Mapping Shoreline Changes in the Situbondo Coastline for a Period of 10 Years Using Landsat 8 Satellite Image Data

by Ary Candra Wibawa

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Abstract. *Coastal areas have the potential to prosper the surrounding community. The coastline is the boundary line between land and sea level that is dynamic. Changes in the coastline can lead to abrasion and accretion. This study aims to determine changes in the coastline on the Situbondo coast for a period of 10 years by taking Landsat 8 satellite image data processed using ArcGIS 10.7. The method used in this study uses the calculation of the Haversin formula and Euclidean Distance. The results showed that the smallest shoreline change in Situbondo Regency over a period of 10 years occurred in transect 24, precisely in Agel Village, Jangkar District with a shoreline change rate of 1.11 meters. While the largest 10-year shoreline change in Situbondo Regency occurred in transect 25, precisely in Kumbangsari Village, Jangkar District with a shoreline change rate of 106.42 meters.*

Keyword*: Mapping, Shoreline, Satellite Imagery, ArcGIS, Transect.*

1. INTRODUCTION

Coastal areas are places of economic activity that include marine and coastal fisheries, transportation and ports, mining, industrial areas, agribusiness and agro-industry, recreation and tourism as well as residential areas and waste disposal sites (Rachmawaty, 2011). Thus, coastal areas have the potential to prosper the surrounding community.

The coastline is the boundary between land and sea level that is dynamic. Shoreline changes can occur slowly to quickly by several factors. Natural factors that can affect shoreline changes such as waves and currents and tides. This is because these parameters can have an impact on abrasion and accretion (Parenta, 2021). The lack of a good understanding of coastal behavior towards utilization efforts in coastal areas can have a detrimental impact on the coastal environment such as abrasion and shoreline accretion processes. The process of abrasion and accretion of the shoreline initially arises naturally, but the process will take place more quickly if the development of human interest facilities is not based on good knowledge of the behavior of the dynamics of coastal waters, in this case shoreline changes (Puspita, 2011). Therefore, every human activity that will be carried out to utilize the coastal area must be based on good science.

Coastal areas in Situbondo Regency include beaches in the northern region that tend to experience sediment accretion. However, there are several coastal areas that are prone to abrasion, such as on the coast of Banyuglugur District and Besuki District (Zainul et al., 2021). Situbondo Regency has a coastline of 131.575 km and some Situbondo people live in coastal areas (Sukandar et al., 2017). Some coastal areas are quite densely populated areas, so the existence of land use change in these areas can reduce the area of coastal areas which can potentially lead to shoreline instability.

2. THEORITICAL REVIEW

Remote Sensing

Remote sensing is a science or technology used to obtain information about objects, areas, and symptoms by analyzing data obtained using tools without direct contact with the objects, areas, or symptoms under study. In its use, remote sensing works by tapping data and information from photographic and non-photo images of various objects on the earth's surface recorded or depicted by sensors. So that remote sensing technology can overcome the problem of measuring data for fast and accurate information

Landsat-8 Satellite Images

Landsat 8 is the eighth satellite in the Landsat program and the seventh to be successfully placed into orbit. Originally named the Landsat Data Continuity Mission (LDCM), it was a partnership between NASA and the United States Geological Survey (USGS). The satellite was built by Orbital Science Corporation as the prime contractor on the mission. The spacecraft instruments were manufactured by Ball Aerospace and NASA's Goddard Space Flight Center and the launch was assigned to United Launch Alliance. During the first 108 days in orbit, LDCM underwent screening and verification by NASA. On May 30, 2013, operations were transferred from NASA to the USGS when LDCM was officially renamed Landsat 8.

Arcgis

ArcGis is a type of software or software that has been developed by ESRI which is a company that provides international geographic information system software, web-based GIS, and geodatabase management. In this research, ArcGis is used to visualize geographic information, as well as analyze geographic information where the version used is ArcGis software version 10.7.

Haversine Formula

The Haversin formula is an equation commonly used in navigation systems. The Haversin formula is used to determine the distance between two points on the earth's surface (spherical shape) taken from longitude and latitude. In its use this formula is quite accurate for most calculations with the assumption that the radius of R is 6,367.45 km and the location of 2 points in spherical coordinates (latitude and longitude) is lon1, lat1, and lon2, lat2. In this study, the Haversin Formula was used to calculate the distance of shoreline changes for 10 years in each transect. The following is the form of the Haversin Formula formula:

$\Delta lat = lat2 - lat1$

$\Delta long = long2 - long\ 1$

$a = \sin^2(\Delta lat/2) + \cos(lat1) \cdot \cos(lat2) \cdot \sin^2(\Delta long/2)$

