Korespondensi Artikel dengan judul “Shoreline *Detection using Image Processing for Coast of Pangandaran*" ke *Journal of Maritime Research*

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1. Proses awal pengiriman Full Paper ke Journal of Maritime Research (10 Desember 2021)
2. Artikel sudah dimasukkan dalam sistem manajemen jurnal secara online (6 Januari 2022)
3. Artikel dalam proses reviu (29 Juli 2022)
4. Hasil reviu (29 Juli 2022)
5. Tanggapan terhadap hasil reviu (30 Juli 2022)
6. Keputusan artikel diterima (22 Agustus 2022)
7. Artikel siap diterbitkan (26 Oktober 2022)
8. Pemberitahuan Paper sudah terbit (29 Oktober 2022)

Proses awal pengiriman Full Paper ke *Journal of Maritime Research* (10 Desember 2021)

Penulis telah mengirimkan email ke *Journal of Maritime Research* untuk pertama kalinya pada tanggal 10 Desember 2021 dengan melampirkan *draft* paper dengan judul "*Shoreline Detection using Image Processing for Coast of Pangandaran*."

Kebaruan atau inovasi dalam karya ilmiah yang difokuskan pada pendeteksian perubahan garis Pantai di pesisir Pangandaran menggunakan penginderaan jauh dalam konteks teknik sipil – teknologi pantai dan pelabuhan menghasilkan model prediktif jangka panjang berdasarkan analisis data penginderaan jauh menggunakan Google Earth Engine untuk memperkirakan perubahan garis Pantai di masa depan akibat erosi, sedimentasi, atau kenaikan permukaan laut berkat kebaruan penggunaan pemodelan prediktif untuk memprediksi tren jangka panjang. Di bidang teknik sipil, pemodelan prediktif penting dalam perencanaan pembangunan pesisir dan pelabuhan agar dapat memprediksi perubahan garis pantai dengan lebih akurat. Selain itu, dengan meminimalkan dampak negatif terhadap pesisir dan menjaga stabilitas lingkungan pesisir, hal ini memberikan panduan penting bagi para insinyur dalam merancang infrastruktur pariwisata yang lebih ramah lingkungan, sehingga menjadi lebih efektif. Hal ini juga akan memberikan kontribusi penting terhadap pengembangan metode mitigasi.

Submission Full Paper to JMR

Olga Pattipawaej

To: jmr.info@unican.es; clabajos@unican.es

Cc: Olga Pattipawaej

Reply | Reply all | Forward

Fri 12/10/2021 5:40 AM

Full Paper JMR Olga Pattipaw...
4 MB

Dear Mr. Perez-Labajos,
My name is Olga Pattipawaej, a lecturer from Civil Engineering Department, Universitas Kristen Maranatha. Indonesia.
I would like to submit my full paper of my research related to coastline changes using satellite imagery.
Attached is the full paper written in MSWord. Please let me know if the file is received well.
I am looking forward to further steps.
Thank you in advance.

Sincerely,
Olga Pattipawaej

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JOURNAL OF MARITIME RESEARCH

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Shoreline Detection using Image Processing for Coast of Pangandaran

O. Pattipawaej[1,2*]

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ABSTRACT

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Keywords:
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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.

This study intends to explore the shoreline changes along Indonesia's Pangandaran coast, a popular tourist destination for both domestic and foreign visitors. 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. Planting soft and/or hard structures is one way to prevent changes to Pangandaran's coastline. Further research requires analysis of coastal protective structures such as mangroves 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. Using satellite imagery from Google Earth Pro, the Pangandaran coastline data is obtained for the years 2011 to 2020. (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).

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

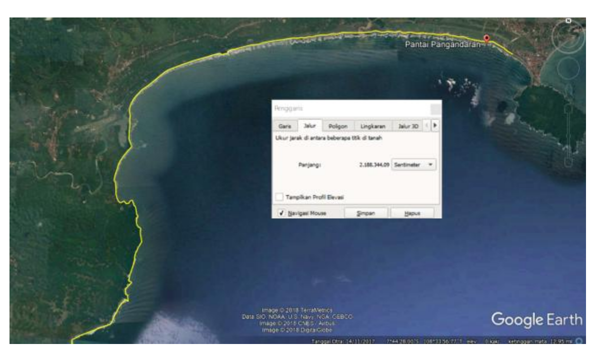
Figure 9: Condition of Plants Section 2 on the West Coast of Pangandaran at Coordinates 07° 42' 03.47" S; 108° 39' 23,20" E

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.

