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Study on Abrasion and Sediment in Angso Duo Island Pariaman City West Sumatera, Indonesia

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Abstract: ***The purpose of this study was to determine threshold of abrasion rate at coastal area of Angso Duo Island, Pariaman City, West Sumatera, using sediment analysis and image data processing in February 2017. The sample of coastal sediment was collected at four stations in the study area. The change of coastline was observed by using Landsat 5 TM (year 1996 and 2006) and Landsat 8 LDCM (year 2016). The Angso Duo Island is characterized by the fine-grain sediment (sand) and by the high rate of abrasion as shown by the image data interpretation for 20 years (1996-2016 reaches 17 meter which equal to 0.85 meter/year). The major contributing factor for the coastline changes in the study area is due to the wave and the current systems which flow from Indian Ocean through the study area.***

Keywords: Coastline movement, abrasion, wave and current

1. Introduction

Angso Duo Island is located close to Indian Ocean. It is one of island in Pariaman City, West Sumatera Province, Indonesia. Coastline movement rate at Angso Duo Island using satellite data indicates that high abrasion area was found on this island. Coastal movement is the process of stability (either forward or backward) caused by various phenomenon such as abrasion, accretion, sedimentation, reclaimed or natural disasters [10].Abrasion is a physical process, lost and abdicate material as sediment in coastline areas [7].

Abrasion is a serious issue in the world now. According to [2] almost 70% of the world's beaches are experiencing coastal erosion. Coastal erosion is a major crisis in developing countries, and it potentially impacts the coastal population and natural environment [5]. Coastal erosion is a severe problem, particularly for a country facing explosive population growth along the coastal areas [4].

In recent time the integration of latest techniques of remote sensing with Geographical Information System (GIS) has been proven to be an extremely useful approach for the shoreline changes studies due to synoptic and repetitive data coverage, high resolution, multi-spectral database and its cost effectiveness in comparison to conventional techniques [1]. Remote sensing technique is able to acquire image almost everywhere in the world regardless of national boundaries or inaccessible area as well as a variety of spectral and spatial resolution and its capability to acquire image over large area very quickly [11].

Based on the introduction, this research was conducted to determine the threshold of abrasion rate at coastal area of Angso Duo Island, Pariaman City, West Sumatera Province, Indonesia, using sediment analysis and image processing by Landsat with remote sensing technique.

2. Method

The samples of coastal sediment were collected from 4 stations along the coastal area of the Angso Duo Island in February 2017. The positions of the sampling stations were determined by using the Global Positioning System (Figure 1).

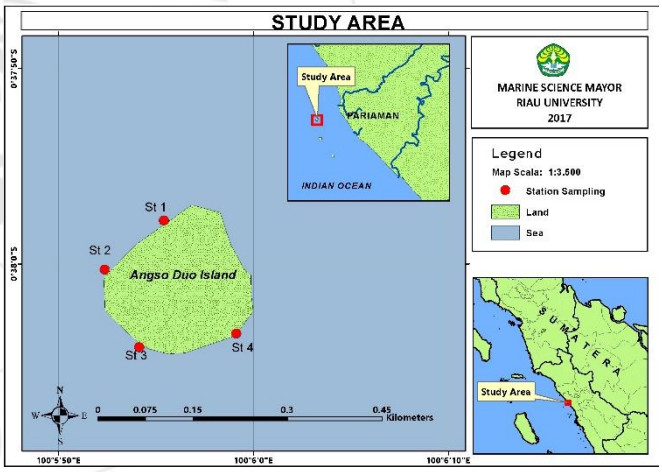

Figure 1: Study Area

All sediment samples were collected by using grab sampler. The samples were analyzed based on the mechanical grain size using the graphical method by Folk and Ward on [9]. The calculation includes the mean size (Mz ø), Skewness (Sk_i), sorting coefficient ($Ó_i$) and Kurtosis (K_G)of the sediments.

The current system and wave of the coastal area were also measured at each station. The currents system were measured during the high tide using the following formula:

$$v = \frac{s}{t} \quad (1)$$

Where: v = velocity of current (m/s)
s = distance (m)
t = time (s)

Wave energy is also calculated at high tide using the following formula:

$$E = \frac{1}{8} \rho g h^2 \qquad (2)$$

Where: E = Total energy (Nm/m^2)
ρ = Sea water density (kg/m^3)
g = Gravity acceleration (9,8 m/s^2)
h = Wave height (m)
1= Wave Energy Constant
8

The image data was used in this study consists of Landsat 5 TM level 1T periods of 1996. 2006 and Landsat 8 LDCM level 1T periods 2016. Data obtained from U.S Geological Survey (USGS) can be downloaded at www.earthexplorerer.gov. The data were analyzed by using Semi-Automatic Classification Plugin (SCP) from ENVI 4.5 and ArcGIS 10.4.1.

