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Mapping Coastline Changes In The Mentawai Islands Using Remote Sensing

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ABSTRACT

The mentawai Island are an active deformation zone caused by the movement of the Indo-Australian plate under the Eurasian plate at a speed of 5-6 cm/year/ The movement of these plates that occur continuously can be a source of earthquake disasters in the future. However, the information on how much the value of the distance to the coastline changes and the direction of the change has not been well mapped. In this study, a mapping of shoreline changes caused by plate movement along the coast in the Mentawai Islands was carried out using Landsat Imagery. The method used in this research is the Overlay method between Landsat Imagery 2005, 2010, and 2020 using ArcGIS software and the Digital Shoreline Analysis System (DSAS) which is used to determine the distance between shoreline changes and the direction of the change. Based on the results of the study, it was found that the coast of the Mentawai Islands showed a change in the coastline with the average distance of change, namely Siberut Island of -2,109 m, Sipora Island at -2,979 m, North Pagai Island at -3,282 m, and South Pagai Island -1,557 m. From the results obtained, the distance of significant shoreline changes that occur in South Pagai Island with the direction of change towards the Northeast.

INDEX TERMS ***Coastline Shift, Digital Shoreline Analysis System (DSAS), Mentawai Islands, Plate Movement.***

I. INTRODUCTION

The Mentawai Islands are one of the regencies in West Sumatra Province with an area of 6,011.35 km² and a coastline of 1,402.66 km [1]. The Mentawai Islands Regency consists of 4 large islands, namely Siberut Island, Sipora Island, North Pagai Island, and South Pagai Island [2] [3]. The Mentawai Islands, which are surrounded by the Indian Ocean, are located along the westernmost part of the island of Sumatra [4] [5] [6]. The Mentawai Islands are an active deformation zone caused by the movement of the Indo-Australian plate under the Eurasian plate [7]. Plate movements that occur continuously are one of the physical elements that influence the occurrence of shoreline changes. The coastline is a dynamic meeting between land and sea with an unstable position and can move due to tectonic movements, geomorphological earthquakes and earthquakes [8] [9] [10]. With the geological conditions of the Mentawai Islands, this area has a high potential for earthquakes to occur. The author used remote sensing and landsat image data to conduct this research. The use of this technology is an effective and easy way to collect data without having to go to the field or without direct contact with the object under study, to save time and costs in its implementation [11]. In this study, the author uses remote sensing, with Landsat image data. The use of this technology is an effective and easy way to collect data without having to go to the field or without direct contact with the object under study, to save time and costs in its implementation. Coastline data obtained from remote sensing image processing and by using additional software Digital Shoreline Analysis System (DSAS) can provide information on how big the average shoreline change is. The working principle in analyzing shoreline changes using DSAS is to use the points generated from the intersection of the transect line made with the coastline based on time as a measurement reference [12]. The calculation of the distance change of each point was analyzed using the Net Shoreline Movement (NSM) method [13] [14] [15]. Net Shoreline Movement (NSM) is used to calculate the distance of shoreline changes, where the distance referred to is the distance between the initial and final year of coastal digitization on each transect in meters [16] [17]. The NSM method will show the results of data that are positive (+) which means the coastline is advancing, while data that is negative (-) means the coastline is backward.

II. BACKGROUND OF STUDY AREA

The Mentawai Islands are one of the regencies in West Sumatra Province which are located opposite the Indian Ocean with a recorded area of 6,011.35 km² and a coastline of 1,402.66 km. Geographically, the Mentawai Islands are located at the coordinates of 98°35'00"-100°32'00" East Longitude and 0°55'00"-3°21'00" South Latitude [18].

The Mentawai Islands Regency consists of 4 large islands plus small islands. The four major islands are

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Siberut Islands, Sipora Islands, North Pagai Islands, and South Pagai Island.

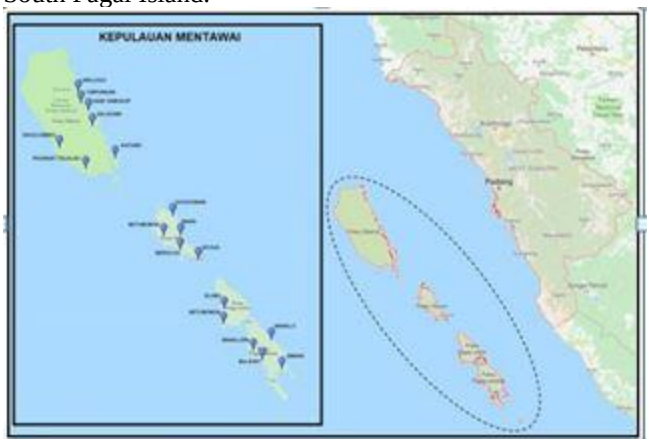

Figure 1. Map of the Mentawai Islands (Hidayat & Raharjo, 2020).