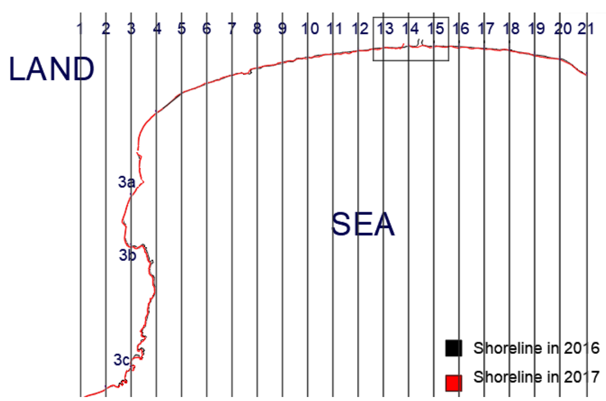
Figure 10: Distance on Google Earth



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.

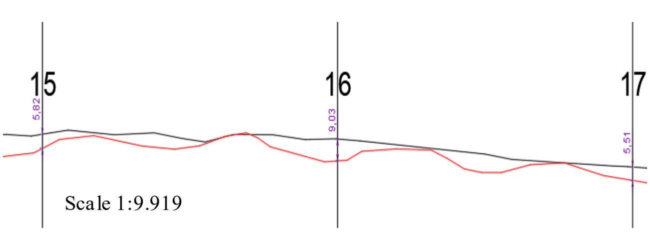
Figure 11: Coastlines in the year 2016 and 2017



Source: Author

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



Source: Author

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.

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

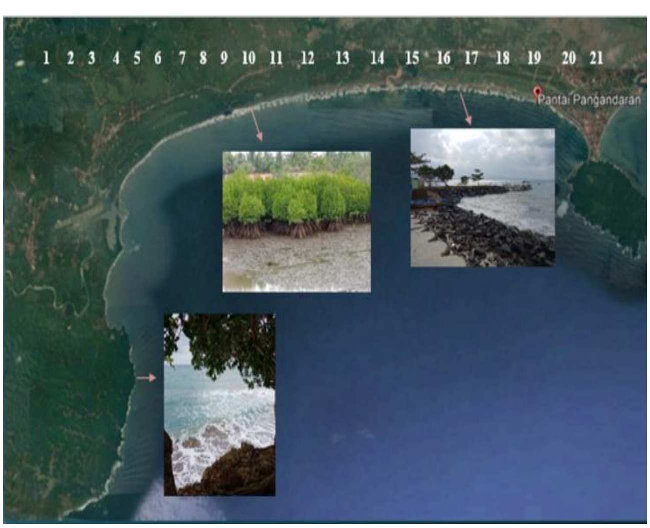
Table 4. Shoreline change from point 17 to point 21

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

The coastline changes at Pangandaran's coast over a ten-year period are obtained using remote sensing techniques from the Google Earth Pro application. Using AutoCAD software and a straightforward tracing method, the shoreline change rate is determined. Using an arithmetic sequence, the rate is used to predict the change in the coastline. 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 mangrove and/or breakwaters

Acknowledgment

The authors would like to thank Civil Engineering Department and Institute for Research and Community Service, Universitas Kristen Maranatha, Indonesia for providing the grant and supporting this research.

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Editor Journal of Maritime Research memberitahukan via email bahwa artikel sudah masuk dalam sistem manajemen jurnal secara online pada tanggal 6 Januari 2022

[JMR] Submission Acknowledgement

CP Carlos A. Perez-Labajos<clabajos@unican.es>

To: Olga Pattipawaej

Reply Reply all Forward ...

Thu 1/6/2022 8:36 AM

Olga Pattipawaej:

Thank you for submitting the manuscript, "Shoreline Detection using Image Processing for Coast of Pangandaran" to Journal of Maritime Research. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

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If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Carlos A. Perez-Labajos

Reply Forward

Artikel dalam proses reviu (29 Juli 2022)

Pada tanggal 29 Juli 2022 diperoleh Informasi bahwa artikel dalam proses reviu.

