Study for Comparative Analysis of Changes in Shore Line Using Multi Stage Satellite Images (Case Study: Gresik and Bangkalan, Indonesia)

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SUMMARY

The shoreline is always a very significant change from year to year. Shoreline changes are caused by many factors such as erosion, sedimentation, currents, tides, and other factors such as human activities. In Gresik and Bangkalan, Indonesia, an example of shoreline change is influenced by the presence of high activity in the coastal zone that serves as a port.

One method that can be used to determine changes in the shoreline is delineation method. This research employs this method with Landsat ETM 7 satellite imagery and QuickBird. Multi-stage method is also applied to determine the pattern of shoreline change.

The results showed that there was a reduction of length in 2002 along the shoreline, around 1.65 km in Gresik area. But, in 2007 Gresik has the addition of up to 18.05 km, while in Bangkalan there is a reduction approximately to 2.06 km. Reduction of land area occurred in 2002, it is around to 1,228.33 ha in Gresik and Bangkalan 147.44 ha. In 2007, there is additional area around 389.07 ha in Gresik and around 571.77 ha in Bangkalan. Then, there is additional area around 825.61 ha for both regions.

INTRODUCTION

The coastal area is a meeting area between the mainland and water (sea). This area is an important region since most of the world's population inhabits that region. The coastal area is continuously changing due to the dynamic interaction between sea and land. Wave and wind along the coast resulting erosion of rocks and sediment continuously. Erosion of rocks and sediment accumulation varies from day to day throughout the area. As a result of these factors, it can lead to a variety of things such as environmental pollution, coastal intrusion, as well as changes in the pattern of shoreline. In addition to the above factors, generally coastal areas are densely populated areas. One reason is the presence of high activity in the harbor. For example, Gresik and Bangkalan are examples of coastal areas in East Java, Indonesia. High activity at the port due to transportation ships in and out of the harbor is not directly result in sediment transportation. One of the effects of sediment transport is shoreline change. There should be an investigation in order to investigate the pattern of shoreline change in the region to support the plan and coastal management. Satellite imagery is one technology that can be used to analyze changes in the shoreline. By using multi stages satellite imagery we can compare the results of image processing to determine the shoreline change.

Research Objectives

The purpose of this study is as follows:

a. Comparing shoreline change based on Landsat ETM 7 satellite images of 2002 and Quickbird satellite images of 2007.
b . Analyzing pattern of shoreline change based on Landsat ETM 7 satellite images of 2002 and Quickbird satellite images of 2007.

RESEARCH METHODOLOGY

This research took the study area in Gresik and Bangkalan District. The location shows by the image below:

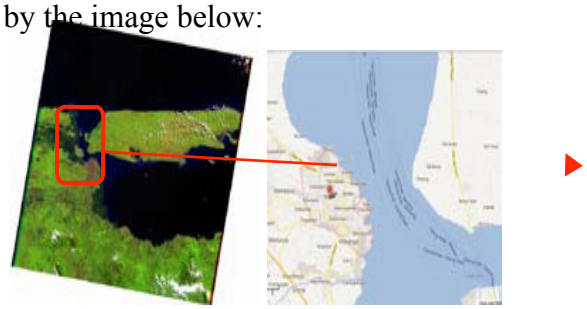

Figure 1. Research location

Data

The data used in this study consists of two types of data that are:

a. Spatial Data

1.Landsat 7 ETM image in 2002

Figure 2. Landsat 7 ETM image in 2002

2.Quickbird image acquired on 2007

3. Landsat 8 ETM imagery acquired in 2013

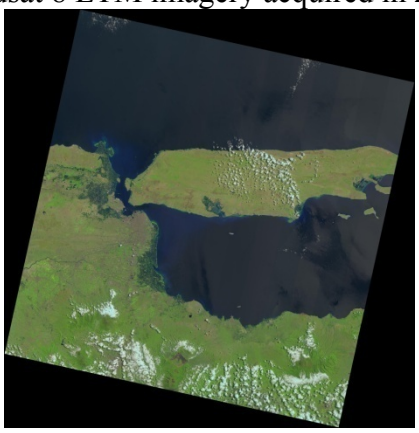

Figure 4. Landsat 8 ETM imagery in 2013

4. Ortho Landsat 7 ETM^{+} in 2002 is used as a reference in the geometric correction.

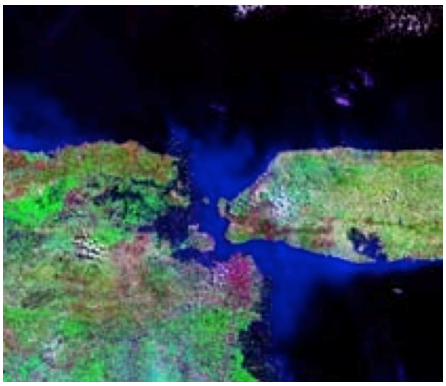

Figure 3. Quickbird imagery in 2007

Figure 5. Landsat orthorectified in 2002

b. Non-Spatial Data
Tidal data Gresik and Bangkalan 2002 and 2007.

