Analysis of mangrove forest changes as a natural beach protection in Surabaya, East Java Indonesia

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Abstract. Surabaya is the most populous city in East Java with high human activities and needs. These human needs include opening new land for residential areas so that some mangrove areas began to be converted into residential areas. This activity can directly cause ecological impacts and threaten the sustainability of the coastal environment. On the other hand, mangrove areas in Surabaya are also developed for conservation and tourism areas. The purpose of this study is to determine the changes in mangrove area in the Surabaya area during the period 2015 to 2019 based on GIS. This study is using maximum likelihood classification method then the area calculation is done by calculate geometric method. The results were obtained from 2015 to 2019 shows an area change every year. So far the exact cause is unknown, but the condition of area changes can occur due to several things, for example from the conversion of mangrove forests to residential areas, drainage needs in rivers or estuaries and stand growth.

1. Introduction
Surabaya is the capital of the East Java Province, which is partly adjacent to the coast. Besides, Surabaya is also the main center of activity in East Java Province with high human activity and needs as well as trade, industry and settlement activities that develop each year. Given these factors, pollution and land-use change have the potential to become ecological impacts that threaten the sustainability of the coastal environment and mangrove forest areas. The number of human activities such as industrial growth which is increasingly widespread can threaten the existence of mangrove ecosystems that cause damage to the beach.

Damage to plant ecosystems, especially mangroves found in coastal areas caused by human activity or from natural processes caused by natural factors, such as hydro-oceanography (currents, sediment transport, and waves) must be considered by all parties. The parties that play a role in realizing solutions and prevention of the problem of loss of coastal ecosystems as natural protectors are not only the surrounding community but also the government that manages the environment. In planning and making policies related to the implementation of development in the area requires data and information about accurate and up-to-date coastal conditions. Also, mangrove forests have an important role in protecting the environment.

Mangroves have many benefits that can be obtained in the growth of their ecosystem. Mangrove forests have ecological functions that are very good for the environment and surroundings. Besides, this ecosystem is one component that has an important role in the stabilization of coastal ecosystems both physically and biologically. Another important role of the mangrove ecosystem in preserving the environment is as a natural coastal protector from sea waves, prevention of abrasion, supporting species life in breeding, spawning, and foraging [1].

In the research conducted, to support the study material that needs to be investigated, science is needed related to the hydro oceanographic conditions in the area. The oceanographic hydro condition of the eastern coast of Surabaya has the characteristics of a double daily mixed tidal mixture, where in one day there are two tides and two tides with height and periods different from sediment type dominated by silt clay [2].

To answer the problems that arise in the case studies studied, the authors conducted a research study to identify the changes in the extent of mangrove forests in Surabaya. This study aims to determine and prevent negative impacts that may occur in the future. Identification of changes that occur requires continuous monitoring. By using remote sensing technology and GIS identification of changes in mangrove area during the period 2015 to 2019 can be a spatial and temporal solution for solving the problems in this study.
2. Methodology

2.1 Description of the study sites.

This research was conducted in the city of Surabaya, especially in eastern Surabaya. Retrieval of image data was taken from 2015 to 2019 to see the changes that have occurred in the mangrove area in the city of Surabaya in the last 5 years.

![Figure 1. The experiment location of mangrove area, Surabaya, Indonesia.](image)

2.2 Composite Image

The composite band process aims for classification, where the band selection must be following the purpose of classification. For the process of identifying mangrove vegetation with Landsat 8 satellite imagery, the RGB (red green blue) composite 564 [3] was used. The composite band process is carried out using ENVI 5.3 software.

2.3 Image Classification

Image classification is the process of arranging, sorting or grouping pixels in several classes based on objective criteria or category. Every pixel in each class is assumed to have homogeneous characteristics [4]. The classification used in this study is the supervised classification with the maximum likelihood classification method. Maximum likelihood quantitatively evaluates the variance and correlation of response patterns of the spectral category when classifying unknown pixels [4].

