Temporal and Spatial Analysis of Mangrove Forest Change in the North Coast of East Java

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Abstract. The north coast of East Java has high human activities and needs. These human needs include opening new land for housing areas, so that some mangrove areas have begun to be converted into residential areas. This can directly cause ecological impacts that threaten the sustainability of the coastal environment, but on the other hand, mangrove areas on the north coast of East Java are also developed as conservation and tourism areas. The purpose of this study is to determine changes in mangrove area and changes in coastlines in the northern coastal region of East Java during the period 2013 to 2019 based on Geographical Information Systems (GIS) using the Supervised-Maximum Likelihood image classification method. The results of this study showed that the largest change in mangrove forest area was in Sidoarjo Regency by 95%, while the lowest change in mangrove forest area was in Tuban Regency at 7.20%.

1. Introduction

East Java Province is one of the provinces located in Java Island and is located between 111°0' to 114°4' East Longitude, and 7°12' to 8°48' south latitude. In general, the East Java region is divided into two major parts, namely East Java mainland amounting to 90% and the Madura Islands area around 10%. The coastline of the East Java coast 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].

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 in North Coast of East Java. 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 2013 to 2019 can be a spatial and temporal solution for solving the problems in this study.

2. Study Area
This research is located along the north coast of East Java as shown in Figure 1, which consists of Tuban Regency, Lamongan Regency, Gresik Regency, Surabaya City, Sidoarjo Regency, Pasuruan Regency and City, Probolinggo Regency and City and Situbondo Regency.

![Figure 1. Map of Research Location](image1.png)

3. Methodology
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 [2] was used. The composite band process is carried out using ENVI 5.3 software.

![Figure 2. Landsat 8 Image with Composite Combination RGB 564](image2.png)

The first paragraph after a section or subsection heading should not be indented; subsequent paragraphs should be indented by 5 mm. 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. 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.

The calculation of probability or known as likelihood aims to find a pixel from a class, which can be explained from the following equation:

$$P (i | x) = \frac{P(x | i) P(i)}{P(x)}$$  \hspace{1cm} (1)

Where:
- $P (i | x)$ : The conditional probability of a class i, which is calculated by providing that the vector x is unconditional.
- $P (x | i)$ : The conditional probability of the vector x, which is computed by the unconditional class.
- $P (i)$ : The probability that a class i emerges from an image.
- $P (x)$ : The probability of the vector x

![Figure 3. Landsat 8 Image with Composite Combination RGB 564 [3]](image)

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. According to Utama (2005), calculate geometrically is an automatic calculation procedure on ArcMap based on the geometric shape of GIS data drawn from the coordinate system used. 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.
4. Result

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. On the map of mangrove area for a period of 7 years (2013 - 2019), each year is grouped in a different colors to facilitate analysis and observation of changes in mangrove area. Yellow for 2013, orange for 2014, purple for 2015, green for 2016, pink for 2017, grey for 2019 and blue for 2019.

Figure 4. Calculation of Mangrove Area using Calculate Geometric

Figure 5. The Map of Differences in Mangrove Areas in 2013 and 2014
Figure 6. The Map of Differences in Mangrove Areas in 2014 and 2015

Figure 7. The Map of Differences in Mangrove Areas in 2015 and 2016
Figure 8. The Map of Differences in Mangrove Areas in 2016 and 2017

Figure 9. The Map of Differences in Mangrove Areas in 2017 and 2018
Figure 10. The Map of Differences in Mangrove Areas in 2018 and 2019

The calculation of mangrove areas in North Coast of East Java 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.

Table 1. Mangrove Areas Calculation in North Coast of East Java from 2015 to 2019

| Year | Tuban (Ha) | Lamongan (Ha) | Gresik (Ha) | Surabaya (Ha) | Sidoarjo (Ha) | Pasuruan (Ha) | Probolinggo (Ha) | Situbondo (Ha) | Total / Year |
|------|------------|---------------|-------------|---------------|---------------|---------------|-----------------|---------------|--------------|
| 2013 | 155.49     | 80.07         | 2127.15     | 927.4         | 3210.14       | 828.07        | 705.89          | 462.92        | 8497.13      |
| 2014 | 149.58     | 78.33         | 2194.83     | 945.01        | 2074.63       | 816.28        | 786.06          | 506.69        | 7551.41      |
| 2015 | 125.73     | 76.8          | 2503.44     | 889.92        | 2308.54       | 711.28        | 771.05          | 522.78        | 7909.54      |
| 2016 | 143.54     | 87.07         | 2686.95     | 965.79        | 1801.62       | 746.41        | 775.8           | 555.31        | 7762.49      |
| 2017 | 127.35     | 88.84         | 2791.11     | 944.82        | 2046.66       | 792.79        | 835.08          | 566.88        | 8199.47      |
| 2018 | 153.79     | 87.8          | 2624.13     | 1008.06       | 2065.96       | 768.33        | 873.45          | 555.52        | 8137.04      |
| 2019 | 163.05     | 69.12         | 2492.46     | 1016.93       | 1943.78       | 795.42        | 815.04          | 634.45        | 7930.25      |
| Total/District | 1018.53 | 568.03 | 17426.07 | 6697.93 | 15451.27 | 5458.58 | 5562.37 | 3804.55 | 

Calculation of the area of mangroves in the North Coast of East Java using the calculate geometric in ArcGIS 10.5 software from 2013 to 2019 is shown in Table 1. The lowest mangrove area was in 2014, amounting to 7551.41 hectares, while the mangrove area with the highest value was found in 2013 amounted to 8497.13 hectares.
The change in mangrove area from 2013 to 2019 is also illustrated in the graph below. There was an increase in 2015 and 2017 while the largest decrease in mangrove area occurred in 2014 and 2016. From 2017 to 2019 changes in mangrove area were stable.

5. Conclusion
Mapping of mangrove area on the North Coast of East Java in the last 7 years (2013 - 2019) shows changes in area every year. Based on the calculations that have been done, the increase in mangrove area is more dominant than the decrease in mangrove area. The highest mangrove area was in 2013. The largest reduction in mangrove forest area was in 2014 and 2016. From 2017 to 2019, changes in mangrove area were stable. Changes in the area of mangroves, both increase and decrease in area can occur due to several factors, for example the conversion of mangrove forests to housing, drainage needs in rivers or estuaries, mangrove growth or mangrove planting to support coastal conservation.

6. References
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[3] Purwanto A D and Ardli E R 2019 Development of a Simple Method for Detecting Mangrove using Free Open Source Software J. Segara Vol.16 No.2 (71-82)
[4] Humboldt State University 2019 GSP 216 Introducing to Remote Sensing https://gsp.humboldt.edu/OLM/Courses/GSP_216_Online/lesson3-1/composites

Figure 11. Graph of mangrove changes area in North Coast of East Java