Data Processing

The following is a description of the data processing phase:

a. Image cropping
Cropping the image is done to limit the area of research, reduce the size of the image processing and speeding up the process more thoroughly.

b. Geometric correction
The first image processing is to design network points as ground control point based on Ortho Landsat 2002 as a reference. Point network should satisfy standard value for strength of figure, approaching 0 (zero). Ground control points as reference for geometric correction, it is order to reduce the geometric error. Root mean square error value must be less than or equal to one pixel ($RMS_e \leq 1$ pixel).

c. Image masking
This step uses specific algorithm. The purpose of the algorithm is to distinguish boundary of land and water.
Algorithm used is as follows:

if I1/I2 > 0:50 then I2 else null

d. Overlay
Overlaying raster of the processed images and digitized maps results to find out the differences line.

f. Analysis
Analysis of shoreline change is obtained the result of image processing, based on factors influencing it. The analysis is done by comparing the results of each overlapping image. Tidal data used in 2002 and 2007, it is to determine the position of the shoreline.

g. Making of shorelines change map
The next process is the plotting of shoreline change, in Gresik and Bangkalan.

RESULTS

a. Cropping image
The image below is the result of cropping the image:

Figure 6. Cropping result for Landsat 7 ETM 2002 with composition of band 3, 2, 1

Figure 7. Cropping result for Quickbird 2007 with composition of band 3, 2, 1

Figure 8. Cropping result for Landsat 8 ETM 2013

b. Masking for water and land

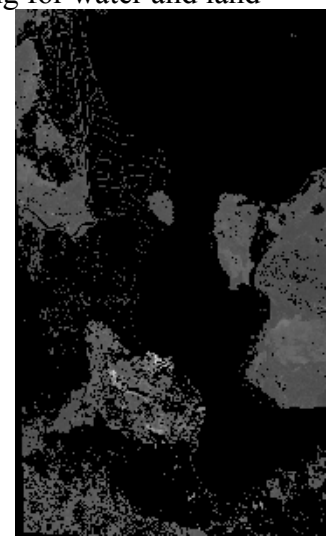

Figure 9. Masking result for Landsat 7 ETM 2002

Figure 10. Masking result for Quickbird 2007

The two pictures above are result for separation of land and sea (masking) by algorithm that compares the two types of bands in the image, band 4 and band 1. Applying with the combination of two bands, it appears that display images are quite clear distinction between land and sea. In the second image, land is described by gray or white colors while the black is presented for waters. Black color in the water caused by the reflectance is absorbed, but it is not reflected back. The result of masking process for two images is different because level of resolution.

ANALYSIS

Shorelines experienced several changes from year to year. In 2002 based on the shoreline Landsat 7 ETM, Gresik shoreline experiences a reduction of as much as -11.04 km, whereas Bangkalan experiences otherwise. In 2007, both the shoreline Gresik and Bangkalan, they experience reductions respectively -5.36 and -2.12 km as in Table 1 below

Table 1. Change in shoreline length

Data	Shoreline of Gresik (km)	Shoreline of Bangkalan (km)	Shoreline change (km)	
			Gresik	Bangkalan
LPI	42,59	33,96	0	0
Landsat	40,94	36.08	-1,65	2,12
Quickbird	58,99	34,04	18,05	-2,06

Based on the results of the shoreline overlay, it conclude that there is significant change of land area both in Gresik and Bangkalan as presented in table 2 below.

