Shoreline Detection using Image Processing for Coast of Pangandaran

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Shoreline Detection using Image Processing for Coast of Pangandaran

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ARTICLE INFO ABSTRACT

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As the world's largest archipelagic country, Indonesia has about 81,000 km of coastline. Coastline in Indonesia are not defenseless to natural processes but are also subjected to strong burdens from human processes. Thus, coastline changes are shown by changes in position, not only determined by a single factor but by number of factors and their interactions which are the combined results of natural and human processes.

The aim of this study is to investigate the shoreline changes at the coast of Pangandaran, Indonesia, which is a popular destination either for domestic or international tourists. The shoreline at the coast of Pangandaran is obtained by using satellite imagery from Google Earth Pro for 10 years. The shoreline change rate is estimated using a simple statistical method. The rate is used to predict the shoreline change using arithmetic sequence. The forecast of Pangandaran's shoreline changes in the year 2030 are the largest abrasion of 3.2 m and the largest sedimentation of 0.7m. Efforts to prevent changes in Pangandaran's coastline is planting soft and/or hard structures. Further research requires analysis of coastal protective structures such as mangrove and/or breakwaters.

1. Introduction

Indonesia is the largest archipelago country in the world. The coastal region in Indonesia is a very intensive area utilized for human activities, such as a central area of government, settlement, industry, ports, aquaculture, agriculture/fisheries, tourism, and so on. The existence of these various activities can lead to an increase in the need for land, infrastructure, etc. which in turn will lead to new problems such as coastal erosion or coastal sedimentation.

The coastal area is the boundary between land and sea waters. Furthermore, the coastline is the boundary between the sea and land portions when the highest tide occurs (Narayana, 2016). Proper management of the coastline will increase the economic and environmental potential around the coast (Powell, et al, 2019).

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Changes in the coastline are shown by changes in position, not only determined by a single factor but by number of factors and their interactions which are the combined results of natural and human processes (Meilianda et al., 2019). Natural factors come from the influence of hydro-oceanographic processes that occur in the sea such as wave blows, changes in current patterns, tidal variations, and climate change. The causes of beach damage due to human activities (anthropogenic) include conversion and conversion of coastal protective land for development facilities in coastal areas that are not in accordance with applicable rules so that the balance of sediment transport along the coast can be disrupted, sand mining triggers changes in current and wave patterns (Dada et al., 2019).

Pangandaran beach is one of West Java's best keep secrets as far as international tourists are concerned. Located on a peninsula on the south coast of West Java. Pangandaran beach facing the Indian Ocean offers uniquely black and white sand and calm waved beaches. The data of coastline at the seashore of Pangandaran is attained for the year of 2011 to 2020 by using satellite imagery from Google Earth Pro (Dewi and Bijker, 2020). The shoreline change rate is estimated using a simple tracing method by AutoCAD

(Yasmin, 2019). The rate is used to forecast the shoreline change (Maiti and Bhattacharya, 2009).

2. Methodology

The research method used is data processing and field observations, this method was chosen to determine and investigate changes in the coastline. The first step taken is visual identification by carrying out a field survey. The survey location is Pangandaran coastal area, West Java Province, Indonesia. Field observations spotted at the beach conditions are location observations, beach observations, such as: abrasion, land use, and community activities around the coastal Pangandaran.

Shoreline data in the form of satellite photos were obtained from the Google Earth platform. Satellite photos obtained from 2011 to 2020. The coastline for 2020 can be seen in Figure 1. Changes in the coastline can be caused by sea level rise by global warming, erosion, sedimentation on the coast, and the influence of human activities (Hakim et al., 2021). Each image shows the land-water boundary traced and marked. Once the shorelines from various time periods have been extracted, they are superimposed on a single reference map. The change in shoreline position is calculated by comparing the distance between older and more recent shoreline positions at various points along the coast. The average rate of shoreline change is calculated using the change in shoreline position over a given period. This may be positive (indicating accretion) or negative (indicating erosion). When combined with forecasting models like arithmetic sequences, the rate helps predict future shoreline positions.

Figure 1: Coastline of Pangandaran beach in the year of 2020

Source: Google Earth

The first stage was carried out field observations on Pangandaran coastal area. The thing to do is to inspect the location, observe the coastal area, such as: abrasion, land use around the coastal Pangandaran, and community activities around Pangandaran coastal area. The condition of Pangandaran coastal can be seen in Figure 2 to Figure 4.

Figure 2: Condition of the Pangandaran West Coast at Coordinates 07° 41' 52.64" S; 108° 39' 09.20 " E

Source: Author

Figure 3: Coastal Condition of Batu Hiu coastal in Pangandaran at Coordinates 07° 41' 33.72" S; 108° 32' 18.76" E

Source: Author

Figure 4: Condition of the Batu Hiu coastal area in Pangandaran at Coordinates 07° 42' 09.71" S; 108° 30' 41.52" E

Source: Author

The condition of breakwater at Pangandaran Beach can be seen in Figure 5 to Figure 7.