The Mentawai Islands are one of the areas where two large plates collide, namely the Indo-Australian Plate in the south and the Eurasian Plate in the north, which are characterized by the presence of centers of tectonic movement. The Mentawai Islands are located along the westernmost part of Sumatra Island and are surrounded by the Indian Ocean. The Mentawai Islands are an active deformation zone caused by the movement of the Indo-Australian plate under the Eurasian plate. The area to the west of Sumatra is experiencing convergent plate movements, where the Indo-Australian plate moves northward, downwards to the Mentawai islands and the island of Sumatra is a continental plate called the Eurasian plate. The movement at the boundary between these two plates is called a subduction zone.

III. METHODOLOGY

In this study, Landsat 5, 7, and 8 images were used as imaging. The purpose of this study is to produce a map of shoreline changes caused by plate movement. This research is expected to produce information in the form of areas that have the potential for earthquakes based on shoreline changes in the Mentawai islands caused by the movement of tectonic plates. The stages in this study are shown in figure 2.

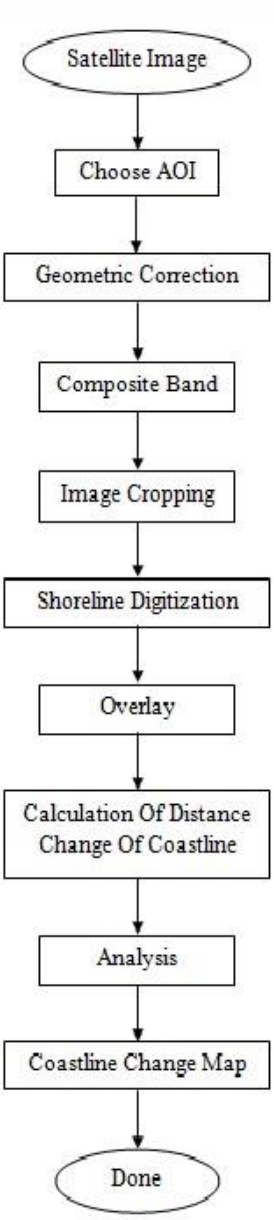

Figure 2. Research Stages

a. Image Acquisition Stage

The initial step in obtaining Landsat images is to download them from the official Landsat USGS website (U.S Geological Survey). Then choose an image based on the area of interest (AOI), then filter the image based on time and cloud.

b. Geometric Correction

Geometric correction is done because there is a geometric distortion between the sensing image and the object. Geometric distortion is the imperfection of the geometry of the image recorded at the time of imaging, this causes the size, position (latitude and longitude coordinate system), and image shape that do not match the actual conditions. This geometric distortion must be corrected first to produce good quality satellite imagery.

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c. Composite Band

In this process, sharpening is carried out to improve image quality with composite bands. A composite band is a combination of bands in a Landsat image.

d. Image Cropping

Image cropping is done to focus on the research area, as well as reduce the map file extract to speed up the image processing process.

e. Coastline Digitizing

This digitization is the stage of converting from raster to vector form. The digitization process in ArcGis 10.4.1 can be done using the Analysis Tools data setting command. The digitization process is used to distinguish each coastline in the image so that changes in the coastline of each image will be seen. In the ArcGis 10.4 program, this is done by using the Editing command on the image to be digitized.

f. Overlay

This process is used to determine the digitization results of shoreline changes. With the overlapping process between 2003 and 2020, the distance between the coastline changes will be visible.

g. Steps of Calculation of Distance to Coastline Changes

The calculation of the distance of the shoreline change is carried out using the Digital Shortline Analysis System (DSAS) tool which is integrated with the ArcGis 10.4 software. Predictions are made to determine the distance between shoreline changes.

h. Output (Map Layout)

The final process of image interpretation is to make the final result (output) in the form of a map of changes in shoreline changes, either in the form of softcopy or hardcopy (print out). The step in creating a layout is to select View>Layout view. Then set and adjust the shape of the map with the desired attributes under the correct map-making rules. After all is done, save the data that has been completed in the layout by selecting file> export map> jpeg> ok.