$c = 2\ atan\ 2\ (\sqrt{a}, \sqrt{1-a})$

$d = R.c$

Euclidean Distance

Euclidean distance is a calculation used to measure the distance of two points by studying the relationship between angle and distance. This calculation method has advantages in terms of time efficiency and fast process. Both points must be represented in 2-dimensional coordinates (x, y) to get the results of this calculation. Where the two points used become p1 = (x1, y1) and p2 = (x2, y2). The Euclidean Distance calculation can be written with the following equation:

$$d = \sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2}$$

Description:

d = Distance

X1 = Coordinate latitude 1

X2 = Latitude 2 coordinate

Y1 = Longitude coordinate 1

Y2 = Longitude coordinate 2

t-Test

The paired t-test is one method of comparative hypothesis testing or comparative testing. Paired t-test is a statistical test that compares the average of two data and comes from one sample group. This means that each data in the sample group will contribute to the first data and the second data. The purpose of the Paired t-test is to see if there is a significant difference between the two groups of data. The hypothesis of this case can be written:

$H_{0=}\mu_1 - \mu_2 = 0 \; atau \; \mu_1 = \mu_1$

$H_{1=}\mu_1 - \mu_2 \neq 0$ atau $\mu_1 \neq \mu_1$

H_1 means that the true difference of the two means is not equal to zero.

Formula of paired t-test:

$$t_{hit} = \frac{\Delta D}{\frac{SD}{\sqrt{n}}}$$

$$SD = \sqrt{var}$$

$$var\,(s^2) = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \Delta x)^2$$

To interpret the t-test, we must determine the significant value α and Df (degree of freedom) = N-k, specifically for the paired t-test df = N-1 and then compare the t hit value with t tab = a;n-1. Then from the comparison results it can be concluded if:

$t_{crit} > t_{tab} \rightarrow$ significantly different (H0 rejected)

$t_{crit} < t_{tab} \rightarrow$ not significantly different (H0 accepted)

3. RESEARCH METHODS

Data Collection Technique

In this study only using 1 type of data, namely secondary data. Secondary data is data obtained indirectly from the object of research. In this study, the data was obtained with a remote sensing system. Data collection was carried out to obtain Landsat-8

Satellite Image data from usgs.explore.co.id. Secondary data obtadined from this study are:

1. LC08_L1TP_117065_20150727_20200908_02_T1
2. LC08_L1TP_117065_20160729_20200906_02_T1
3. LC08_L1TP_117065_20170716_20200903_02_T1
4. LC08_L1TP_117065_20180719_20200831_02_T1
5. LC08_L1TP_117065_20190722_20200827_02_T1
6. LC08_L1TP_117065_20200724_20200911_02_T1
7. LC08_L1TP_117065_20210727_20210804_02_T1
8. LC08_L1TP_117065_20220730_20220805_02_T1
9. LC08_L1TP_117065_20230717_20230725_02_T1
10. LC08_L1TP_117065_20240601_20240611_02_T1

Research Flowchart

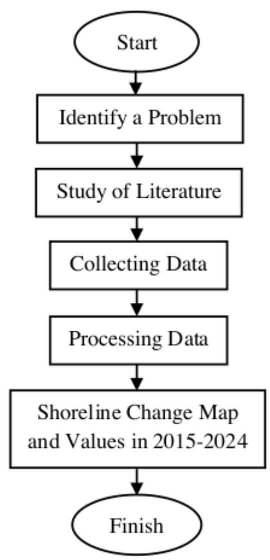

Figure 1 Flowchart

Data Processing Flowchart

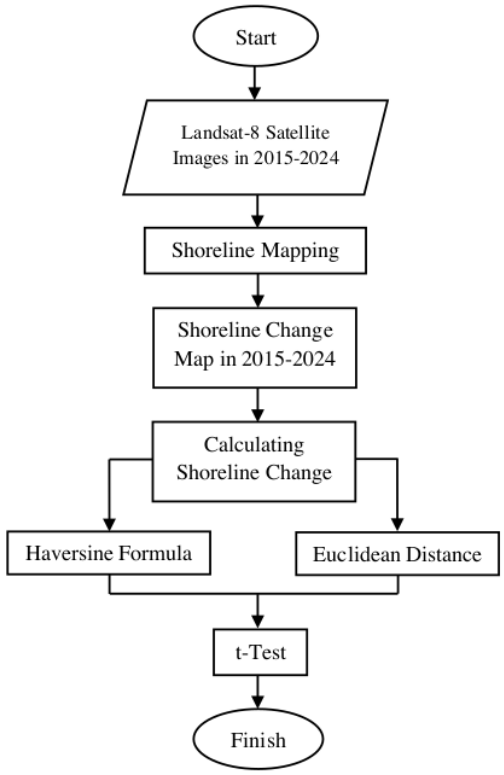

Figure 2 Data Processing Flowchart

Research Tools

In the process of processing data, several tools are needed to help and facilitate this research process. The tools needed are divided into two, namely hardware and software as follows:

a. Hardware includes:
   1. Laptop/Computer to run software.

b. Software includes:
   1. Arcgis software ti analyze data from satellite images.
   2. Microsoft Office Word and Microsoft Excel to compile research and analyze data.

