



2nd International Seminar on Ocean and Coastal Engineering, Environment and Natural Disaster Management, ISOCEEN 2014

Determination of Shoreline Changes from 2002 to 2014 in The Mangrove Conservation Areas of Pamurbaya using GIS

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Abstract

Shoreline along mangrove ecosystem in the East Coast of Surabaya (*Pamurbaya*) changed over the years. This study used Landsat Thematic Mapper (TM) 2002 and Google Earth images in 2002 and 2014, as well as field data. Geographic information system (GIS) technology was used to overlay some satellite images to study shoreline changes. The results showed that shoreline in the specified study area have changed, that is 5.387 m, 5.428 m, 5.128m, and 7.431 m in 2002, 2007, 2011 and 2014 respectively. Over the past 12 years the areas of the study tend to increase. The changed areas in 2007, 2011, and 2014 based on shoreline in 2002 are 683.970 m², 1.617.807 m², and 2.397.289 m² respectively. The total mangrove conservation areas that experienced accretion are 287.16 hectares whereas those for abrasion are 11.02 hectares. These results are important for the government in making management strategies of the coastal areas.

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Peer-review under responsibility of the Department of Ocean Engineering, Institut Teknologi Sepuluh Nopember.

Keywords: *Keywords:* Shoreline changes; Geographical Information System; and Mangrove Areas.

1. Introduction

The coasts in the North Coast of Java are very dynamic, including the east coast of Surabaya (Pamurbaya). They are results of erosion and sedimentation processes. Abrasion process in several places on the East Coast of Surabaya has been increasingly eroded the shoreline, causing some loss of residential land and mangroves and increased land in other places. In other places, especially near the mouth of the river raised sedimentation processes are quite heavy.

With the sedimentation process that takes place in coastal areas causing shoreline change tend increasingly toward the sea. Usually the emergence of new land in this area will be used for various activities. Changes in mangrove areas

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especially shoreline that includes changes in land use and the shoreline itself can be seen through remote sensing image. Results of the analysis of remote sensing data processing are performed with geographic information systems and then they can be used to analyze shoreline changes.

Gainau (2011)¹ has conducted an overlay image of TM in 2000 and 2009 and states that the maximum shift the coastline as far as 444.87 m with a shift of the shoreline every year as far as 49.43 m / year is located in the north of the east coast of Surabaya, in the village Kejawan Putih. He suggest to perform calculations and a more accurate assessment.

This study will be carried out analysis of satellite imagery TM2002, google earth 2002, 2007, 2011 and 2014 as well as the field investigation to several places in Central Mangrove Pamurbaya to clarify areas of abrasion and accretion that has occurred. With the accretion and abrasion, we will provide alternative solutions in the management of coastal areas of Pamurbaya, especially around the mangrove areas.

Therefore, the purpose of this study was to determine changes in the coastline and land area changes in mangrove conservation areas of Pamurbaya. The results of shoreline analysis in these areas can be used for making development and management strategies of the areas.

2. Materials and Methods

This research was carried out for 8 months from March to October 2014. Location of the study is the mangrove conservation areas in the Pamurbaya of East Java at position 7°12' South Latitude - 112°36' East Longitude and 7°21' South Latitude - 127°54' East Longitude. Map of study sites in Fig. 1. Materials or data used in this study include: Data used in this study is the topographical map scale of 1: 25,000, satellite imagery data of Surabaya in multi-years, TM, 2002, google earth image, 2002, 2007, 2011 and 2014. Three of software used to process satellite imagery data and calculate the area of land that is experiencing accretion and erosion, namely: software ArcView 3.3, and image Analysis 1.1. The method used in this study includes a survey and GIS analysis method. In summary, this study flow diagram is presented in Fig. 2.