Table 2. Changes in Land Area

In Year	Gresik (ha)	Bangkalan (ha)
1993	1523,59	686,38
2002	-1228,33	-147,44
2007	389,07	571,77
2013	230.52	595.09

In 2002, there was a reduction in both locations is equal to 1228.33 ha in Gresik and 147.44 ha in Bangkalan. On the map overlay between LPI and Quickbird imagery, it seemed addition of extensive at some point is caused by sedimentation. Especially in area of the Port of Gresik in District Manyar, sedimentation can be induced sediment transport from the Bengawan Solo River. Stream sediment flowing into the area is due to the influence of the eastern monsoon. The eastern monsoon winds acrossing Indonesia in the rainy season is from October to March, which coincides with the time Quickbird image acquisition in such a way to produce the data. District of Bangkalan shows variations between gain reduction and wider but it is still dominated by the reduction in the District Bangkalan and Socah. The reduction caused by erosion of the rocks is located along

the coast. Profound changes can also be caused by the difference in resolution of the data used. Display of overlaying Landsat 7 ETM and Quickbird demonstrates that changes in land dominated by sedimentation. They can be seen clearly in all districts Gresik, Manyar, and in most of the District Bungah. Beside, this phenomenon is occurred on the side Kamal and Socah in Bangkalan. Based on the result of shoreline change, there are some changes in the pattern of shoreline. In the coastal region of Gresik there are some pattern changes since development of infrastructure along the coast. Based on the shoreline derived from Quickbird imagery in 2007, it looks any of several buildings; one of those is building in the port. As the area is a region of Gresik industry, the buildings that look is supporting the building industry. In the area of shoreline Bangkalan, patterns generated based on data processing imply not so many changes. This may be due to the absence of a significant development as it occurs in Gresik regency.

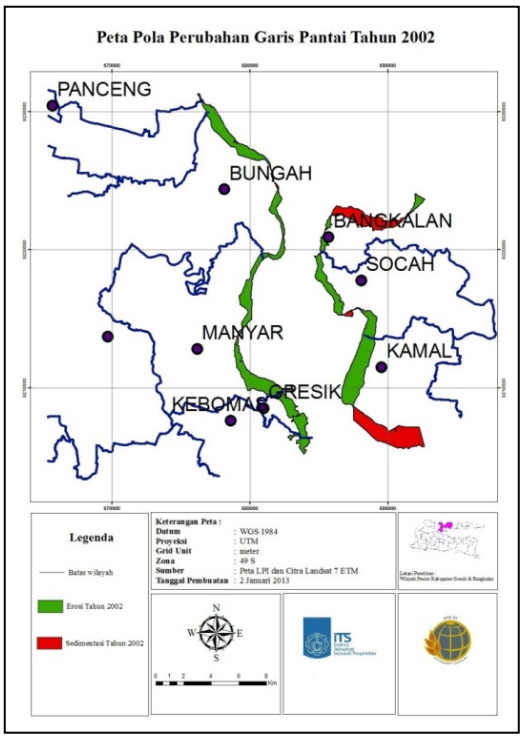

Figure 10. Shoreline change map of 2002

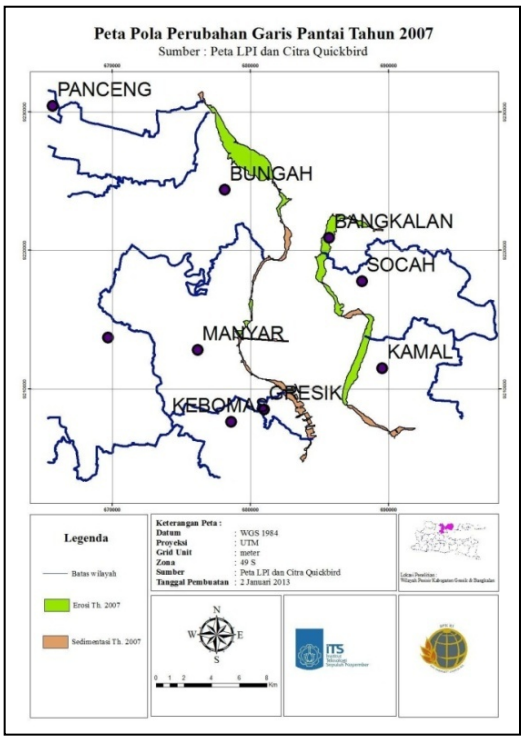

Figure 11. Shoreline change map 2007 based overlaying LPI Map and satellite imagery in 2007