4. RESULTS

Mapping

The shoreline changes were digitized with the aim that the data that had been obtained could be processed later. The digitization process is carried out using the ArcGis 10.7 application in the form of polygons. Where later the coastline will be obtained in the form of a polyline shapefile. After digitizing, the transect that will be used in the calculation of shoreline changes can then be determined. In calculating shoreline changes, it is necessary to determine the transect in order to divide the calculation area of shoreline changes. There are 25 transects that will be analysed using Arcgis and Microsoft Excel applications. The division of the transect can be seen in the following figure:

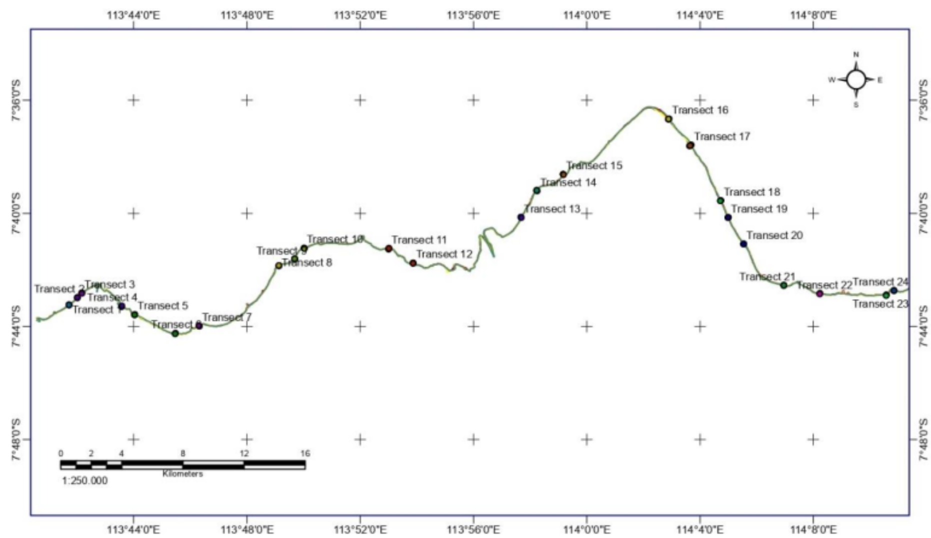

Figure 3 Coastal Section of Situbondo District

After obtaining the coordinates of 25 transects in a period of 10 years, calculations were made using the Haversine and Euclidean Distance formulas with the Microsoft Excel application. The Haversine Formula calculation uses coordinates in decimal degree units, while the Euclidean Distance calculation uses coordinates in UTM units. From these two calculations, the value of shoreline changes in a period of 10 years will be obtained.

Calculation and Analysis Using Haversine Formula

The Haversin formula was used to determine the distance of shoreline change at each transect. The following is a graphic image of the value of shoreline changes in Situbondo Regency using the Haversin formula:

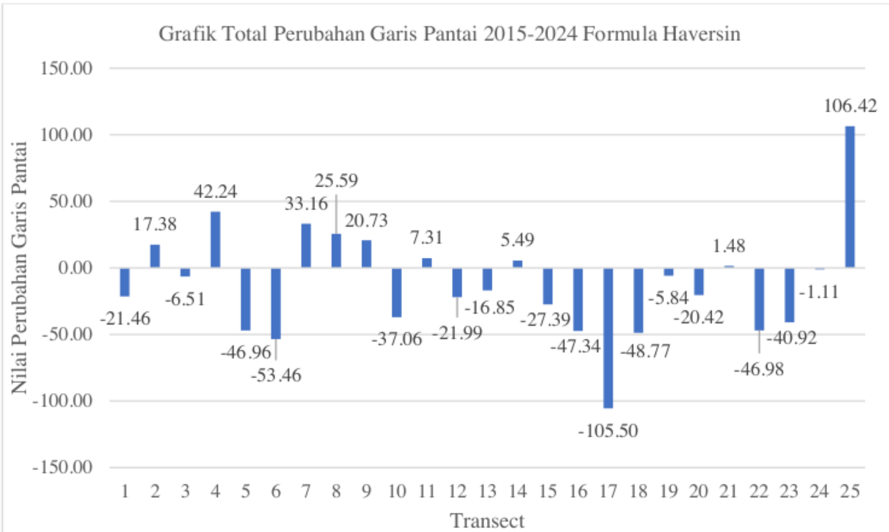

Figure 4 Graph of Total Shoreline Change 2015-2024 using Haversine Formula

Based on this figure, the smallest shoreline change occurred in transect 24 with a shoreline change value of 1.11 meters. While the largest number of shoreline changes occurred in transect 25 with a shoreline change value of 106.42 meters.