IV. RESULTS AND DISCUSSION

This research uses Landsat 5, 7, and 8 images as the imaging. The purpose of this study is to produce a map of shoreline changes caused by plate movement. This research is expected to produce information in the form of areas that have the potential for earthquakes based on changes in coastlines in the Mentawai islands. The images used in this study are 2005, 2010, and 2020. The following are the results of image interpretation with coastline overlays from 2005, 2010, and 2020 images.

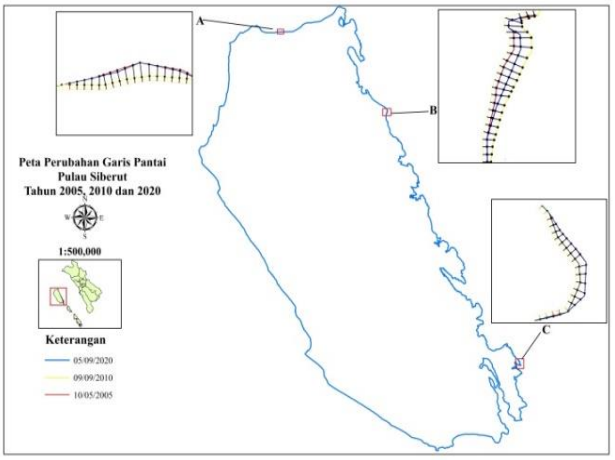

Figure 3. **Overlay Siberut Island.**

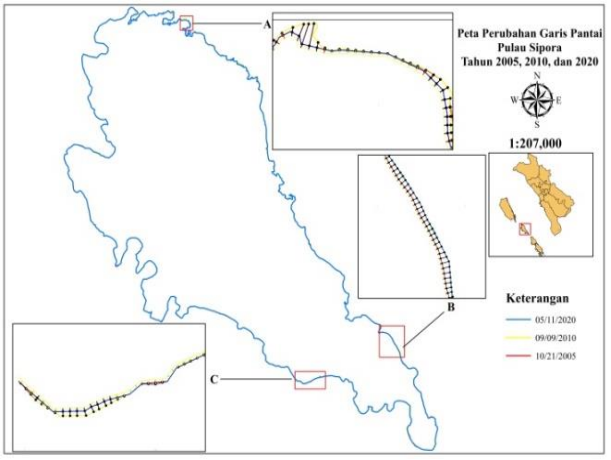

Figure 4. **Overlay Sipora Island.**

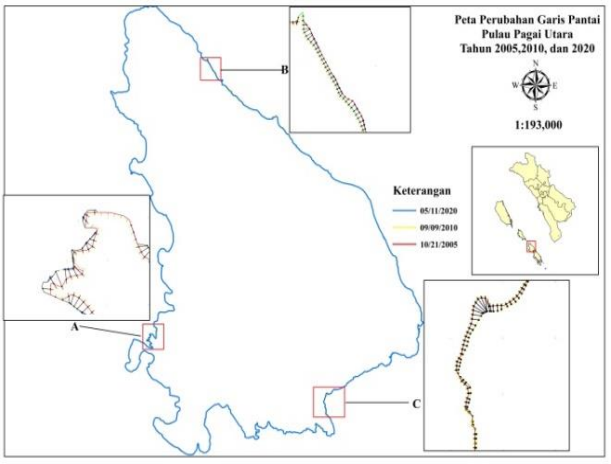

Figure 5. **Overlay Pagai Utara Island.**

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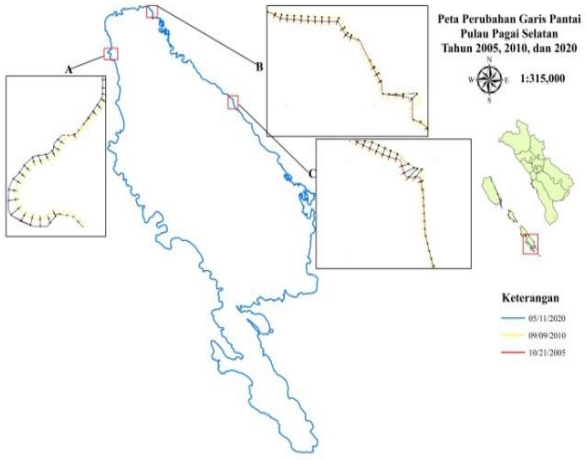

Figure 6. **Overlay Pagai Selatan Island.**

Based on the interpretation of the Landsat image overlay which was carried out using ArcGIS 10.4.1 software, it was found that in general, the Mentawai Islands experienced changes in the coastline. It can be seen in Figure 3 that there are several areas for each Island in the Mentawai Islands experiencing significant changes.