Figure 5: Condition of Breakwater in East Coast Pangandaran at Coordinates 07° 41' 55.62" S; 108° 39' 33.20" E

Source: Author

Figure 6: Condition of Breakwater in the East Coast Pangandaran at Coordinates 07° 41' 54.69" S; 108° 39' 33.54" E

Source: Author

Figure 7: Conditions of Breakwater in the East Coast Pangandaran at Coordinates 07° 41' 55.93" S; 108° 39' 33.23" E

Source: Author

Planting plants around Pangandaran coastal area which is used as a barrier to erosion and/or sedimentation can be seen in Figure 8 to Figure 9.

Figure 8: Plant Condition Part 1 on the Batu Hiu at Coordinates 07° 41' 33.72" S; 108° 32' 18.76" E

Source: Author

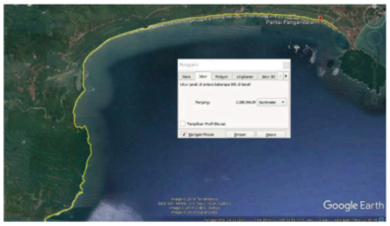
Figure 9: Condition of Plants Section 2 on the West Coast of Pangandaran at Coordinates 07° 42' 03.47" S; 108° 39' 23.20" E

Source: Author

3. Results

Changes to the coastline can be seen through the Google Earth Pro application, by plotting an image of the Pangandaran Beach location in the AutoCAD application. The distance to the image obtained from Google Earth Pro is obtained by using the ruler of the application which can be seen in Figure 10.

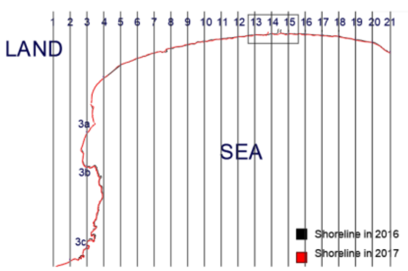
Figure 10: Distance on Google Earth



Source: Google Earth

Scale measurements on Pangandaran Beach using measurements on Google Earth Pro, obtained two coordinate points namely the starting point and end point by changing the degree to Universal Transverse Mercator in the settings menu. After getting two coordinate points at each point using the Google Earth Pro application, a calculation is performed to get one point at each point using Microsoft Excel. With two known points, a horizontal distance is obtained from the depiction in AutoCAD. The largest coastline change is known from December to January, so based on environmental load data and shoreline change data on Google Earth Pro it is proven that significant changes occurred in January. Therefore, shoreline calculations are taken every January for each year. Changes in the shoreline at Pangandaran Beach between the year 2016 and 2017 can be seen in Figure 11.

Figure 11: Coastlines in the year 2016 and 2017



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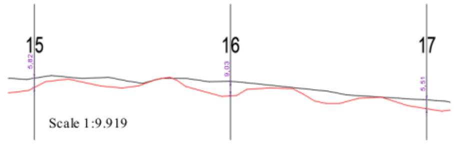
An analysis of shoreline changes in the year 2019 and 2020 per 1000m can be seen in Figure 12 by tracing the AutoCAD using a known scale.

Figure 12: Distance of Coastline Change in 2019 and 2020 at points 15 to 17



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Example of steps to calculates shoreline change point 15 by tracing is the distance of changing coastline equal 5.82 times 9.919 divided by 100 or 0.58m. Changes in the coastline of 2019 and 2020 approach the ocean, therefore are given a positive sign.

The change in coastline at Pangandaran Beach at point 15 each year is obtained from the average change in coastline per year at point 15 is

$$\frac{(-0.81)+(-0.01)+(0.57)+(-0.63)+(0.07)+(-0.11)+(-0.28)+(0.27)+(0.58)}{9}$$

The average shoreline changes per year at the point 15 is -0.04m in each year. Changes in the coastline at Pangandaran Beach at point 15 each year amounting to -0.04 m, approaching the mainland. At point 15, having an abrasion of 0.04m each year.

The arithmetic sequence method is suitable for forecasting linear shoreline changes, where the rate of change is relatively constant over time. It assumes a uniform rate of erosion or accretion, which may not always be the case due to variable factors like storms, tidal patterns, or human intervention. However, when the shoreline changes at a constant average rate, this method provides a straightforward way to predict future shoreline positions.

Using the arithmetic progression or arithmetic sequence

$$U_n = a_m + (n - m)b \quad (1)$$

where the initial term (m) of an arithmetic progression is a_m and the common difference of successive member is b, the nth term of the sequence U_n, the estimation for the year 2030 to have an abrasion of 0.4m, i.e.,

$$U_{2030} = 0 + (2030 - 2020)(-0.04) = -0.4 \text{ m}$$

4. Discussions

Calculations at other points can be carried out with the same analysis each year. Changes in the Pangandaran coastline at each point can be seen in Tables 1-4.

