attract people near the coastal area. Figure 1 shows the study area for both districts in Terengganu.

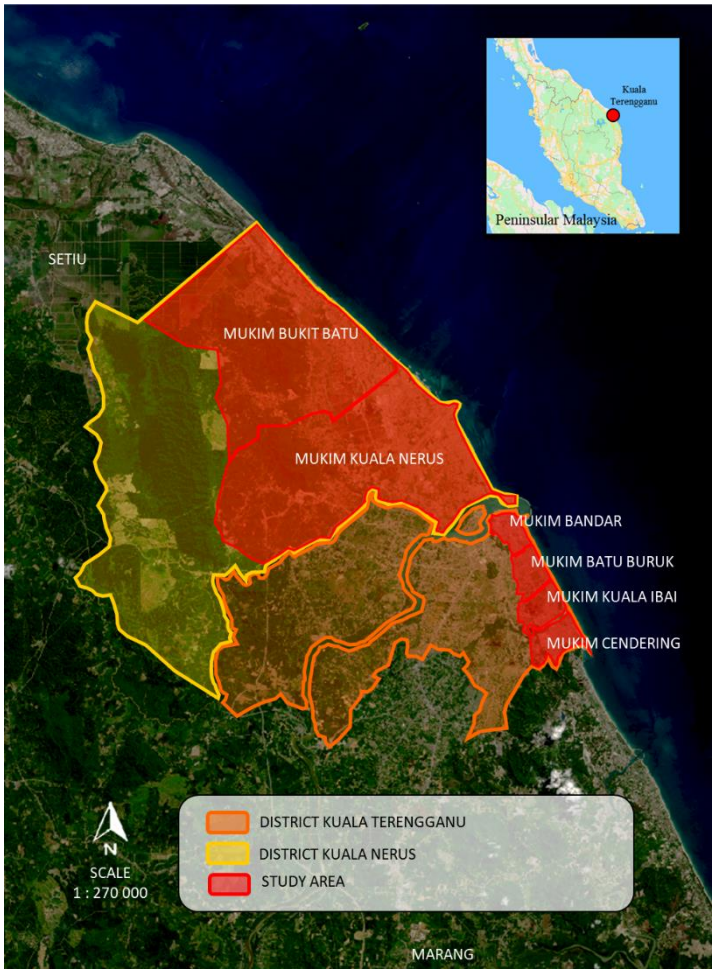

Figure 1: Map of Kuala Terengganu in Peninsular Malaysia.

Other than that, Kuala Terengganu beaches also acts as the local residents' income source. They may have lost their place as the coastal area has been eroding due to the monsoon season held in Kuala Terengganu. Every year, Kuala Terengganu faces two monsoonal seasons, between mid-October and January, and southwest monsoon, between June and September. According to Husain (1995), the monsoon is one of the reasons that erode the coastal area on the east coast of peninsular Malaysia. Consequently, shoreline rate changes must be monitored to protect the coastal area.

Kuala Terengganu and Kuala Nerus are under the same Kuala Terengganu City Council management. This location has been chosen as the area is the most focused development area. The District of Kuala Terengganu has 20 mukim, but only 4 Mukim has been selected to be the study area as they are located near the coasts. Meanwhile,2 out of 3 Mukim in the district of Kuala Nerus are selected. The Mukim includes Cendering, Kuala Ibai, Batu Buruk, Bandar, Kuala Nerus and Bukit Batu. This analysis divides several sectors according to the severity of the area, from Sector 1 until 10 respectively, from the south to north.

METHODOLOGY

The following steps are the methodology for generating the data that is needed in the analysis of the shoreline changes rate in the site area (Misra, 2015):

1. Shoreline Change Analysis

Several cloudless Landsat image data is downloaded for different years (http://earthexplorer.usgs.gov/). The essential variables for finalising the satellite images were cloud cover, similar tide conditions, season data, and uniform projection factors, to name a few. The satellite data further undergone radiometric correction and data scaling to enable maximum visual interpretation. The selected satellite images are non-cloudy days for the research from 1995 until 2019.