Fig. 1. Map of Research Location in the City of Surabaya

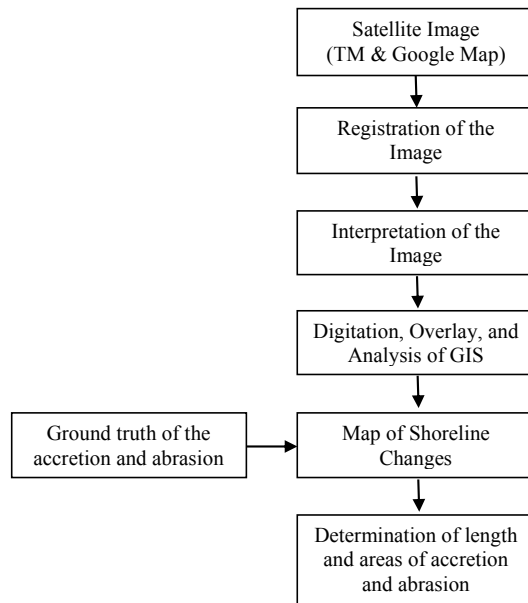


Fig. 2. Flowchart of Research Methods

Spatial data were processed using ArcView 3.3 software. In principle the processing of data with geographic information systems (GIS) are data entry, data analysis and display of data. Data entry associated with spatial data and tabular/textual data. Spatial data is inserted through the process of scanning, digitization, or import data from existing digital maps. Textual data entry will follow the spatial data. Once the data is entered, the next step is to process spatial data in accordance with the needs, for example: overlaying, buffering, counting area. The last stage is the display of data. Display data could be maps, graphs, tables or storage in electronic media, such as multimedia.

Some important spatial data processing operations used in this research is the process of digitized maps, overlaying process, the calculation of the long coastline and land, as well as the manufacturing process of (layout) maps.

In the data processing rate of change of the coastline, we do digitization process map "shoreline" in a good image in 2002, 2007, 2011, and 2014. Previous to be ensured that the image has been corrected geometric correctly in the previous stage. Furthermore, data from digitized shoreline in 2002, 2007, 2011, and 2014 are displayed in a single layer. Both coastlines are used to cut the polygon to be determined total area. Thus, the area as a result of changes in shoreline areas can be determined by count tool.

In determining changes in the coastlines used a line perpendicular to the shoreline as the basis for its determination. In this study used a line perpendicular to the coastlines of satellite imagery in 2002 as a baseline.

3. Result and Discussion

3.1. Mean Sea Level

As the basis for determining the shoreline used mean sea level and perpendicular to the coast line which has been described in the research methods. Mean sea level is also used as the basis for the coastline of topographic maps of

the Geospatial Information Agency and bathymetric map of Hydro-Oceanographic Department of the Navy. Therefore, the two maps are used as a basis for determining changes in the coastline.

As the observation of shoreline selected reference location tend coastline remains, namely in the village Nambangan, Kenjeran Surabaya geographically in a position 7°12' South Latitude - 112°36' East Longitude and 7°21' South Latitude - 127°54' East Longitude. This position is also used by Prasita and Kismarti (2013)², for the tide observations in the determination of the mean sea level. One point on the mean sea level is at the position X = 9,201,353 and Y= 49,697,948 with UTM projection.

3.2. Result of Satellitete Image Data Processing

To equalize the position of the satellite imagery from different years and different types of satellite imagery, then use a clear identification of objects, among others: Object in Kenjeran roundabout at the position (699,389.09: 9,197,757.17), Road to the intersection with the position longest (695,131.04: 9,197,928.53), mapped mangrove on the border of Gunung Anyar with position (701,812.15 : 9,186,826.10), and Central Bridge with position (695,170.85: 9,191,648.29), as well as the intersection of Jemursari - Ahmad Yani with position (691,103.40: 9,189,531.78). Projection map in ArcView software are as follows: Projection = TM, spheroid = WGS84, Map units = meters, Distance units = meters, Central Meridian = 111.00072, R.L. = -90.0167, S.F. = 0.9996, East False and False = 500000 North = 200.

By using projection and some connective point the satellite imagery maps from different years and different sources of the map can be displayed properly position. Thus, the results of the digitization process for TM satellite imagery and Google Earth 2002, 2007, 2011 and 2014 can be seen in Fig. 3a and Fig. 3b below. Digitization process use polyline features to determine the shoreline and use polygons to determine the area to undergo changes. They can be converted from polygon features into polyline features to determine the shoreline changes.

