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Coastline Mapping in Pati District Utilising Landsat-8 Satellite Images in 2015-2024

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Abstract. *The coastline changes from time to time in line with natural changes such as wave activity, and sediment. This study aims to determine the changes in coastline on the coast of Pati Regency in 2015-2024. The research method utilises Geographic Information System (GIS) and remote sensing technology by taking Landsat-8 satellite image data processed using ArcGis application then calculated using Haversin Formula and Euclidean Distance calculation. The results showed that the largest shoreline change was found in transect 3 located in Dukuhseti Subdistrict, Kembang Village with a value of 453.92 metres within 10 years and the smallest shoreline change value occurred in transect 8 located in Tayu Subdistrict, Tunggulsari Village with a change value of 2.41 metres within 10 years.*

Keyword*: Coastline, Landsat-8, Remote Sensing, Geographic Information System (GIS), Arcgis,*

1. INTRODUCTION

Pati Regency has a 60 km coastline with muddy beach characteristics. Coastal communities in Pati Regency are highly dependent on coastal and marine products, so the coastal area needs to be preserved. A decline in the quality of the coastal environment can be indicated by looking at changes in the coastline.

The coast functions as a centre for tourism, government, settlements, ports, fishing industry, aquaculture and so on. This causes land use in coastal areas to be increasingly limited, resulting in new problems such as reduced land carrying capacity that causes coastal erosion such as coastal abrasion which can damage settlements or other infrastructure or land arising from sedimentation in coastal areas. On the one hand, sedimentation or land arising in coastal areas can be said to be beneficial because of the emergence of new land, while on the other hand it can cause urban drainage problems in coastal areas (Triatmodjo, 1999). According to Cui in (Marsiska, 2020) the coastline tends to have a dynamic nature and its position can change. Shoreline changes occur due to two important events, namely abrasion and accretion.

According to the Law of the Republic of Indonesia No. 4 of 2011 Article 13 paragraph 1, the coastline is the meeting line between land and sea which is influenced by tides. According to Muchlisin in (Aulia et al., 2021) The coastline changes from time to time in line with natural changes such as wave activity, currents, wind, tides, and sediments around the estuary.

Abrasion is the process of eroding the coast by the destructive power of ocean waves and ocean currents, also known as coastal erosion. While sedimentation or accretion is the process

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of physical development, gosong or bura towards the sea through the deposition of sediments carried by littoral drift (Setiyono, 1996). Abrasion is an event of retreating coastlines that are vulnerable to mangrove logging activities, sand mining, as well as the phenomenon of high waves and tides causing the impact of abrasion or coastal erosion (Triatmodjo, 1999).

2. THEORITICAL REVIEW

Remote Sensing

Remote sensing is the science and art of obtaining information about objects, areas, or phenomena by analysing information obtained by instruments without direct contact with the objects, areas, or phenomena being investigated. Remote sensing is the use of electromagnetic radiation sensors to record images of the Earth's environment that can be interpreted to provide useful information. Defines remote sensing as the measurement or collection of objects on the Earth's surface by satellites located above or far from the observed object.

Landsat-8 Satellite Images

Landsat 8 is an American Earth observation satellite launched on 11 February 2013. It is the eighth satellite in the Landsat programme and the seventh to successfully enter orbit. Originally named the Landsat Data Continuity Mission (LDCM), it is a partnership between NASA and the United States Geological Survey (USGS). NASA's Goddard Space Flight Centre provided development services, mission systems engineering, and purchase of the launch vehicle, while the USGS provided ground systems development services and will perform mission operations.

Arcgis

Arcgis is a type of software developed by ESRI which is an international supplier of geographic information system software, web-based GIS, and geodatabase management. Arcgis is used in this research to visualise geographic information, and analyse geographic information. In this research, Arcgis software version 10.7 was used.