2. Digitisation of Shoreline

The shoreline features were identified using the tonal differences between the land and the sea. This study applied a band ratio technique to differentiate the land and water pixels. A further step is to get the shoreline features in the ArcGIS environment using the vectorisation technique.

3. Study of Shoreline Change

The Digital Shoreline Analysis System (DSAS) is a freely available software application that works within the Environmental Systems Research Institute (ESRI) Geographic Information System (ArcGIS) software. The digitised shoreline for the years 1990, 2001, and 2014 in the vector format (.shp) are input into Digital Shoreline Analysis System (DSAS) to calculate the shoreline changes rate. The analysis also requires transect information; hence, transects are laid at every 500m interval along the shoreline. The DSAS tool estimated the Net Shoreline Movement (NSM) and End Point Rate (EPR), which are used to derive the output maps of this study. The NSM calculated the distance between the oldest and the youngest shoreline for each transect. The EPR is obtained by dividing the NSM by the years elapsed between the two shoreline positions. The linear extents with a negative NSM or EPR values indicates erosion, whereas those with a positive value indicates accretion. In this research, the data to determine the coastal erosion is the Linear Regression (LRR) data from the generated DSAS software. It is crucial to observe the highest rate of shoreline changes to illustrate coastal erosion in the study area.

ANALYSIS

The figure below shows a map of shoreline changes using DSAS analysis. Figures 2 and 3 show the map of Sector 1 until 10. The rate of coastal erosion can be differentiated by understanding the indicators of the rate of shoreline changes. The red line shows a high rate of coastal erosion (6m/yr), and the orange colour shows a moderate coastal erosion rate. The yellow line shows a low rate of coastal erosion, and the green line shows no erosion of shoreline.