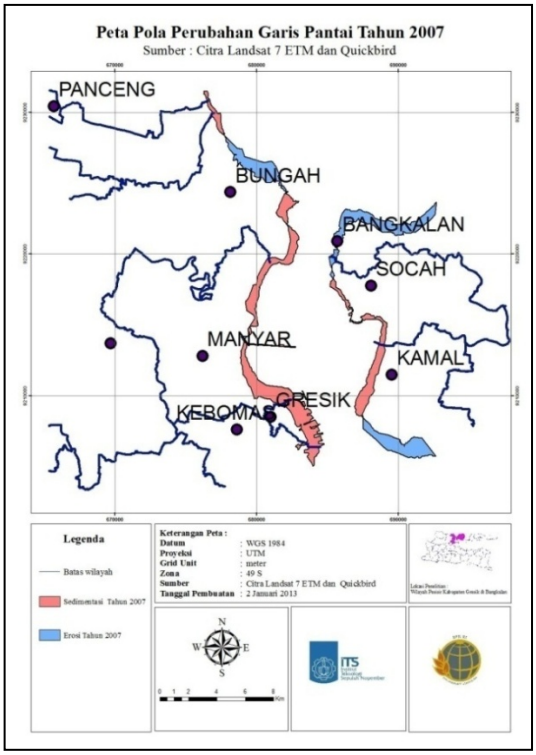

Figure 12. Shoreline change map 2007 based overlaying satellite imagery 2002 and satellite imagery in 2007

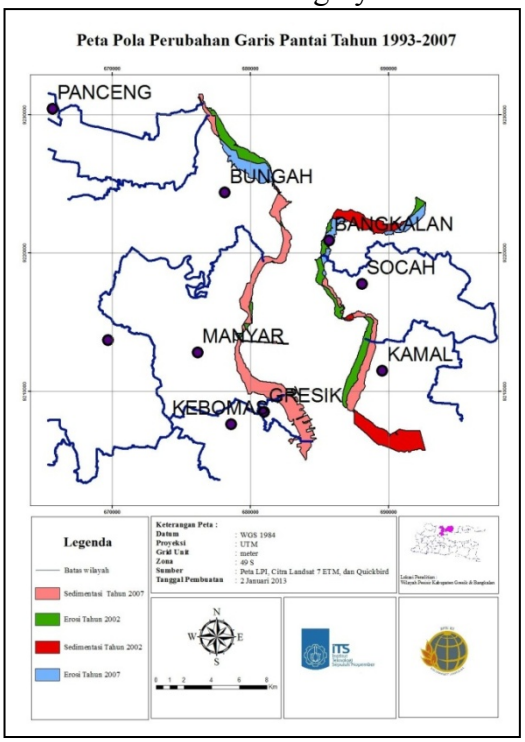

Figure 13. Map patterns of shoreline change 1993 – 2007

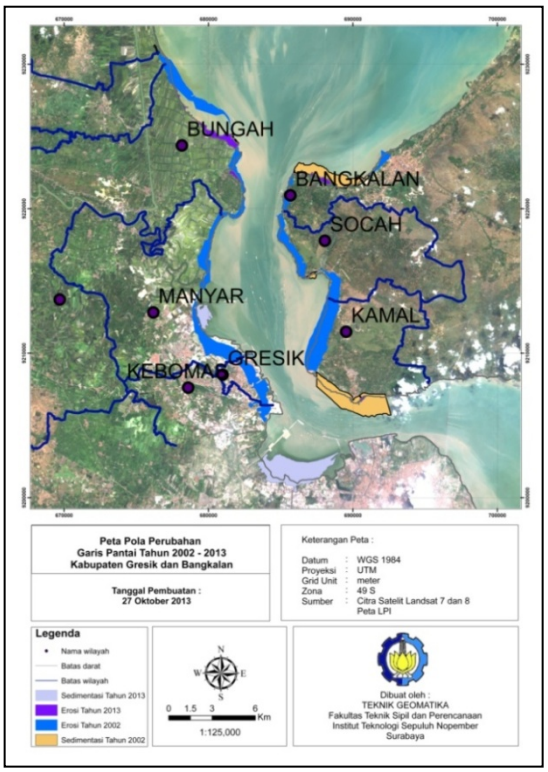

Figure 14. Map patterns of shoreline change 2002 – 2013

CONCLUSIONS

Based on the results, it can be concluded as follow:

1. In 2002, long shoreline presents a reduction of 1.65 km for Gresik, while it shows increments of 2.12 km for Bangkalan. In 2007, the shorelines at Gresik have added up to 18.05 km long, while the region experienced a reduction of as much Bangkalan 2.06 km.
2. For land area at 2002, there is reduction about 1228.33 ha in Gresik, while in Bangkalan, the reduction is about 147.44 ha. The both of changes is due to a dominant erosion. For 2007, the land of Gresik has additional broad around 1228.33 ha while in Bangkalan, it has additional area about 571.77 ha.
3. Changes occured in Gresik and Bangkalan could be due to sedimentation by high activity in the harbor since sediment transport from Solo River during east monsoon blown. The factor of shoreline change in Gresik is caused majorly by the construction in coastal areas such as ports.

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