Haversine Formula

Haversine Formula is a method to determine the distance between two points by taking into account that the earth is not a flat plane but is a plane that has a degree of curvature. The Haversine Formula method calculates the distance between two points based on the length of a straight line between two points in longitude and latitude (Pamungkas, 2019). In this research, the Haversine Formula is used to calculate the distance of shoreline changes for 10 years in each transect. The following is the form of the Haversin Formula formula:

$\Delta lat = lat2 – lat1$

Δlong = long2 – long 1

a = $\sin^2$ (Δlat/2) + cos (lat1) . cos (lat2) . $\sin^2$ (Δlong/2)

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

d = R.c

Description:

R = radius of the earth of 6371 km

Δlat = magnitude of change in latitude

Δlong = magnitude of change in longitude

c = axis intersection calculation

d = distance (km)

1 degree = 0.0174532925 radians

Euclidean Distance

The Euclidean Distance method is a method of finding the proximity of the distance of two variables, besides being easy this method is also more time efficient, and a fast process. Euclidean Distance is a heuristic function obtained based on obstacle-free direct distance such as to obtain the value of the length of the diagonal line in a triangle. But before getting the results the two points must be represented into 2-dimensional coordinates (x, y). Two points p1 = (x1, y1) and p2 = (x2, y2) become the following equation (Euclidian formula):

$$d = \sqrt{(Lat_1 - Lat_2)^2 + (Long_1 - Long_2)^2}$$

t-Test

The paired t-test is one of the hypothesis testing methods where the data used is not independent (paired). The characteristics most often encountered in paired cases are that one individual (research object) gets 2 different treatments. Although using the same individual, the researcher still obtains 2 kinds of sample data, namely data from the first treatment and data from the second treatment(Paisal et al., 2021). 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_119065_20150725_20200908_02_T1 (2015)
2. LC08_L1TP_119065_20160727_20200906_02_T1 (2016)
3. LC08_L1TP_119065_20170730_20200903_02_T1 (2017)
4. LC08_L1TP_119065_20180701_20200831_02_T1 (2018)
5. LC08_L1TP_119065_20190618_20200827_02_T1 (2019)
6. LC08_L1TP_119065_20200604_20200824_02_T1 (2020)
7. LC08_L1TP_119065_20210607_20210615_02_T1 (2021)
8. LC09_L1TP_119065_20220618_20230411_02_T1 (2022)
9. LC09_L1TP_119065_20230621_20230621_02_T1 (2023)
10. LC09_L1TP_119065_20240607_20240607_02_T1 (2024)