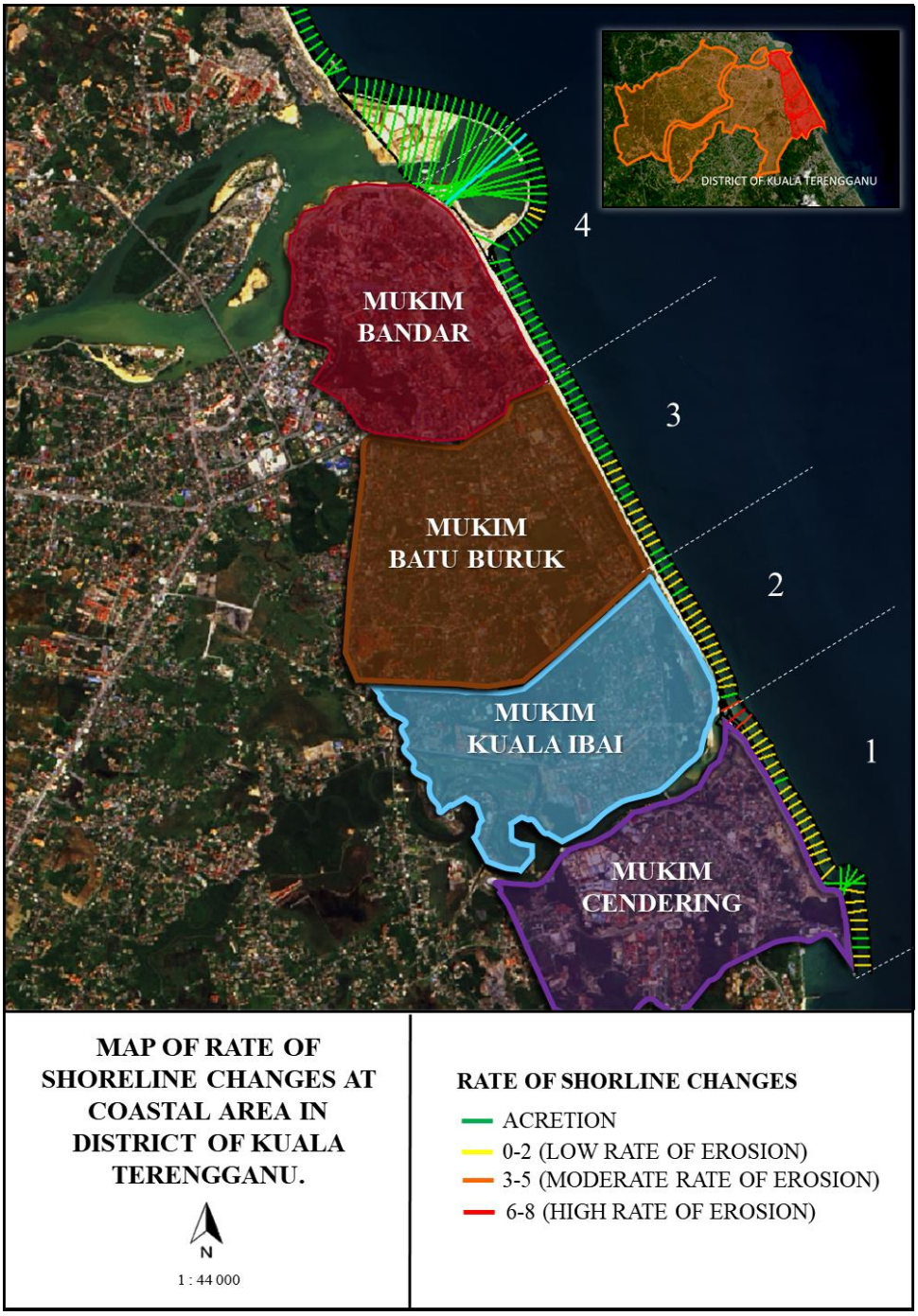

Figure 2: Map of sectors 1 to 4 from the ArcGIS and DSAS analysis.