Receipt and review

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Participants

Carlos A. Pérez-Labajos (editor1)

Olga Pattipawaej (olga1712)

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

Source: Google Earth

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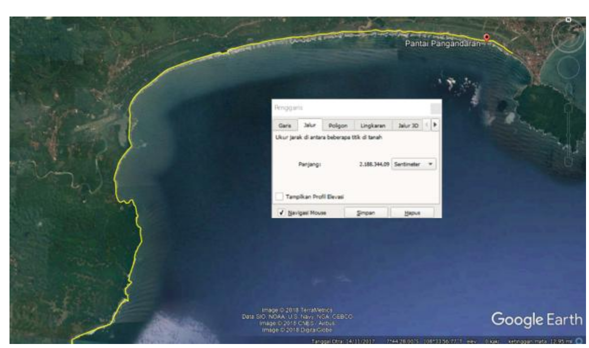
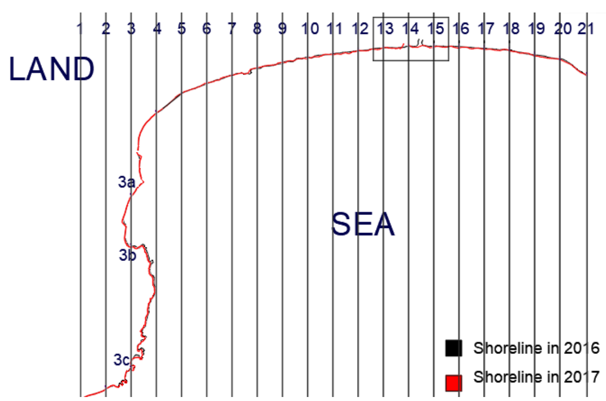


Source: Google Earth

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.

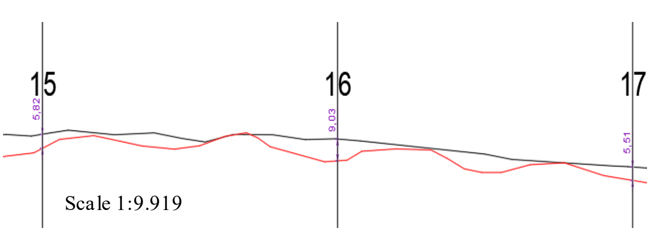
Figure 11: Coastlines in the year 2016 and 2017



Source: Author

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



Source: Author

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.

Using the arithmetic progression or arithmetic sequence

$$U_n = a_m + (n-m)b \tag{1}$$

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

The coastline changes at Pangandaran's coast over a ten-year period are obtained using remote sensing techniques from the Google Earth Pro application. Using AutoCAD software and a straightforward tracing method, the shoreline change rate is determined. Using an arithmetic sequence, the rate is used to predict the change in the coastline. 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 mangrove and/or breakwaters

Acknowledgment

The authors would like to thank Civil Engineering Department and Institute for Research and Community Service, Universitas Kristen Maranatha, Indonesia for providing the grant and supporting this research.

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Hasil reviu (29 Juli 2022)

Hasil reviu dari 2 *reviewer* telah dikirim via email pada tanggal 29 Juli 2022.

Reviewer 1 memberikan beberapa perbaikan.

Reviewer 2 memberikan tanggapan dan beberapa rekomendasi yang dapat ditambahkan dalam artikel.

[JMR] Review Report

CP
Carlos A. Perez-Labajos<clabajos@unican.es>
To: Olga Pattipawaej

Reply Reply all Forward ...

Fri 7/29/2022 8:36 AM

Olga Pattipawaej:

The reviewers have submitted their review reports. Please be prepared to respond to requests for revisions to your manuscript when they do.

Carlos A. Perez-Labajos

****

Independent Review Report, Reviewer 1
EVALUATION
Please list your revision requests for the authors and provide your detailed comments, including highlighting limitations and strengths of the study and evaluating the validity of the methods, results, and data interpretation.
The manuscript titled "Shoreline Detection using Image Processing for Coast of Pangandaran."
The objective of shoreline detection using image processing is to accurately identify and delineate the boundary between land and water bodies in coastal or riverine environments from digital images. Monitoring changes in the shoreline over time helps in understanding erosion, sedimentation, and the effects of natural disasters. Using image processing techniques, such as edge detection, segmentation, and classification, the shoreline is extracted from satellite, making the process faster, more accurate, and automated compared to traditional methods.
However, there are still some parts that need to be improved from the manuscript.