Calculation and Analysis Using Euclidean Distance

The Euclidean Distance calculation was used to determine the distance of shoreline change at each transect. The following is a graphic image of the value of shoreline changes in Situbondo Regency using the calculation of Euclidean Distance:

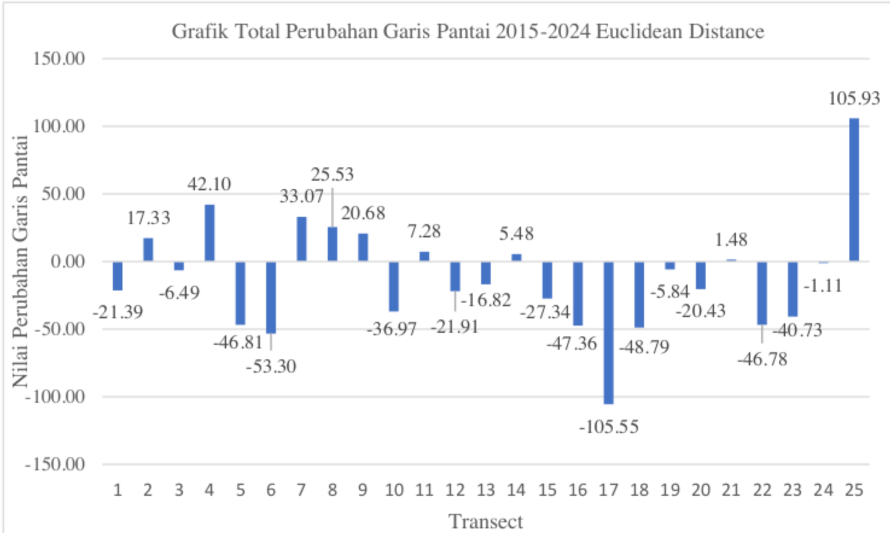

Figure 5 Graph of Total Shoreline Change 2015-2024 using Euclidean Distance

Based on this figure, the smallest shoreline change occurred in transect 24 with a shoreline change value of 1.11 meters. While the largest number of shoreline changes occurred in transect 25 with a shoreline change value of 105.93 meters.

t-Test

The T-test was conducted to determine whether there is a difference in the values and methods used to calculate shoreline changes. The following are the results of the T-test by comparing the Haversin and Euclidean Distance formulas:

t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	-11,55028371	-11,54966197
Variance	1703,635722	1695,441066
Observations	25	25
Pearson Correlation	0,999997657	
Hypothesized Mean Difference	0	
df	24	
t Stat	-0,023274323	
P(T<=t) one-tail	0,490811943	
t Critical one-tail	1,71088208	
P(T<=t) two-tail	0,981623886	
t Critical two-tail	2,063898562	

Based on the table, it can be seen that Thitung < Ttabel. So that H0 is accepted, and H1 is rejected, which means that there is no difference between the Haversin formula and Euclidean Distance methods used in calculating shoreline changes.

Thus, based on the calculations in the table above, it can be concluded that the Haversin and Euclidean Distance formula methods have no difference in calculating shoreline changes in Situbondo Regency for a period of 10 years

CONCLUSION

1. Based on the map of shoreline changes in Situbondo Regency, it is found that the utilization of remote sensing imagery can be used to obtain information about shoreline changes. By using Landsat-8 satellite images, it can be analyzed that there are changes in the coastline in Situbondo Regency with changes occurring in the form of abrasion and accretion.
2. Based on the results of the T test by comparing between the Haversin and Euclidean Distance formulas where from the table that has been obtained, with Thitung < Ttabel so that H0 is accepted and H1 is rejected, it can be seen that from the two methods there is no difference in the value of coastline changes in Situbondo Regency. Thus, both methods can be used to calculate the value of shoreline changes in Situbondo Regency for a period of 10 years.
3. Based on the calculation of shoreline changes in Situbondo Regency for a period of 10 years, it can be seen that using the Haversin formula, the smallest shoreline change rate occurred in transect 24 with a shoreline change value of 1.11 meters and the largest shoreline change rate occurred in transect 25 with a shoreline change value of 106.42 meters. While using the Euclidean Distance formula, the smallest number of shoreline changes occurred in transect 24 with a shoreline change value of 1.11 meters and the largest number of shoreline changes occurred in transect 25 with a shoreline change value of 105.93 meters.

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