Table 1. Shoreline change from point 1 to point 4

Year	Point					
	1	2	3a	3b	3c	4
2011-2012	-0.47	0.51	-2.74	3.73	-0.82	-2.23
2012-2013	0.02	1.77	0.57	-4.27	1.61	-0.67
2013-2014	0.25	-0.59	0.51	-1.06	0.27	1.34
2014-2015	-0.74	0.27	-0.77	0.65	-0.42	-0.43
2015-2016	0.06	-0.81	-0.01	0.10	-0.37	-0.19
2016-2017	-0.91	-0.45	-0.45	0.38	-0.31	0.34
2017-2018	0.10	-0.27	-0.12	-0.17	-0.30	-0.16
2018-2019	0.77	0.01	0.22	0.50	-0.02	0.17
2019-2020	-0.03	-0.04	-0.11	-0.67	0.99	-0.07
Average	-0.11	0.04	-0.32	-0.09	0.07	-0.21

Source: author

Table 2. Shoreline change from point 5 to point 10

Year	Point					
	5	6	7	8	9	10
2011-2012	-0.63	-1.03	-1.17	-0.49	-0.45	-0.27
2012-2013	0.01	0.00	-0.02	0.14	-0.41	-0.33
2013-2014	0.70	0.74	0.55	0.51	0.79	1.02
2014-2015	-0.61	-0.73	-0.49	-0.63	-0.36	-0.40
2015-2016	0.05	0.28	0.03	0.13	0.25	-0.17
2016-2017	0.51	0.26	0.12	0.44	0.23	0.05
2017-2018	-0.37	-0.52	-0.63	-0.20	-0.30	-0.09
2018-2019	0.15	0.43	0.51	0.13	0.58	0.03
2019-2020	-0.18	-0.54	-0.08	-0.34	-0.67	0.57
Average	-0.04	-0.12	-0.13	-0.03	-0.04	0.05

Source: author

Table 3. Shoreline change from point 11 to point 16

Year	Point					
	11	12	13	14	15	16
2011-2012	-0.55	-0.48	-0.76	-0.83	-0.81	-0.84
2012-2013	-0.13	-0.06	0.14	-0.02	-0.01	0.18
2013-2014	0.79	0.51	0.43	0.14	0.57	0.52
2014-2015	-0.70	-0.59	-0.41	-0.15	-0.63	-0.75
2015-2016	0.13	0.03	0.02	-0.03	0.07	0.18
2016-2017	-0.04	0.08	-0.12	0.04	-0.11	0.01
2017-2018	0.06	0.07	-0.22	-0.92	-0.28	-0.24
2018-2019	-0.07	-0.18	0.28	0.90	0.27	0.06
2019-2020	0.65	0.14	-0.06	-1.35	0.58	0.90
Average	0.01	-0.05	-0.08	-0.25	-0.04	0.00

Source: author

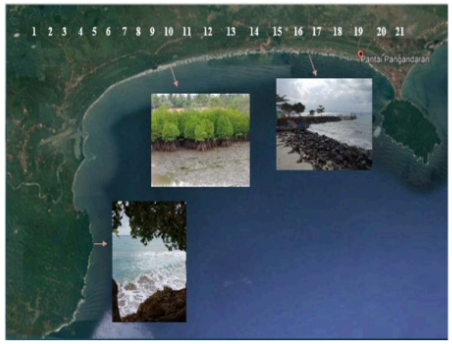
Table 4. Shoreline change from point 17 to point 21

Year	Point				
	17	18	19	20	21
2011-2012	-1.22	-0.84	-0.48	-0.83	-0.53
2012-2013	0.22	-0.06	-0.07	-0.12	-0.05
2013-2014	0.48	0.68	0.76	-0.13	0.59
2014-2015	-0.61	-0.82	-0.85	0.24	-0.62
2015-2016	0.02	0.04	0.07	-0.37	0.08
2016-2017	0.04	-0.04	-0.14	0.23	-0.08
2017-2018	0.27	-0.27	-0.79	-0.20	0.03
2018-2019	-0.30	0.35	0.94	0.20	0.09
2019-2020	0.55	0.20	0.43	0.40	0.13
Average	-0.06	-0.08	-0.01	-0.06	-0.04

Source: author

The largest average shoreline change due to erosion is 0.32 m at point 3a and due to sedimentation is 0.07m at point 3c, respectively. The shoreline changes at Pangandaran Beach at points 1-7 experienced a large shoreline change because around the coast there were no breakwater buildings or mangrove plants. While points 8-13 shoreline changes were not too large due to mangrove planting around the coast. At points 14-21 experienced a change in the coastline not too large also because there were breakwater buildings around the coast. Figure 13 shows the condition at some points of Pangandaran seashore.

Figure 13: Condition at some point of Pangandaran Beach



Source: Author

Conclusions

By using remote sensing method from Google Earth Pro application, the coastline changes at the coast of Pangandaran for 10 years is attained. The shoreline change rate is assessed by a simple tracing method using AutoCAD software. The rate is used to expect the coastline change using arithmetic sequence. The forecast of Pangandaran's coastline changes in the year 2030 are the largest abrasion of 3.2 m and the largest sedimentation of 0.7m. Efforts to avoid changes in Pangandaran's coastline is imbedding soft and/or hard structures. Further research involves analysis of coastal protective structures such as mangroves and/or breakwaters.

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