The process of analysis and interpretation of Landsat data consist of data classification, radiometric correction, band stacking, image enhancement, digitization, and overlaying. The result of the analysis and interpretation is used to determine the coastline movement. The flow chart of the image data processing is shown in Figure 2.

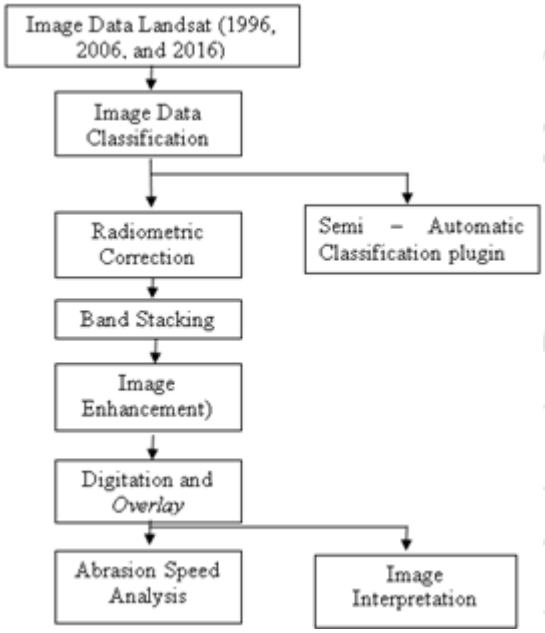

Figure 2: Analysis and interpretation schemaof the abrasion velocity in Angso Duo Island

3. Results and Discussion

Current and Wave in Angso Duo Island

Current is the sediment transport media and abrasion agency [6].Current play an important role in the distribution and direction of sediment in the water. Waves can form and damage the coastal area. According to [3] beach erosion through wave action, long shore drift and rip current that moves the beach sediment perpendicular to the shoreline is some other ways of altering the shorelineposition over the time.

Oceanography activity such as current and wave were found in Angso Duo Island. The value of current velocity, wave high, and wave energy are shown in Table 1.

Table 1: Current and Wave in Angso Duo Island

Station	Date	Current (m/s)	Wave High (m)	Wave Energy (Nm/m^2)
1	16-2-17	0.16	0.30	112,90
	17-2-17	0.15	0.35	53,66
	18-2-17	0.16	0.35	53,66
2	16-2-17	0.28	0.45	254,02
	17-2-17	0.27	0.50	313,60
	18-2-17	0.28	0.50	313,60
3	16-2-17	0.22	0.40	200,70
	17-2-17	0.21	0.45	254,02
	18-2-17	0.22	0.45	254,02
4	16-2-17	0.12	0.28	98,34
	17-2-17	0.10	0.30	112,90
	18-2-17	0.12	0.30	112,90

Table 1 discovered that the current velocity, wave height, and wave energy have a correlation. It is found out that the current velocity (0.28 m/s), wave height (0.50 m), and wave energy (313.60 Nm/m^2) on Station 2 were the highest.

Coastline movement (Abrasion)

The results of coastline movement of Angso Duo Island based on the interpretation of image data of Landsat 5 and 8 in periods of 1996 to 2006 and 2006 to 2016 years are shown in Figure 3.

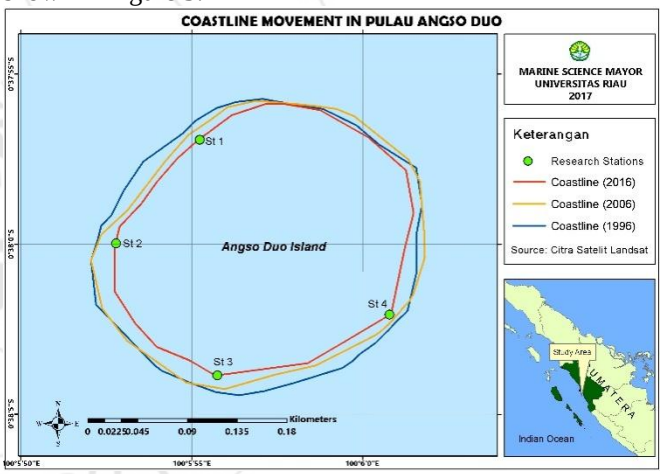

Figure 3: Coastline Movement in Angso Duo Island in Period 1996-2016 years

The Figure 3 shown coastline of Angso Duo Island tend to moved forward to the land due to the abrasion process and almost 80% areas are experiencing abrasion. The Figure 3 shown that coastline movement (abrasion as happened for all stations), Due to the different line color. The completed data is shown in Table 2.