2.4 Area Calculation

The process of calculating the area aims to see changes in the area of mangroves from 2015 to 2019. The calculation of mangrove areas is processed using the calculate geometric method. The calculate geometrically is an automatic calculation procedure on ArcMap based on the geometric shape of GIS data drawn from the coordinate system used [5]. In this process vector data is used so that in this classification process raster data will be converted into vector data. The conversion of raster data to vector data was carried out to simplify the calculation of the area of land cover change from the image of the classification results that have been cut. This data conversion uses one of the processes in ENVI.
software that converts raster data to vector data in the form of shapefiles (.shp). Then from the shapefile, the area will be calculated through the process of calculating the geometric contained in ArcMap 10.5 software.

3. Results and Discussion
Based on the results of Landsat 8 satellite image processing by compiling the RGB 564 band, then performing the maximum likelihood classification stage to distinguish mangrove and non-mangrove objects, a map of the mangrove area of Surabaya from 2015 to 2019 was obtained.

Figure 2. The map of differences in mangrove areas in 2015 and 2016.
Figure 3. The map of differences in mangrove areas in 2016 and 2017.

Figure 4. The map of differences in mangrove areas in 2017 and 2018.

Figure 5. The map of differences in mangrove areas in 2018 and 2019.
The calculation of mangrove areas in Surabaya from 2015 to 2019 using the geometric calculation method in ArcMap 10.5 software shows changes in the area every year as shown in Table 1.

| No | Year | Area (m²) | Area (Ha) |
|----|------|-----------|-----------|
| 1  | 2015 | 5,897,700 | 589.77    |
| 2  | 2016 | 6,716,700 | 67.67     |
| 3  | 2017 | 6,647,850 | 664.785   |
| 4  | 2018 | 6,737,400 | 673.74    |
| 5  | 2019 | 6,682,500 | 668.25    |

The lowest mangrove area was found in 2015 of 589.77 Ha, while the highest area of mangrove was found in 2018 of 673.74 Ha. Mangrove area in 2016 increased by 81.9 hectares compared to 2015. Mangrove area in 2017 decreased by 6.885 hectares when compared to 2016. Mangrove area in 2018 increased by 8.955 hectares when compared to 2017. Mangrove area in the year 2019 has decreased again by 5.49 hectares when compared with 2018.

Mangrove species in the mapped area are dominated by several species, including Avicennia sp., Bruguiera sp., Exoecaria sp., Xylocarpus sp., Sonneratia sp., and Rhizophora sp. (Dinas Lingkungan Hidup Kota Surabaya, 2018).

Changes in the extent of mangroves from 2015 to 2019 are also illustrated in the graph below. There has been an increase in 2015 to 2016 while 2016 to 2019 land area changes tend to be stable.
The Surabaya City Government is planning the development of the Mangrove Botanical Garden which is located on the east coast of Surabaya. The development was carried out to improve the quality of the environment of the City of Surabaya as well as efforts to safeguard the Green Open Space protected areas from inappropriate use. In 2017 the Surabaya City Government worked closely with various parties both educational institutions, State-owned enterprises (SOE) and the private sector to carry out mangrove planting activities. Recorded in 2017 is 42 mangrove planting activities with a total number of trees planted reaching 42,450 stems [6].

Mangrove planting activities will also continue in 2019, as many as 5,000 mangrove seedlings of *Rhizophora* sp. planted in the Gunung Anyar Botanical Garden, these activities besides aiming to support the Surabaya City Government's program for the development of the Mangrove Botanical Garden also aim to prevent soil erosion [7].

Based on the results of a field survey by [8], the condition of changes in mangrove areas that occurred in the last 5 years is not yet known with certainty, but it is predicted that the change will occur due to several things, such as growth of stands, conversion of land into housing, pond and drainage development.

### 4. Conclusions
Mapping of mangrove forests in Surabaya in the last 5 years, from 2015 to 2019, shows an area change every year. So far the exact cause is unknown, but the condition of area changes can occur due to several things, for example from the conversion of mangrove forests to residential areas, drainage needs in rivers or estuaries and stand growth.
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