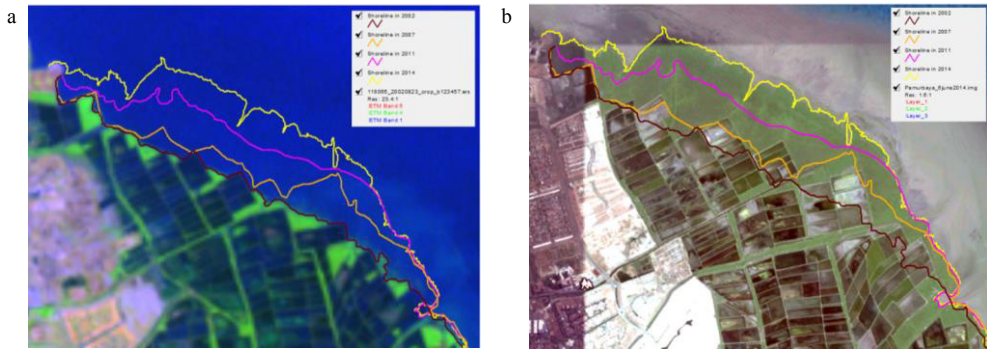


Fig. 3. Result of shorelines' digitation in 2002, 2007, 2011 and 2014 with (a) the background of TM satellite image in 2002; (b) the background of google map satellite image in 2014.

By using the tool overlay and count areas, the area of the polygon can be calculated. One example of how to calculate the length of the coastline and the area is shown in Fig. 4. The calculation result of areas, perimeters, and shorelines are shown in Table 2.

Table 2. The calculation result of areas, perimeters, and shorelines of the highest accretion areas in the year of 2002, 2007, 2011, and 2014

Year	Area (m ²)	Changed Area (m ²)	Perimeter (m)	Shoreline (m)
2002 (Baseline)	597,000	0	9,514	5,387
2007	1,280,970	683,970	9,673	5,428

2011	2,214,807	1.617,807	9,729	5,128
2014	2,994,289	2.397,289	12,127	7,431

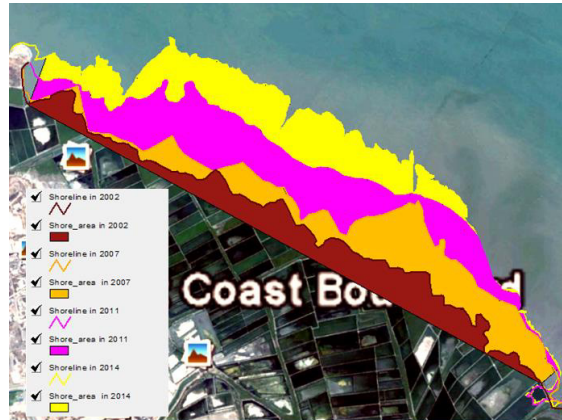


Fig. 4. Result of overlay, polygons are picked from shoreline of Satellite image TM in 2002 and Google Earth in 2002, 2007, 2011 and 2014

3.3. Shoreline Changes in Pamurbaya

Shoreline change occurs as a result of two events, accretion and abrasion. Accretion beach is a beach which experienced material addition caused by the deposition of material from the river, while the coastal erosion is a condition of the coast on the skirts because of the activities of sea water.

The process of erosion, transport and deposition of sediments depends on two factors, namely the physico-chemical properties of the sediment itself and the surrounding hydrological conditions (Mc Dowell and O'Connor, 1977)³. Sediment carried in layers will be mixed flow and so up in the estuary so that sediment lifted to the upper layer and might be carried to places further by currents and waves (Olson and Burgess, 1967)⁴. Carefoot (1977)⁵ states that the grains of sediment can be transported in large quantities due to currents and wave activity intensified in the estuary. It can be seen from the changes in the coastline near the mouth of the river.

King (1974)⁶ stated that the changes in the coastline can not be separated from the three main processes, namely wave, tidal and wind. The third process is to act as variables to the beach material, which affects the shape of the beach profile.

The focus of this research is mangrove conservation area in Pamurbaya with an area of 2541.84 ha 25,418,402.629 m² = the length limitation of 31022.102 m. Mangrove areas were developed for tourism area that needs wise and sustainable management. Mangrove areas can be seen in Fig. 5 below. Mangrove areas in 2007 were determined based on the Surabaya City Regulation No. 3 Year 2007 on Spatial Surabaya (Surabaya City Government, 2007)⁷ look wider than the condition of mangroves in 2002 shown in Satellite Imagery TM 2002.