1. The objective needs to be stated in the abstract and introduction part.
2. Typo and grammatical errors need to be corrected
3. Conclusions need to address the objective of the study.
****
Independent Review Report, Reviewer 2
EVALUATION
Please list your revision requests for the authors and provide your detailed comments, including highlighting limitations and strengths of the study and evaluating the validity of the methods, results, and data interpretation.
The methodology for shoreline detection using image processing typically involves a series of steps that convert raw satellite or aerial imagery into an accurate delineation of the shoreline. The final shoreline can be overlaid onto existing maps, integrated into AutoCAD, or used for further analysis, such as identifying areas prone to erosion or land loss. This workflow can be adapted based on the type of imagery, the complexity of the shoreline, and the specific application (e.g., coastal management, erosion monitoring).
A comment and few recommendations are needed to improve the quality of the manuscript.
1. The use of remote sensing for shoreline change detection is now common. The authors must explicitly clarify what constitutes the novelty of their predictive model. How can remote sensing data analyzed with Google Earth Engine be utilized to create a long-term predictive model that accurately forecasts future shoreline changes at Pangandaran Beach, and how can the resulting predictions inform sustainable civil engineering decisions in coastal and port development?
2. Provide one sentence describing the methodology of the research in the abstract.
3. Provide theoretical background on the development of arithmetic progression or arithmetic sequence.
4. Please provide a brief explanation about the method to determine the shoreline change.
5. Check Typo and Grammatical Error in the manuscript.

Reply Forward

Tanggapan terhadap hasil reviu (30 Juli 2022)

Penulis memberikan tanggapan terhadap hasil reviu dari 2 *reviewer* disertai dengan perbaikan artikel sesuai dengan tanggapan dari *reviewer* pada tanggal 30 Juli 2022.

Response to the Review Reports

Olga Pattipawaej

To: jmr.info@unican.es; clabajos@unican.es

Cc: Olga Pattipawaej

Reply Reply all Forward ···

Sat 7/30/2022 7:40 AM

Dear Editor,
Regarding my manuscript, "Shoreline Detection using Image Processing for Coast of Pangandaran," I appreciate your correspondence. I am grateful for the comments and recommendations from your Reviewers 1 and 2. I am happy to resubmit my manuscript with the revisions, having carefully considered each reviewer's feedback in the response below.
I think those changes have enhanced my manuscript and made it more appropriate for your journal's publication. I'm hoping you'll think about publishing it in your journal. I appreciate all your time and thought.

Sincerely,
Olga Pattipawaej

****

Response to the comment from Reviewer 1

1. The objective needs to be stated in the abstract and introduction part.

   Response from author:

Thank you for providing feedback. The author agrees that the objective of my research could be stated more clearly in the abstract and introduction sections. The author has changed the sentence to more clearly state the objective in both the introduction and the abstract.

2. Typo and grammatical errors need to be corrected
   Response from author:
   I appreciate you bringing up the typo and grammatical mistake. This error has been fixed by the author. Additionally, the author has thoroughly proofread the entire document once more to fix any additional typos or grammatical mistakes. I appreciate your assistance in making the manuscript better.

3. Conclusions need to address the objective of the study
   Response from author:
   Thank you for the suggestion. The author took the suggestion. Conclusions have already been modified to address the study's objectives.

****

Response to the comment from Reviewer 2

1. The use of remote sensing for shoreline change detection is now common. The authors must explicitly clarify what constitutes the novelty of their predictive model. How can remote sensing data analyzed with Google Earth Engine be utilized to create a long-term predictive model that accurately forecasts future shoreline changes at Pangandaran Beach, and how can the resulting predictions inform sustainable civil engineering decisions in coastal and port development?
   Response from author:
   Thank you for providing feedback. The novelty of using arithmetic progression to predict shoreline change from satellite imagery is its power as a parsimonious and efficient alternative to complex modeling. Since the arithmetic progression model requires only the x,y coordinates of past shorelines derived directly from the imagery, its innovation lies in demonstrating that this simple, easily auditable, and highly-scalable approach can

achieve sufficiently accurate predictions over short-to-medium time scales or in low-energy environments. Yes, remote sensing data analyzed with Google Earth Engine can be used to create a powerful, long-term predictive model that provides essential data for sustainable civil engineering decisions at Pangandaran Beach. The process moves from historical analysis to a fully integrated predictive forecast. The development of an accurate, long-term predictive model for Pangandaran involves main steps (long-term shoreline extraction, integration of physical forcing data, and predictive modeling) leveraging GEE's massive data catalog and processing power. The resulting long-term predictions and their uncertainty estimates are vital inputs for sustainable planning and decision-making for coastal and port development.

