Analyzing mangrove forest area changes in coastal zone of Langsa City using landsat imagery

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Abstract. Mangrove forest is the most well known in Langsa City. Mangrove forest has high productivity and rich of biodiversity. However, the mangrove area has decreased in quantity. It caused by human activities (anthropogenic factors) and natural conditions. Aims of this research are to map the spatial distribution of mangrove forest in Langsa City, analyze the changes occurring mangrove area, and identify the factors that leading to the changes. Landsat 5 and Landsat 8 OLI images are selected to represent data with multi temporal images (1996, 2006, 2016, and 2018). This study used the maximum likelihood classification on multispectral data. The result of the research showed the accuracy of Landsat 8 OLI images in 2018 was 62.50%. Mangrove area changes during three periods of observed data, i.e has decreased to 419.04 ha in 1996-2006, increase to 459.76 ha in 2006-2016, and decreased 330.57 ha in 2016-2018. These changes were generally caused by anthropogenic factors such as logging, garbage buildup, over function of mangrove to café, bridge and settlement. On the other hand, natural factors did not caused the change. Natural factors value in research location are accepted by mangrove growth requirements, i.e water pH was 7.8, temperature was 34°C, salinity was 33.03, and DO (Dissolved Oxygen) was 5.28.

1. Introduction

Mangrove forest is one of the forests that have high potential and productivity. According to Alikodra (2012) mangrove has rich of nutrients which needed for organisms survival that depend on the mangrove ecosystem. The function of mangrove ecosystems for the organisms survival includes carbon storage, fish spawning sites, shoreline protection, and as an economic source for coastal communities.

According to data of LHK Ministry (2015) Indonesia is one of the regions that has the largest mangrove forest ecosystem in the world, which is 3,489,140.68 hectares or 23% of the world's total mangrove forest ecosystem. The condition of Indonesia's mangrove forests is divided into two conditions, i.e. 1,671,140.75 ha in good condition and 1,817,999.93 ha in bad condition. The amount of mangrove ecosystem in Indonesia is inseparable from the characteristics of the coastal areas of Indonesia which are more paired by tides.

The area of mangrove forests in Indonesia changes at any time, i.e increase and reduction area. Changes in the extent of mangrove forests in Indonesia do not have definite data, this is because area changes of mangrove forests occur in a very short period of time. These changes are caused by various factors such as logging of mangrove forests for ponds, industrial needs, settlements, natural disasters, and will also affect the balance of ecosystems and the lives of coastal communities.

The coastal city of Langsa is one of the regions in Indonesia that has mangrove forest ecosystem. Up until now, there is only few data or information about mangrove forest in Langsa. The need for mangrove forest data is very important because mangrove forests have high productivity. One of the
technologies that can be used to obtain information on mangrove forest is remote sensing technology. The use of remote sensing technology has advantages regarding the distribution of temporal, effective and efficient mangrove forests. Aims of this research are to map the spatial distribution of mangrove forest in Langsa City, analyze the changes occurring mangrove area, and identify the factors that leading to the changes. Landsat 5 and Landsat 8 OLI images are selected to represent data at various multi temporal images (1996, 2006, 2016, and 2018)

2. Method

2.1. Research Location
Research location was in coastal zone of Langsa City which divided into three administrative areas, i.e., Gampong Kuala Langsa, Gampong Seuriget, and Gampong Sungai Pauh (Figure 1).

![Figure 1. Administration Area of Research Location.](image)

2.2. Research Tools and Materials

| Tools                                      |
|--------------------------------------------|
| Software ENVI 4.5                          |
| ArcGIS,                                    |
| Laptop ASUS A450L Core i5; 1.60 GHz; 2.30 GHz; RAM 8 GB, |
| _Global Positioning System (GPS)_          |
| Garmin Oregon 650                          |
| Camera                                     |
| Handheld Refraktometer                     |
| eutech instrument                          |
| Transparent bottle                         |
| _Dry bag_                                  |

Table 1. Research tools.
Table 2. Research materials.

| Materials                                      |
|-----------------------------------------------|
| Landsat Imagery 5 OLI year 1996 and 2006      |
| Landsat Imagery 8 OLI year 2016 and 2018      |

2.3. Research Process

![Research Process Diagram]

3. Result

3.1 Map Accuracy Test
This research using confusion matrix for accuracy test of the map. Based on the test results on the map of mangrove change area for the maximum likelihood classification is 62.50%.

3.2 Changes Area
The mapping of mangrove forest area in this study was obtained based on the results of the multispectral maximum likelihood algorithm. Bands used in the classification are band 5, 4, and 2 on
Landsat 5 and band 6, 5, and 3 on Landsat 8 OLI. This selection was made because it could provide clear appearance on the image object.

Table 3. The mangrove forest changes area in coastal zone of Langsa City.

| Year | Mangrove Forest Area (Ha) | Changes (Ha) |
|------|--------------------------|--------------|
| 1996 | 1.631.88                 | -            |
| 2006 | 1.212.84                 | -419.04      |
| 2016 | 1.668.60                 | +455.76      |
| 2018 | 1.338.03                 | -330.57      |

Table 3 shows the changes in mangrove forest area during three periods of observed data from 1996 – 2018. It has decreased to 419.04 ha in 1996-2006, increase to 459.76 ha in 2006-2016, and decreased 330.57 ha in 2016-2018. If we take a closer look, despite the mangrove forest area decreased in 1996 to 2006, but in the next 10 years there has been increase 36.72 ha more than what had lost. However, it is different with the changes that occur in 2016 to 2018, within 2 years, the mangrove forests area 330.57 had lost. If this keep happening, then within the next 8 years (2018 - 2026) it can be predicted that mangrove area will be degraded massively.
Figure 3 shows the result of the maximum likelihood classification for mangrove forest changes area in 1996, 2006, 2016, and 2018. The changes in 1996-2006 were dominated by the reduction of mangrove forest into pond fish farming area, in 2006-2016 there was an increase from pond fish farming area into mangrove forest area, and in 2016-2018 there was a reduction in mangrove forests into settlements. These changes are caused by various sustainability factors (physical and chemical factors), human activities, and natural disasters. Some sustainability factors that influence changes in mangrove ecosystems, they are pH, salinity, surface temperature, and dissolved oxygen. The factors of human activity that influence the changes in mangrove are human activities in utilizing mangrove wood for industrial needs and settlement construction.