Process of accretion and erosion in the mangrove conservation area of Pamurbaya are shown in Fig. 5b. The process of accretion occurs mainly in the coastal sub-district and sub-district Mulyorejo, Gunung Anyar. The total area of the beach that experienced accretion of 287.16 Ha. While the accretion occurs mainly in coastal District of Wonorejo. The total area of the beach that suffered abrasion of 11.02 Ha.

Based on the depth interviews, changes in shoreline rapid accretion on the east coast are in District of Mulyorejo affected by the disposal of dredging the mouth of Kalimas Surabaya are disposed near the region so that with the influence of oceanographic parameters, such as: the ebb and flow, the waste material accelerate the accretion process.

Shoreline change is also observed by Moko *et al.* (2012)⁸. They stated that the addition of the mainland (accretion) in Surabaya, Sidoarjo East of 51.01 ha occurred in 2006-2008 and a reduction in the mainland (abrasion) occurred in 2009 amounted to 18.92 ha.

According Moko *et al.* (2012), changes in shoreline coastal East Surabaya and Sidoarjo can be caused by several things: (1). Sediment carried by the rivers that empty into the beach Surabaya-Sidoarjo, such as: the Brantas River and the Porong River; (2). Reclamation performed by residents or developers in coastal areas.

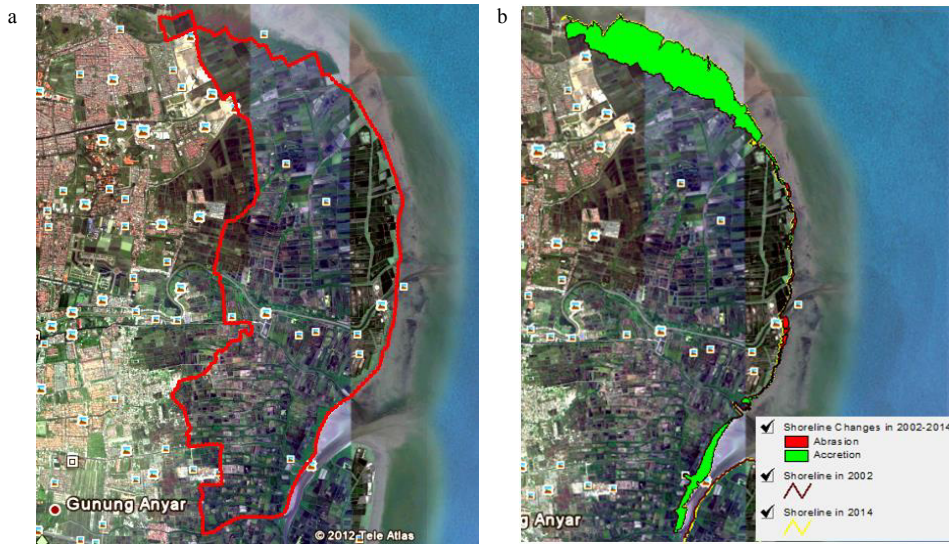


Fig. 5. (a) Mangrove Conservation Area (MCA) based on Perda No 3 Tahun 2007 (Pemkot Surabaya, 2007)⁸ which is shown in satellite image TM 2002; (b) Location of accretion and abrasion in the MCA.

The calculation result of shoreline changes in detail is as follows. Accretion of coastal land and abrasion of coastal land for 12 years from 2002 to 2014 are shown in Table 2. It is found 44 areas of shoreline changes along the coast of Pamurbaya. Total area of the coast which are increased are 2871698.418 m² (287.16 hectares) and the abraded areas of the coast are 110258.206 m² (11.02 hectares).

Table 2. The calculation result of coastland areas which are increased and decreased in 12 years, from 2002 to 2014.