2. Provide sentence describing the methodology of the research in the abstract
   Response from author:
   I sincerely appreciate your suggestion. In response to the reviewer's suggestion, the author modified the sentence in the abstract that described the research methodology.
3. Provide theoretical background on the development of arithmetic progression or arithmetic sequence
   Response from author:
   I appreciate your advice. Theoretical background on the evolution of arithmetic progression or arithmetic sequence is provided by the author. 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. If the rate of change varies significantly over time, more sophisticated models (e.g., geometric sequences, non-linear regression, or machine learning techniques) may be required.
4. Please provide a brief explanation about the method to determine shoreline change.
   Response from author:
   I appreciate the suggestion. A brief explanation of the method used to determine shoreline change is as follows: 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.

5. Check Typo and Grammatical Error in the manuscript

   Response from author:

   The author has thoroughly proofread the entire document once more to fix any additional typos or grammatical mistakes. I appreciate your assistance in making the manuscript better.

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Shoreline Detection using Image Processing for Coast of Pangandaran

ARTICLE INFO

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Received XX January 20XX;
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Satellite imagery.

ABSTRACT

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.
~~This study intends to explore the shoreline changes along Indonesia's Pangandaran coast, a popular tourist destination for both domestic and foreign visitors~~. 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. ~~Planting soft and/or hard structures is one way to prevent changes to Pangandaran's coastline~~. 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).

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

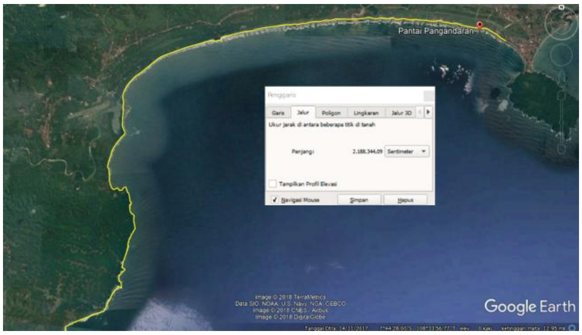
Figure 9: Condition of Plants Section 2 on the West Coast of Pangandaran at Coordinates 07° 42' 03.47" S; 108° 39' 23.20" E

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.

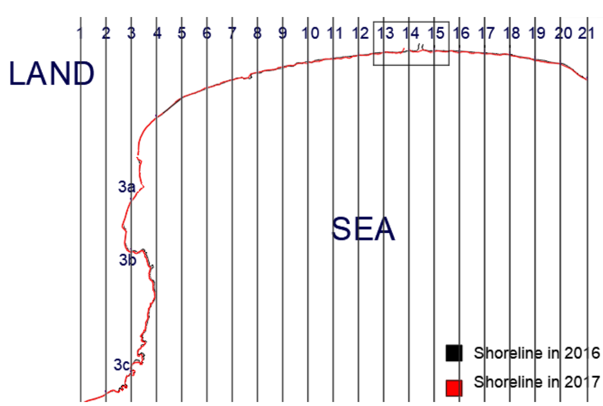
Figure 10: Distance on Google Earth



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.