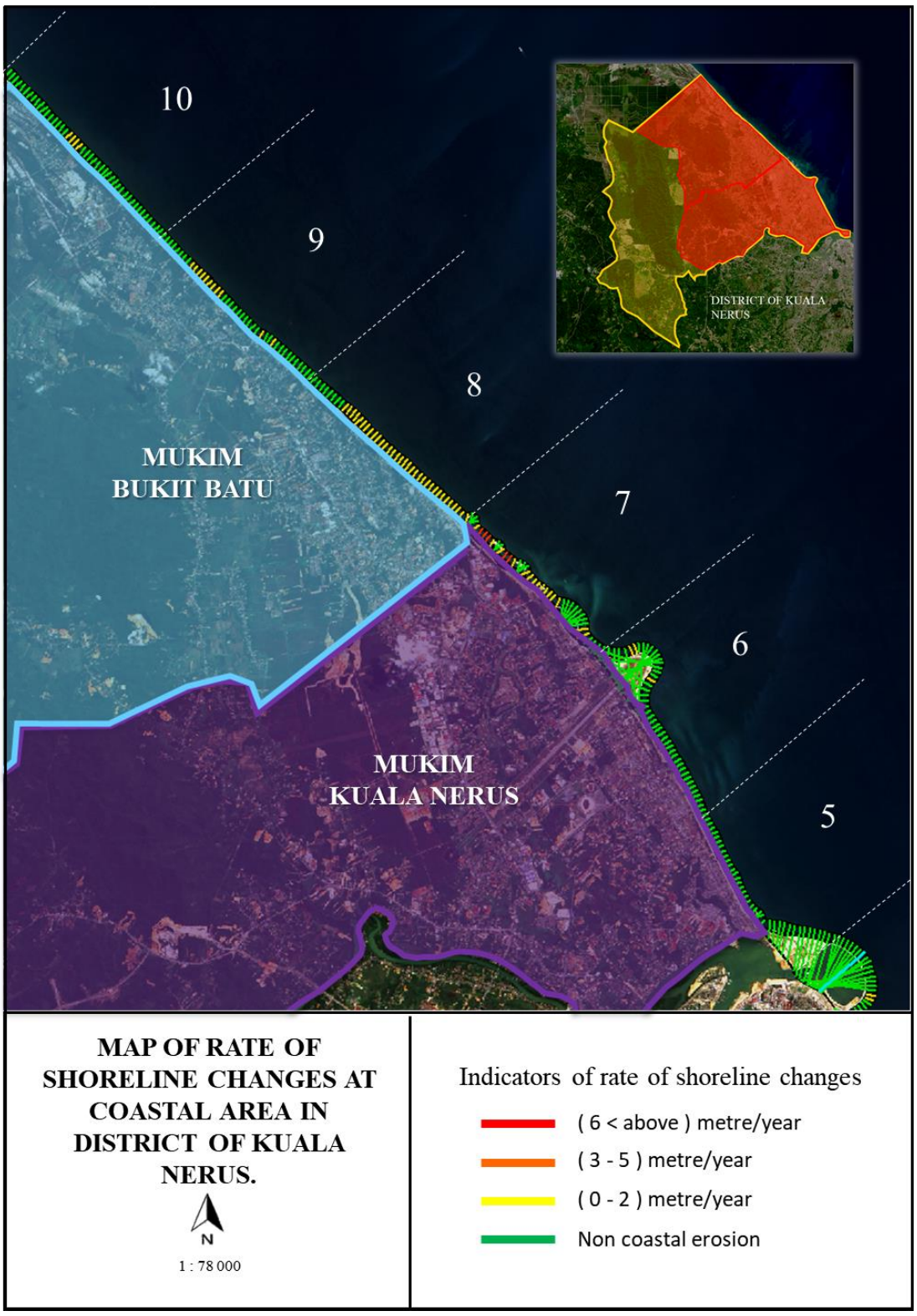

Figure 3: Map of sectors 5 to 10 from the ArcGIS and DSAS analysis.

The highest coastal erosion rate occurs in Sector 1, Pantai Cendering, followed by Sector 7, Pantai Tok Jembal, and Sector 2, Pantai Kuala Ibai. These three sectors show a high-level rate of shoreline changes that need to be taken into consideration in mitigating coastal erosion. The rate of shoreline changes for Pantai Cendering, Pantai Tok Jembal, and Pantai Kuala Ibai are 6.11 m/yr, 5.88 m/yr, and 5.25 m/yr. Pantai Kuala Ibai and Pantai Cendering are eroding due

to the river's open sea, which means that the high current of the river that causes by the monsoon weather. In contrast, Pantai Tok Jembal is eroding due to the development of Sultan Mahmud Airport runaway, which disturbed the current flow of the sea from south to north of the South China Sea. The three locations have been photographed: Pantai Cendering, Pantai Tok Jembal, and Pantai Kuala Ibai, for better illustration of the current site situation as Figure 4, Figure 5, and Figure 6, respectively.

In this case, further action, must be taken and more mitigation strategies need to be developed to these three areas before it worsens. For example, enforcing the shorelines with hard rock or concrete walls to fight this high-water current from eroding the sand and rock along the shoreline. Sand nourishment at locations with low rates of shoreline changes. Actions taken to mitigate are executed concurrently to adapt to the wet seasons due to annual monsoonal strike in Kuala Terengganu.

Figure 4: Illustration of coastal erosion in Kuala Cendering

Figure 5: Coastal erosion at Pantai Tok Jembal

Figure 6: Coastal erosion at Pantai Kuala Ibai.

CONCLUSION

Analysis of the rate of shoreline changes by using GIS software is one of the steps to protect the environment from the devastating human activities and weather. With this analysis, the responsible agency could monitor and manage the shoreline area from coastal erosion, which will damage the infrastructure and properties. The strategy to managing coastal erosion is to offer immediate structural protection in the identified critical area and limit development in the coastal zone to prevent the need for future protection projects. The authority is also able to predict the erosion of the shoreline in future years. Apart from that, they can practice precautionary measures before the situation worsens. Monitoring can be helpful in developing areas where no erosion is observed.

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