ID	Shoreline changes	Accretion (m2)	Abrasion Area (m2)
1	Accretion	2440749.172	-
2	Abrasion	-	10628.855
3	Accretion	376.525	-
4	Abrasion	-	10.789
5	Accretion	18792.762	-
6	Abrasion	-	240.102
7	Accretion	4509.664	-
8	Abrasion	-	5253.256
9	Accretion	4055.111	-
10	Abrasion	-	10097.800

11	Accretion	3163.766	-
12	Accretion	3676.302	-
13	Abrasion	-	12859.067
	Shoreline changes	Accretion (m2)	Abrasion Area (m2)
14	Accretion	8934.141	-
15	Abrasion	-	2404.669
16	Accretion	268.974	-
17	Abrasion	-	23.783
18	Accretion	527.297	-
19	Abrasion	-	292.160
20	Accretion	851.245	-
21	Abrasion	-	10796.929
22	Accretion	1312.396	-
23	Abrasion	-	210.695
24	Abrasion	-	33516.454
25	Abrasion	-	16283.463
26	Abrasion	-	1147.550
27	Accretion	268.854	-
28	Abrasion	-	2081.197
29	Abrasion	-	148.597
30	Accretion	240.714	-
31	Abrasion	-	353.414
32	Accretion	84.290	-
33	Abrasion	-	659.844
34	Accretion	591.702	-
35	Abrasion	-	140.040
36	Accretion	2381.639	-
37	Abrasion	-	51.550
38	Accretion	2235.690	-
39	Abrasion	-	28.723
40	Accretion	31203.825	-
41	Abrasion	-	2915.676
42	Accretion	673.383	-
43	Abrasion	-	113.593
44	Accretion	346800.966	-
	TOTAL	2871698.418	110258.206

4. Conclusion

It can be concluded that (1). Change the length of the shoreline is not always followed by accretion of coastal land areas; (2). The pattern of changes in the shoreline in Northern and Southern Mangrove Region of Pamurbaya tend to accretion but aberration in the eastern; (3). Overall, the land areas increased (accretion) of 287.16 hectares, while the total areas of 11.02 hectares are abraded. Areas experiencing accretion is including Mulyorejo and Gunung Anyar while experiencing abrasion areas are beaches in Wonorejo.

Acknowledgements

The authors acknowledge the Board of Research and Public Services - Higher Education (DP2M-DIKTI), Ministry of Education and Culture of the Republic of Indonesia for financial support of this research as well as Institute of Research and Public Services – Hang Tuah University (LPPM-UHT) Surabaya.

References

1. Gainau, O.Y.S. *Remote sensing analysis for identification of shoreline changes in the East Coast of Surabaya (Analisa penginderaan jarak untuk mengidentifikasi perubahan garis pantai di Pantai Timur Surabaya)*, *Theses of Magister Program*. The Department of Ocean Engineering, Institut Teknologi Sepuluh Nopember Surabaya; 2011.
2. Prasita, V. Dj. and E.A. Kisanarti. Prediction of sea level rise impacts on the coastal areas of Surabaya using GIS, *The International Journal of Engineering and Science*. ISSN(e): 2319 – 1813 ISSN(p): 2319 – 1805 2013:2:7. www.theijes.com
3. Mc. Dowell, D.M. and O'Connor, B.A. *Hydraulic Behavior of Estuaries*. The Macrchollan Press. London ;1977
4. Olson, T.A. and Burgess, F.J. *Pollution and Marine Ecology*. John Wiley and Sons Publisher, New York : 1967
5. Carefoot, T. *Seashore Ecology*. University of Queensland Press. St. Lucia-London – Newyork; 1977.
6. King, C.A. *Coast in geomorphology in environmental management an introduction*. Clarendon Press. Oxford ; 1974.
7. Arifin, Samsul. *Mangrove management based on society empowerment (Pengelolaan mangrove berbasis pemberdayaan masyarakat)*, Dinas Pertanian – Pemerintah Kota Surabaya, Indonesia ; 2011.
8. Moko, G. I., T. Hariyanto, Wiweka, S. Julimantoro. *Evaluation of land cover changes in the coastal zone of Sidoarjo with multi-temporal satellite (Evaluasi perubahan tutupan lahan wilayah perairan pesisir Surabaya Timur Sidoarjo dengan menggunakan citra satelit multi-temporal)*. Institut Teknologi Sepuluh Nopember Surabaya; 2012. <http://digilib.its.ac.id/public/ITS-Undergraduate-15983-3507100025-Paper.pdf>.
9. Pemkot (Pemerintah Kota) Surabaya. *Plan of Spatial Arrangement (Rencana Tata Ruang Wilayah/RTRW) Kota Surabaya*. Surabaya; 2007