Research Flowchart

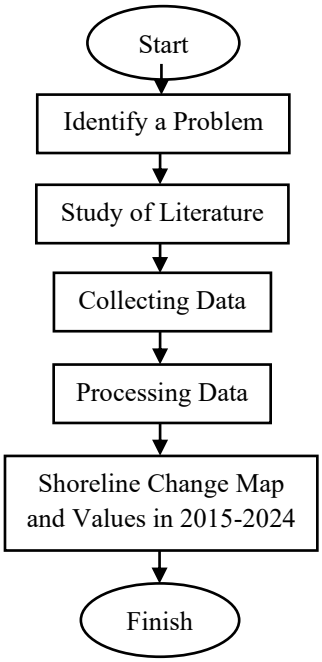

Figure 1 Flowchart

Data Processing Flowchart

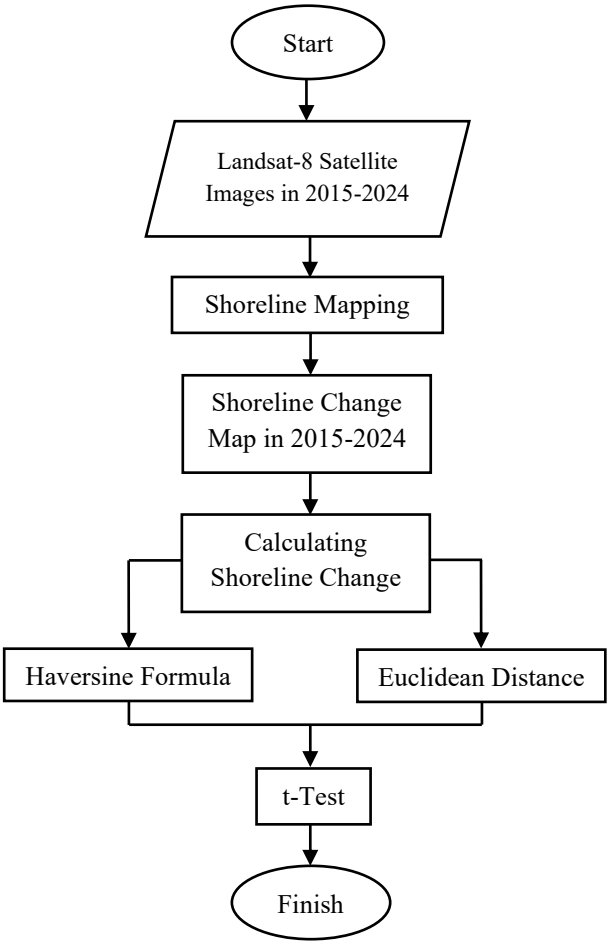

Figure 2 Data Processing Flowchart

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

In calculating shoreline changes, it is necessary to determine the transect in order to divide the calculation area of shoreline changes. There are 22 transects that will be analysed using Arcgis and Microsoft Excel applications. The division of the transect can be seen in the following figure:

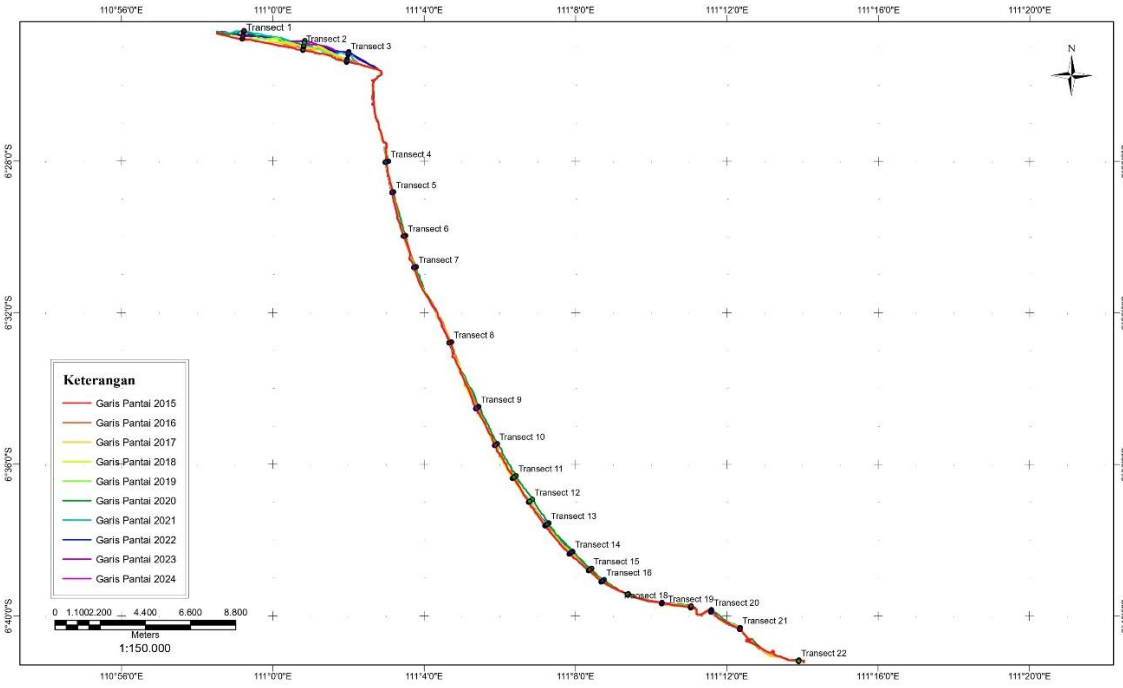

Figure 3 Coastal Section of Pati District

After obtaining the coordinates of 22 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 Haversine method was used to determine the distance of shoreline change in each transect. The value of coastline change in Pati Regency using the Haversin Formula formula can be seen in the following figure:

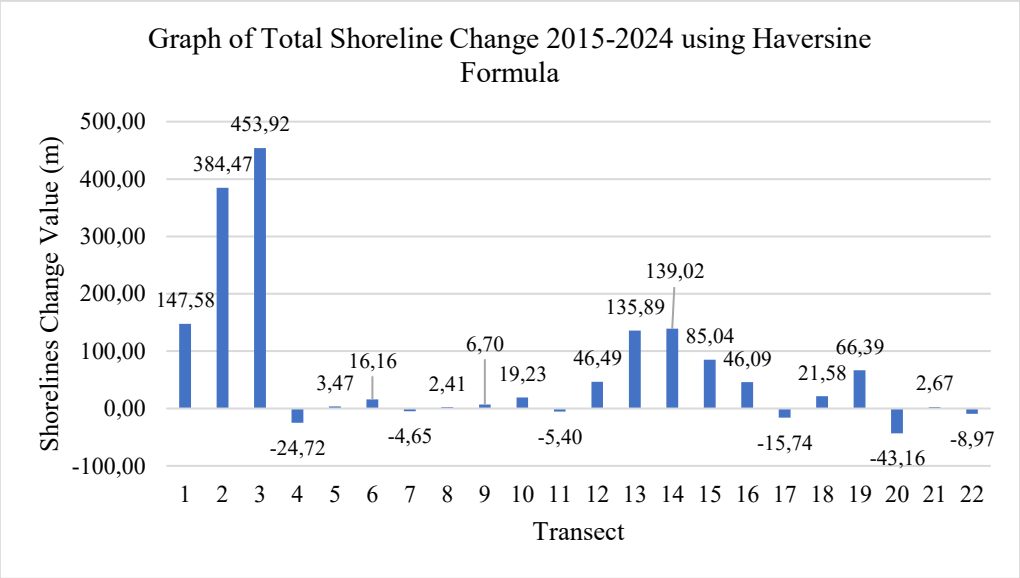

Figure 4 Graph of Total Shoreline Change 2015-2024 using Haversine Formula

Based on the figure above, it can be seen that the largest shoreline change value occurred in transect 3 with a change value of 453.92 metres and the smallest shoreline change value occurred in transect 8 with a change value of 2.41 metres.

Calculation and Analysis Using Euclidean Distance

The Euclidean Distance method was used to calculate shoreline changes over 10 years within each transect. The value of coastline changes in Pati Regency using the Euclidean Distance formula can be seen in the following figure:

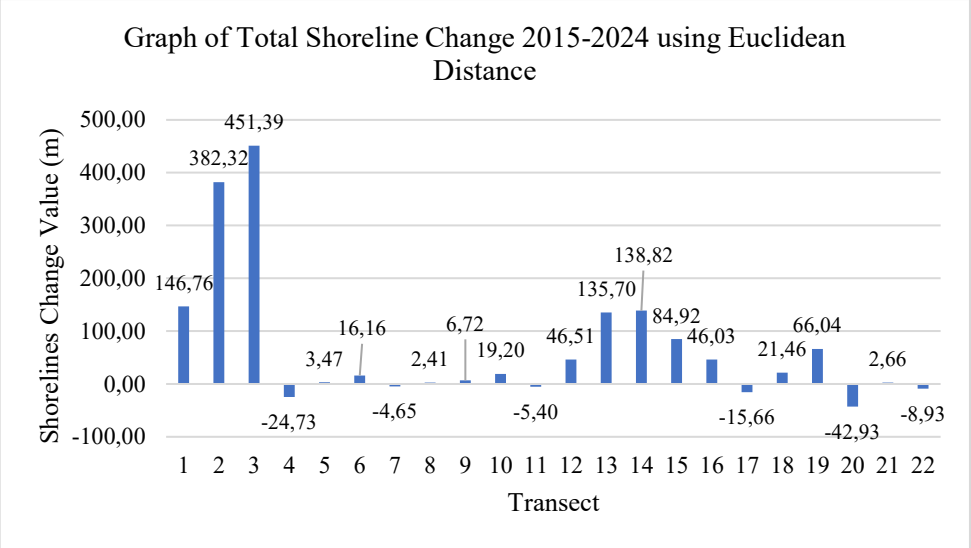

Figure 5 Graph of Total Shoreline Change 2015-2024 using Euclidean Distance

Based on the figure above, it can be seen that the largest shoreline change value occurred in transect 3 with a change value of 451.39 metres and the smallest shoreline change value occurred in transect 8 with a change value of 2.41 metres.

t-Test

From the calculation data using the Haversin Formula and Euclidean Distance methods, a T-test will be conducted to determine whether or not there is a difference in the values and methods to be used in calculating shoreline changes. The T-test results are summarised in the following table:

t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	67,0206373	66,73933023
Variance	15931,25392	15761,76557
Observations	22	22
Pearson Correlation	0,999998909	
Hypothesized Mean Difference	0	
df	21	
t Stat	1,889216946	
P(T<=t) one-tail	0,036375357	
t Critical one-tail	1,720742903	
P(T<=t) two-tail	0,072750714	
t Critical two-tail	2,079613845	

At t Critical two-tail Tstat < Tcrit, then H_0 is accepted, and H_1 is rejected, meaning that there is no difference between the Haversin and Euclidean Distance formula methods used in calculating shoreline change.

Based on the above calculations, it can be concluded that the Haversin Formula and Euclidean Distance methods have no difference in calculating changes in the coastline of Pati Regency 2015-2024.

5. CONCLUSION

1. From the map of changes in the coastline of Pati Regency in 2015-2024 obtained from the processing of Landsat-8 satellite imagery, it can be analysed that changes in the coastline in Pati Regency occur due to accretion and erosion. The largest value of shoreline change occurs on the northern coast of Pati Regency.
2. Based on the T-test results between the Haversine Formula and Euclidean Distance methods, it can be concluded that there is no difference in the value of shoreline change in Pati Regency in 2015-2024 between the two methods. Therefore, both methods can be used to calculate the value of shoreline change in Pati Regency in 2015-2024.
3. Based on the analysis of shoreline changes in Pati Regency in 2015-2024, using the Haversine Formula method, the largest shoreline change value is found in transect 3 located in Dukuhseti Subdistrict, Kembang Village with a value of 453.92 Metres within 10 years and the smallest shoreline change value occurs in transect 8 located in Tayu Subdistrict, Tunggulsari Village with a change value of 2.41 Metres within 10 years.

6. REFERENCES

Agnes, R. (2022). *PERUBAHAN GARIS PANTAI DI PESISIR KABUPATEN LAMPUNG SELATAN FAKULTAS PERTANIAN UNIVERSITAS LAMPUNG BANDAR LAMPUNG 2022 BERDASARKAN ANALISIS CITRA SATELIT LANDSAT 5 DAN 8*. http://digilib.unila.ac.id/id/eprint/64007

Atmojo, Welly, Simbolon, & Zulfikar. (2021). *Studi Perubahan Garis Pantai Pesisir Kota Bandar Lampung Menggunakan Data Penginderaan Jauh*. https://journal.itera.ac.id/index.php/jstvc/article/view/562

Aulia, Welly, Karti, & Zulfikar. (2021). *Studi Perubahan Garis Pantai Pesisir Kota Bandar Lampung Menggunakan Data Penginderaan Jauh*. https://journal.itera.ac.id/index.php/jstvc/article/view/562

BIG. (2013). *Laporan Tahunan*. https://www.big.go.id/uploads/content/produk/Laporan Tahunan BIG/LaporanTahunanBIGTahun2013.pdf

Darmiati, Nurjaya, & Atmadipoera. (2020). *ANALISIS PERUBAHAN GARIS PANTAI DI WILAYAH PANTAI BARAT KABUPATEN TANAH LAUT KALIMANTAN SELATAN*. https://doi.org/http://doi.org/10.29244/jitkt.v12i1.22815

