Analysis of Shoreline Changes Before and After the Tsunami at Tanjung Lesung Beach, Banten Province of Indonesia

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Abstract. This study aims to determine the change in the shoreline in Tanjung Lesung Beach, Banten Province of Indonesia. The population in this study was a pixel. This research uses the descriptive quantitative method with a survey approached. Technological advances in remote sensing and GIS can be used to analyze shoreline changes, such as the following research using Landsat 8 satellite image data to measure how much change occurred after the tsunami on Tanjung Lesung Beach, Banten. Data used derived from 2018 to 2019 (from USGS Landsat 8 OLI) to derived the coastline from satellite, land and sea data must be separated using a combination of 6,5,4 bands. Shoreline data digitized and measured using DSAS (digital shoreline analysis system). The extensions of the Arc GIS application will estimate the rate of change in shoreline with two statistical techniques such as End Point Rate (EPR) and Net Shoreline Movement (NSM). Therefore, this study can be used by the government and society for determining development planning, hazard zoning, accretion-abrasion studies and assess the concept of disaster hazards model such as tsunami.

1. Introduction
The beach is an area that is affected by the dynamics of processes on land and at sea. In this region, complex dynamics occur that can cause structural changes that are relatively fast [4]. Geomorphological processes that work in the coastal zone can be divided into two, namely destructive and construction. Destructive processes tend to damage or change the shape of existing land, while the construction process is producing a new landform [11].

Coastal accretion and abrasion occur due to the presence of sediment input from land to the coast and the influence of hydro-oceanographic factors in the form of waves and currents that carry sediments. If the sediment rate is not proportional to currents and waves, sedimentation will occur on the coast, but if the sediment rate from land is smaller than currents and waves from the sea, abrasion will occur [9]. The process of accretion and abrasion causes unbalanced beach conditions and impacts on damage in the Coastal region [2].

Damage due to accretion can cause closure of the estuary. While abrasion can cause damage to access roads, buildings around the beach (houses, factories, harbor facilities), rice fields, pool areas, and beach recreation areas [8].

The impact of shoreline changes indicates that shoreline monitoring is necessary. Monitoring changes in the coastline is very necessary for the planning of coastal protection buildings, detecting damage in coastal areas, and as a reference in making a policy for the development and management of coastal areas [7].

Tsunami such as one of the natural factors that cause changes in the coastline in a relatively short time. Tsunamis generally occur after tectonic earthquakes on the seabed, but not all tsunamis occur to start with tectonic earthquakes. The research in Lhoknga Beach describes coastline and land cover changes after tsunami caused tectonic earthquake [10]. The difference between this study and other studies is that the data used are Landsat 8 OLI imagery with a resolution of 30 meters sharpened 15 meters and the cause of the coastline change at Tanjung Lesung Beach is the silent tsunami. Tsunamis generally occur preceded by tectonic earthquakes, but in this case, the tsunami occurred caused by waves triggered by the eruption of Mount Anak Krakatau. On December 22, 2018 a tsunami had occurred in the Sunda Strait without beginning with a tectonic earthquake. The tsunami was caused by an abnormal tidal wave due to the full moon and landslides that occurred under the sea after the eruption of Mount Anak Krakatau. The disaster caused a huge disadvantage [14].
2. Methods

2.1. Study Area
Tanjung Lesung Beach, Tanjung Jaya Village, Pandeglang Regency, Banten Province has a coastline of ± 6 Km (Figure 1) chosen as a research location. The study was carried out in July 2019 to August 2019. The field survey conducted on 8-10 August 2019, which included tracking coastlines and checking shoreline changes that occurred at Tanjung Lesung Beach, Tanjungjaya Village, Pandeglang Regency, Banten Province.

![Figure 1. Study Area](image)

2.2. Data Acquisition
The analysis part for the study area is done by direct as well as visually interpreted from the satellite data. The data used in this study are coastline data obtained by the shoreline extraction method from Landsat 8 OLI imagery 2018 and 2019 compiled from the United States Geological Survey (USGS) website (Table 1.). Satellite image data used in this study were selected based on criteria of less than 10% cloud cover.

| No. | Satellite Imagery | Acquisition Date | Sensor Type                       |
|-----|-------------------|------------------|-----------------------------------|
| 1   | Landsat 8         | 20/12/2018       | Operation Land Imager (OLI)       |
| 2   | Landsat 8         | 05/01/2019       | Operation Land Imager (OLI)       |

Source: Earth Explorer USGS
2.3. Data Processing

2.3.1. Radiometric Correction
Landsat 8 images each year will process with several stages, such as a radiometric correction to correct images caused by satellite damage or atmospheric disturbance [3]. The radiometric correction was performed using ENVI 5.3 software with the Reflectance Radiometric Calibration method and FLAASH (Fast Line of Sight Atmospheric Analysis of Spectral Hypercubes). The Reflectance Radiometric Calibration method is used to sharpen satellite images, while the FLAASH method is used to eliminate disturbances caused by the atmosphere.