Table 2: Coastline Movement in Angso Duo Island by Imageyears 1996-2016

Stations	Years 1996-2006	Years 2006-2016	Years 1996-2016	Average Coastline Movement
1	5	9	14	0.70
2	2	15	17	0.85
3	4	12	16	0.80
4	2	6	8	0.40

Table 2 shownthe high rate of abrasion as shown by the image data interpretation for 20 years(1996-2016) ranges from 8 m to17 m equal from 0.40 to 0.80 m/year in average. The effect of coastline movement in Angso Duo Island made

a changes in the area widely. The areas changed is shown in Figure 4.

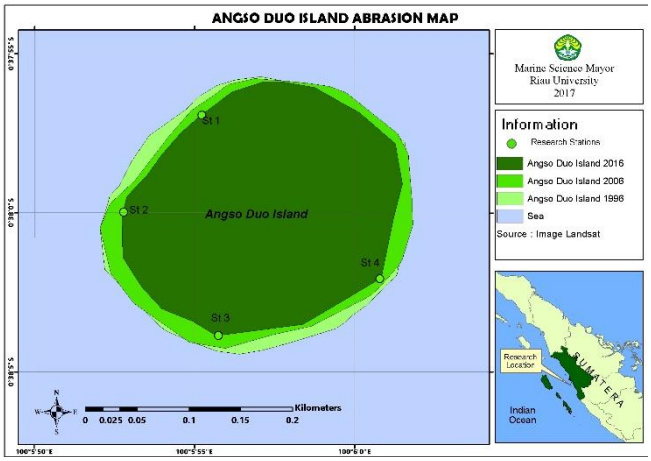

Figure 4: Wide Changing of Angso Duo Island in period 1996-2016

The results of wide changinginterpretationof Angso Duo Islandin periods of years 1996 to 2006 and 2006 to 2016. In periods of year 1996, Angso Duo Island is 60,225 m^2. In periods of year 2006, Angso Duo Island is 57,589 m^2.In periods of year 2016, Angso Duo Island is 49,393 m^2.

Sediment Fraction in Angso Duo Island

Sediment is one of environment parameters which is used to know the real condition in Angso Duo Island. This is supported by [8] who states that in general, abrasion and accretion are the natural phenomenon affected by sediment stability which come in and come out in the coastal. The results of mechanical analysis of the 4 bottom sediment samples are shown in Table 3.

Table 3. Results of mechanical analysis of the Bottom sediments

Stations	Sediment Fraction (%)			Mean Size (MZ)	Skewness (Sk_I)	Sorting ($\sigma 1$)	Kurtosis (K_G)
	% Gravel	% Sand	% Mud				
1	30,48	51,65	17,87	1.80	0.73	3.42	1.46
2	29,59	39,67	30,74	1.90	0.73	3.52	0.45
3	32,25	45,51	22,24	1.80	0.76	3.46	1.27
4	28,62	44,99	26,39	2.00	0.73	3.42	0.45

The bottom sediments are sand, gravel, and mud in the coastline area of Angso Duo Island by percentage of sediment fraction and the bottom sediments is medium sand in the coastline area of Angso Duo Island by mean size (1.8-2.0 ø). Fine-grain sediment shown environment character (Rifardi, 2008).

The results of mechanical analysis of skewness in Angso Duo Island is very fine-skewed. It was shown that the activity of current system and wave are active in this island. The results of mechanical analysis of sorting in Angso Duo Island is very poor-sorted. It was shown that the sedimentation was not stable in Angso Duo Island. It is supported by Rifardi (2008) who state that if an area has poor-sorted character of sediment, it means that the current and wave were unstable in that area.

4. Conclusion

The abrasion process is persistent, and it increase dominantly every years in Angso Duo Island. The velocity of abrasion in Angso Duo Island is 0.40-0.85 m/years.Angso Duo Island has medium sand by sediment analysis. Abrasion in Angso Duo Island can be shown by the image processing and the sediment character.

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