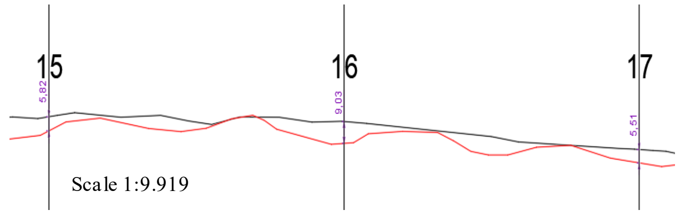
Figure 11: Coastlines in the year 2016 and 2017



Source: Author

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



Source: Author

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

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

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
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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

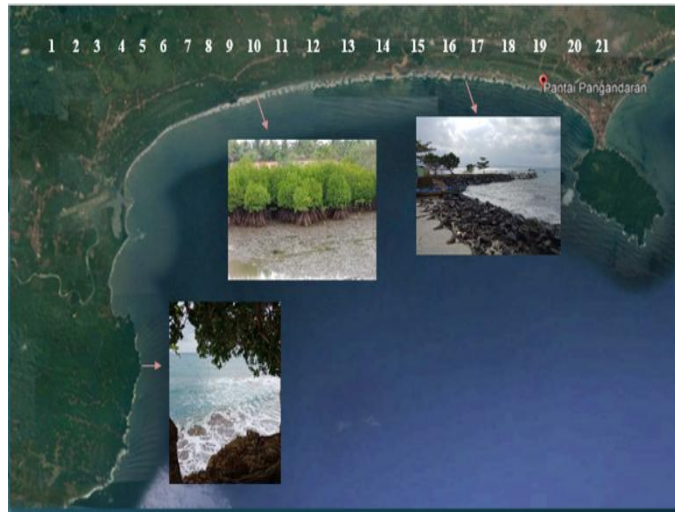
Table 4. Shoreline change from point 17 to point 21

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

~~The coastline changes at Pangandaran's coast over a ten-year period are obtained using remote sensing techniques from the Google Earth Pro application. Using AutoCAD software and a straightforward tracing method, the shoreline change rate is determined. Using an arithmetic sequence, the rate is used to predict the change in the coastline.~~ 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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Keputusan bahwa artikel diterima (22 Agustus 2022)

Editor memberikan keputusan bahwa artikel diterima melalui sistem manajemen jurnal disertai lampiran hasil reviu.

Editor Decision

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Participants

Sr. José Agustfn Gonzalez Almeida (jagonal)

Olga Pattipawaej (olga171 2)

Messages

Note	From
Dear Author We have reached a decision regarding your submission to JMR. Our decision is to: Accept Submission. Please find enclosed the review results of your article. Yours sincerely JMR Editorial Board 642ed.pdf	editor1 2022-8-22 01:39 PM
Thank you so much for the good news for me. Sincerely, Olga Pattipawaej	olga 1712 2022-8-22 02:27 AM

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Review Results:

General Comment	Rate	Comment
Topics	4	The topic of coastline change is highly relevant to the Journal of Maritime Research because it addresses important environmental, social, economic, and policy issues in marine science. Coastal changes affect maritime environments, resource management, and the welfare of coastal communities, while also driving the development of technology and monitoring methods. Its strong connection to these aspects makes coastline change into a fitting subject for maritime research journals.
Abstract and Keywords	3	The abstract explains that Indonesia's coastline is shaped by both natural processes and human activities, with changes reflected in shifting shoreline positions influenced by multiple interacting factors. This study aims to identify coastline changes along the Pangandaran coast, a major tourist destination, using Google Earth Pro satellite imagery. Shoreline change rates were calculated with simple statistical methods and projected with arithmetic sequences, predicting a abrasion and sedimentation. To mitigate these changes, soft or hard protective structures are recommended, while future research should analyze coastal defenses such as mangroves and breakwaters.
Goal	4	The Introduction clearly presents the research objectives and problem formulation. The study focuses on Pangandaran Beach, a top tourist destination in West Java, using satellite imagery from Google Earth Pro to obtain coastline data. The rate of shoreline change was estimated through a simple tracing method in AutoCAD, and these values were used to predict future coastline changes.
Structure	4	The paper is well-structured, presenting a clear and logical flow that makes the research easy to follow. It includes an introduction, problem formulation, methods, results and discussion, conclusions, and references, effectively guiding

		readers through the author's ideas and arguments.
Tools and Methods	4	The research used data processing and field observations to investigate coastline changes in Pangandaran. The study began with visual identification through field surveys to observe abrasion, land use, and community activities, while shoreline data were collected from Google Earth satellite images.
Discussion and Conclusion	3	The method is highly adequate and well-applied, demonstrating strong relevance, rigorous data collection and analysis, and clear procedures that ensure transparency, validity, and reproducibility, making the research trustworthy.
Literature	3	The author includes all relevant data, references, and quotes, allowing readers to verify the findings, confirm claims, and assess the research's reliability.
Wrting Style	3	The author writes with clarity, consistency, strong arguments, and simplicity, ensuring the message is communicated acceptable, understandable, and engagingly to readers.
Publication Decision		Accepted