2.3.2. Composite Band
After radiometric correction, the next process is delineation to obtain shoreline information by separating land and water that will be analyzed using a composite band technique to display the boundary of the observed object [5]. The delineation process uses the MNDWI (Modified Normalized Difference Water Index) method, which is one of the best ways for separating land and water [1]. The formula used for the MNDWI process for Landsat 8 defined as follows [6].

$$MNDWI = \frac{Green - SWIR_1}{Green + SWIR_1}$$

The next process is to convert NDVI raster data into vector data, then digitize using the on-screen digitizing method.

2.3.3. Digital Shoreline Analysis System (DSAS)
Digital Shoreline Analysis System (DSAS) is a statistic and geospatial-based calculation of shoreline changes using points as a measurement reference [7]. All the shorelines added in a single shapefile in a Personal Geodatabase. For every shoreline, the date from which the shoreline made must add in the attribute as MM/DD/YYYY. Baseline, from which the changes calculated, is required in another shapefile in the same Database. The coastline buffered for 100 meters in the shore and it used as the baseline. Using DSAS, transects are laid perpendicular to the shore for every 10 meters along the shore for the entire shoreline from the baseline. The computation of the shoreline change, many methods were available in the DSAS. Still, the Net Shoreline Movement (NSM) and End Point Rate (EPR) are used in this study because they can analyze how much the shoreline changes.

3. Results and Discussion
The result from USGS Landsat 8 OLI image analysis from 2018 to 2019 shows a variation of shoreline changes in Tanjung Lesung Beach. This is due to abrasion and accretion in this area. This change shows the dynamic transformation of shoreline along the coastline of Tanjung Lesung Beach after the tsunami. In the short and long time, the changes of shoreline should be analyzed [13] and mapped as those are important for navigation safety, coastal resource management, environment maintenance, development of coastal resources, and city planning. The shoreline changes are important information for mapping and deformation of coastline [12].

3.1. The Shoreline of Tanjung Lesung Beach Before Tsunami
The shoreline of Tanjung Lesung Beach before the tsunami was undamaged, as shown in Figure 2. It indicates the shoreline of Tanjung Lesung Beach before the tsunami.
3.2. The Shoreline of Tanjung Lesung Beach After Tsunami

The result analysis of the shoreline of Tanjung Lesung Beach area before and after tsunami based on the overlaid result of image using GIS tool from 2018 to 2019 shows various changes in Figure 3.

After the tsunami, the shoreline of Tanjung Lesung Beach changed in certain areas, as noted with the diminished of the green area in Figure 3. This change is caused by the abrasion and accretion caused the effect from the tsunami in the land has diminished some part of the shoreline. However, tracing back the damage can be retrieved again as long as the image data are available.
3.3. The Changes of Shoreline After Tsunami in Tanjung Lesung Beach

The results of the analysis of the shoreline using DSAS showed that there were significant changes such as abrasion and accretion caused by the tsunami disaster at Tanjung Lesung Beach. The change inflicts the residents such as fishers having to rebuild a harbor for ships to dock. Maximum abrasion occurs in the northern part of Tanjung Lesung Beach with an area of 15,229 m² while maximum accretion occurs in the west of Tanjung Lesung Beach with an area of 6,155 m². The total distance and field of erosion and accretion showed in Table 2.

Table 2. Summary of the Result

| Result  | Area (Sq. M) | Length (Km) |
|---------|-------------|-------------|
| Abrasion| 25,802      | 4.43        |
| Accretion| 8,195      | 1.62        |

Source: Result of Data Analysis, 2019

From the various data sets, used to estimate the shoreline change, the change rate of the coast varies randomly for every alternating abrasion and accretion. But the overall average change of the coast shows an Abrasion rate of around 1 meter. According to the length eroded and accreted the Abrasion and accretion Abrasion categorized into High, Moderate, Low Abrasion and accretion.

Figure 4. Shoreline Change of Tanjung Lesung Beach
4. Conclusions
This study aimed to identify and characterized shoreline change before and after the Tsunami in the region of Tanjung Lesung Beach. Tsunami on the Tanjung Lesung Beach caused considerable environmental losses, especially in the field of tourism. Therefore, the shoreline change detection is necessary to find out the impact of the Tsunami. Information obtained from the analysis of shoreline changes can use as a reference for planning infrastructure development and public facilities. The present study suggests that multi-temporal satellites data, along with GIS and statistical techniques, can be effectively used for the detection of shoreline change in the study area.

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