3.3 Factors of Mangrove Ecosystem Sustainability

Mangrove sustainability factors are factors that affect the survival of mangroves in water and have their own role for the survival of mangroves, although there are several types of mangroves that can adapt to extreme environmental conditions. According to Sara (2014) mangrove ecosystems can withstand to environmental disturbances and pressures, but mangroves are quite sensitive to excess sedimentation, stagnation, stagnant water, and oil spills. These confounding factors or suppressing factors reduce oxygen uptake for respiration which results in rapid mangrove death. For more details on the water quality in the Coastal of Langsa City in Figure 4 below.
3.4 *Dissolved oxygen.*

Dissolved oxygen is an important factor for the life of a water ecosystem, which functions as a regulator of the organism's metabolism to grow and reproduce [2]. According to Barus (2002) and the Decree of the State Minister of Environment (2004) a good dissolved oxygen content for the continuity of the mangrove ecosystem is $>5$ - $<8$ mg/liter.

The average dissolved oxygen level found was 5.28 mg/liter with a minimum level of 4.0 mg/liter and maximum level of 6.8 mg/liter. The concentration of dissolved oxygen is $>5$ - $<8$ mg/liter and it was compatible to the value that can be tolerated by mangrove ecosystems to breed.
3.5 Water temperature.

Water temperature is one of the important factors for mangrove survival. According to the Decree of the State Minister of Environment (2004) the temperature that can be tolerated by mangrove ecosystems ranges from 28-32°C. In this research, the average temperature of coastal mangrove forest in Langsa City is 34°C which the lowest temperature is 31.8°C and the highest temperature is 36°C. This temperature condition has exceeded the tolerance limit of the mangrove ecosystem which cause the mangrove ecosystem cannot grow properly. The high water surface temperature of mangrove forest in Langsa City can be caused by various factors, i.e the balance of energy received by the water surface, the influence of global climate change, and the lack of water surface cover.

3.6 Salinity.

Salinity is the salt concentration dissolved in water. Salinity for mangrove is about 34‰. Salinity at the research location had an average concentration 33.03‰, with the lowest was 27.60‰ and the highest was 37.30‰. Salinity at the research location is still quite suitable for the mangrove living conditions. The condition of salinity greatly influences mangrove growth, it is because salinity will affect the photosynthesis process of mangrove ecosystems.

3.7 pH.

pH is a scale used to specify how acidic or basic a water-based solution is. pH greatly affects the growth of mangrove ecosystems and the condition of aquatic organisms in general, the condition of waters that are very acidic and very alkaline will endanger the life of the organism because it will cause metabolic disorders and respiration [4]. The results of field measurements of pH levels at the research location had an average value, its 7.8, with the lowest is 6.9 and the highest is 8.2. This pH value is still suitable for mangrove life and is in a good range.

3.8 Matrix of relationship between mangrove change and water quality in coastal area of Langsa City.

The change relationship matrix is the relationship between changes in mangrove forest and mangrove sustainability factors that have been analyzed. The sustainability factor of mangroves in this study consisted of dissolved oxygen, temperature, salinity, and pH (table 4).

Table 4. Matrix of relationship between mangrove change and water quality in coastal area of Langsa City

| Sustainability factors         | Effect | No Effect |
|--------------------------------|--------|-----------|
| Dissolved oxygen>5 mg/liter    | -      | √         |
| Temperature (28-32°C)          | √      | -         |
| Salinity(34 ‰)                 | -      | √         |
| pH (7-8.5)                     | -      | √         |

Table 4 shows the relationship between mangrove forests changes in the coastal area of Langsa City and the sustainability factor of the mangrove ecosystem. Changes in mangrove ecosystem is influenced by sea surface temperatures. The sea surface temperature from the field measurements has an average value, i.e 34°C with a minimum value was 31.8°C and a maximum value was 36°C. The high temperatures of sea surface will affect the change in the area of mangrove forests in Kuala Langsa coast.

Along in Poedjirahajoe (2017) states that the stomatal conductance and assimilation rate on the mangrove leaves that are maximal range between temperatures 25-30°C and will experience a rapid decline at temperatures above 35°C. According to Cahyani in Poedjirahajoe (2017) high water
temperatures will affect the physiological processes of mangrove plants and other ecosystem activities that depend on mangrove ecosystems.

4 Conclusions
Mangrove area changes during three periods of observed data, i.e has decreased to 419.04 ha in 1996-2006, increase to 459.76 ha in 2006-2016, and decreased 330.57 ha in 2016-2018. These changes were generally caused by anthropogenic factors such as logging, garbage buildup, over function of mangrove to cafe and bridge. On the other hand, natural factors did not caused the change. Natural factors value in research location are accepted by mangrove growth requirements, i.e water pH 7.8, temperature 34°C, salinity 33.03, and DO 5.28

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