*Rate: (5) Excellent, (4) Good, (3) Fair, (2) Needs Improvements, (1) Poor

Additional comments:

The article *Shoreline Detection using Image Processing for Coast of Pangandaran* is a technical engineering study that applies existing theories to practical problems using technological solutions. It demonstrates how remote sensing and image processing can be implemented to detect shoreline changes, presenting results supported by strong data and analysis that answer the research questions. The discussion interprets these findings, explains their implications for engineering, and shows their contribution to advancing knowledge and innovation in remote sensing. The conclusion highlights the key outcomes and suggests directions for future research and applications.

Analyzing coastline changes in Pangandaran with remote sensing offers key benefits for environmental monitoring, disaster risk management, resource management, spatial planning, and climate change tracking, while supporting follow-ups such as policy implementation, advanced research, community involvement, institutional collaboration, and adaptive solutions for coastal management.

Artikel siap diterbitkan (26 Oktober 2022)

Informasi telah diterima via sistem manajemen jurnal secara online maupun email pada tanggal 26 Oktober 2022 bahwa artikel akan diterbitkan pada tanggal 31 Oktober 2022.

Article ready for publication

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Participants

Sr. José Agustín González Almeida (jagonal)

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Messages

Note	From
Dear Author Please find enclosed the final layout of your article which will be published in the next issue of JMR on 31 October 2022. If there is any incorrect information, please let us know. Yours sincerely JMR Editorial Board 642.pdf	editor1 2022-10-26 01:39 PM
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Shoreline Detection using Image Processing for Coast of Pangandaran

O. Pattipawaej[1,2]*

ARTICLE INFO ABSTRACT

Article history:
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Keywords:
Coastline change, Forecast, Satellite imagery.

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

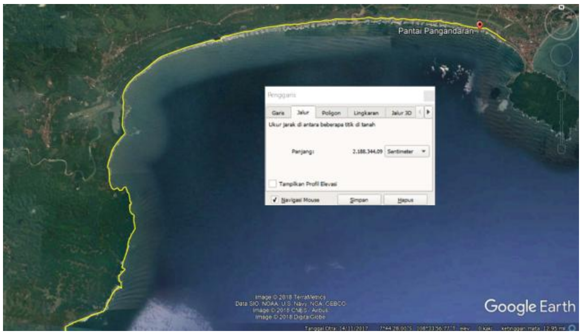
Figure 9: Condition of Plants Section 2 on the West Coast of Pangandaran at Coordinates 07° 42' 03.47" S; 108° 39' 23.20" E

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.

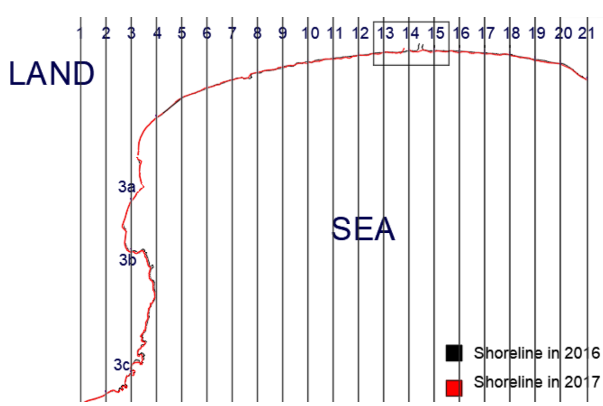
Figure 10: Distance on Google Earth



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.

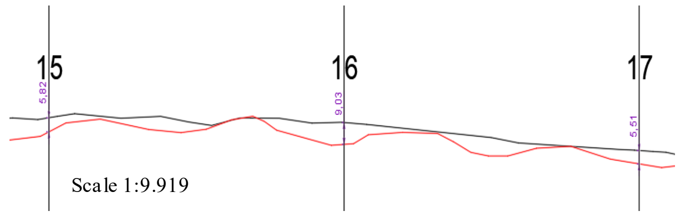
Figure 11: Coastlines in the year 2016 and 2017



Source: Author

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



Source: Author

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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