Desmayanti, & Rahman. (2022). *PEMANFAATAN CITRA SATELIT GOOGLE EARTH UNTUK PEMETAAN GARIS PANTAI DI KOTA PADANG*. https://jgia.itp.ac.id/index.php/jgia/article/view/11/13

Elisa, N. (2022). *Pemetaan Perubahan Garis Pantai Menggunakan Citra Satelit Landsat dan Sentinel di Tepi Laut Kota Tanjung Pinang* [Universitas Maritim Raja Ali Haji]. http://repositori.umrah.ac.id/3872/

Fuad, Fajari, & Hidayati. (2021). *PEMODELAN DAN ANALISIS PERUBAHAN GARIS PANTAI DI KABUPATEN SITUBONDO, JAWA TIMUR*. https://www.academia.edu/download/87176689/265.pdf

Israil, Hamzah, Lisdawati, Rahmat, & Virlayani. (2023). *Analisis Karakteristik Gelombang Dan Proses Abrasi Di Pesisir Pantai Popo Galesong Selatan*. https://journal.unismuh.ac.id/index.php/hidro/article/view/12701/6396

Maharani, Mario, & Esty. (2023). *Pemetaan Perubahan Garis Pantai Di Pantai Tanjung Siambang, Pulau Dompak Dengan Metode Digital Shoreline Analysis System (DSAS)*. https://doi.org/https://doi.org/10.21107/jk.v16i2.18298

Marsiska. (2020). *Deteksi Perubahan Garis Pantai Kabupaten Padang Pariaman dan Kota Pariaman Menggunakan Aplikasi Penginderaan Jauh*. https://doi.org/10.21063/jts.2020.V702.01

Mayang, Meirany, & Lestari. (2023). *PEMETAAN PERUBAHAN GARIS PANTAI DI KECAMATAN SINGKAWANG SELATAN*. https://doi.org/https://dx.doi.org/10.26418/jelast.v10i1.62602

Nurdiansyah, Helena, & Warsidah. (2023). *Pemanfaatan Citra Landsat 8/ETM+ dan Google Earth Engine untuk Identifikasi Pesisir di Desa Sungai Nibung Kabupaten Kubu Raya Kalimantan Barat*. https://doi.org/https://doi.org/10.35800/jip.v12i1.52191

Pamungkas, M. K. (2019). Aplikasi Penghitung Jarak Koordinat Berdasarkan Latitude Dan Longitude Dengan Metode Euclidean Distance Dan Metode Haversine. *Jurnal INFORMA Politeknik Indonusa Surakarta*, *5*, 8–13.

Prahesti, Bashit, & Wahyuddin. (2021). *ANALISIS PERUBAHAN KERAPATAN TANAMAN MANGROVE TERHADAP PERUBAHAN GARIS PANTAI DI KABUPATEN PATI TAHUN 2017-2020 DENGAN METODE PENGINDRAAN JAUH DAN APLIKASI DIGITAL SHORELINE ANALYSIS SYSTEM (DSAS)*. https://doi.org/https://doi.org/10.14710/jgundip.2021.29635

Rizka, N. (2022). *PEMETAAN GARIS PANTAI DI KECAMATAN KOTO TANGAH MENGGUNAKAN CITRA PENGINDERAAN JAUH MULTITEMPORAL TAHUN 2002 2012 DAN 2022*. http://repository.unp.ac.id/id/eprint/43997

Roziqin, & Gustin. (2017). *Pemetaan Perubahan Garis Pantai Menggunakan Citra Penginderaan Jauh di Pulau Batam*. https://doi.org/https://doi.org/10.35313/irwns.v8i3.738

Setiyono. (1996). *Kamus Oseanografi*.

Supriharyono. (2000). *Pelestarian dan pengelolaan sumber daya alam di wilayah pesisir tropis*.

Triatmodjo. (1999). *Teknik Pantai*. Beta Offset.