After overlaying or overlapping, the distance of shoreline changes is calculated using the Digital Shortline Analysis System (DSAS). The value of the results of the DSAS calculation analysis for the Mentawai Islands in 2005-2020 can be seen as follows:

1. Siberut Island

Figure 7. **Map of Siberut Island Coastline Change in 2005, 2010 and 2020.**

The results showed that the direction of the change in the coastline on Siberut Island was towards the Northeast. The average distance of shoreline changes is obtained from the NSM (Net Shortline Movement) value on the island of Siberut, which is -2,109 m.

2. Sipora Island

Figure 8. **Map of Sipora Island Coastline Change in 2005, 2010, and 2020.**

The results showed that the direction of shoreline change on Sipora Island was towards the southwest where the shoreline changes experienced a retreating shoreline. The average distance of shoreline change is obtained from the NSM (Net Shortline Movement) value on Sipora Island, which is -2,979 m.

3. North Pagai Island

Figure 9. **Coastline Change Map of North Pagai Island in 2005, 2010 and 2020.**

The results showed that the direction of shoreline changes on North Pagai Island was to the southwest where the shoreline changes experienced a retreating coastline. The average distance of shoreline change is obtained from the NSM (Net Shortline Movement) value on North Pagai Island, which is -3.282 m.

4. South Pagai Island

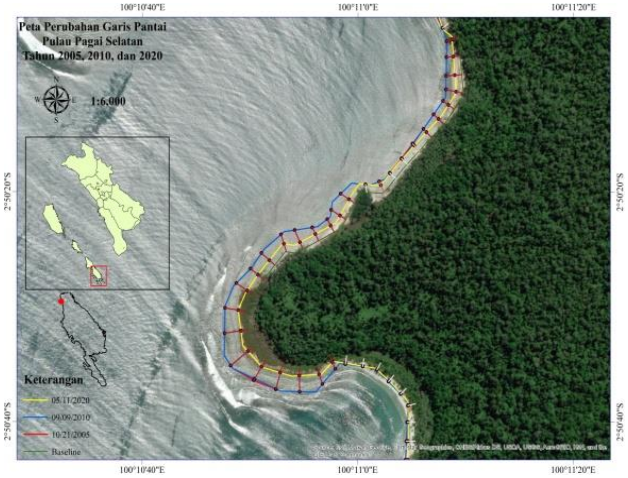

Figure 10. Coastline Change Map of South Pagai Island in 2005, 2010, and 2020.

The results showed that the direction of shoreline change on South Pagai Island was towards the northeast where the shoreline changes experienced a retreating shoreline. The average distance of shoreline changes is obtained from the NSM (Net Shortline Movement) value on South Pagai Island, which is -1,557 m.

From the map of the distance changes to the coastline, it was found that in general, the Mentawai Islands experienced a retreating coastline, meaning the loss of land in the coastal area based on a map of 4 islands, namely Siberut Island, Sipora Island, North Pagai Island and South Pagai Island, resulting in the Mentawai Islands is small.

Changes in the coastline in the Mentawai Islands are not only caused by plate movements. Significant earthquakes are also one of the causes of shoreline changes. Where are the Mentawai Islands which is an active deformation zone so that earthquakes often occur. The earthquake that struck the Mentawai Islands on October 25, 2010, was 7.8 on the Richter Scale and resulted in a tsunami, considering it one of the most significant to ever happen there.

V. CONCLUSION

Based on the research conducted, it can be concluded that the coastline changes that occur in the Mentawai Islands generally experience a retreating coastline. This can be seen in the results of the Digital Shoreline Analysis System (DSAS) processing, the average distance of shoreline changes that occur on Siberut Island is -2,109 m, Sipora Island -2,979 m, North Pagai Island -3.282 m, and South Pagai Island -1,557 m. From these results, the distance of significant shoreline changes in the Mentawai Islands occurred on South Pagai Island.

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