Analysis of coastal vegetation density changes of Langkat Regency, North Sumatera, Indonesia

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Abstract. Coastal is a dynamic area which is changing rapidly in response to natural processes and human activities. The significant increase in population and development activities around the coast of Langkat Regency have caused changes in land cover and vegetation density. This research was done by overlaying spatial data occurred from 2006 to 2016 to obtain land cover change data, NDVI (Normalized Difference Vegetation Index) values, and to find out vegetation density in the coastal area of Langkat Regency. The research found that the highest area in the coastal of Langkat in year 2006 was under very dense class with 37.38%. In 2016, the highest area covering coastal of Langkat was Dense class with 38.21%. The decrease area found from very dense class to dense class for 34.06%. This research is expected to provide information as a consideration in the effort of coastal management of Langkat Regency.

1. Introduction

The increase of population has put pressure on land uses. People tend to use their land for fulfilling their needs. Land use changes become an important issue in the coastal area. People need land for settlements and doing cultivation. According to Umayah et al. [1], coastal area has been utilized by people for their living activities such as fishpond, fisheries, transportation, and tourism. Activities in the coastal area will give impact to the environment.

Shore is a part of a coastal area which has essential ecological functions. The shore has a function for buffer and protection of settlement from sea waves. Shore is dynamic which means the zoning (form and location) will change rapidly as a response to natural process and human activities [2].

Population pressure to the forest area and development activities around the coastal area of Langkat have increased. Some land use changes in the area are mainly for the livelihood of the people. Mangrove conversion is along the activity as mentioned by Onrizal and Kusmana [3] that one factor of destruction is a land conversion of mangrove to the fish pond and mangrove trees cutting for charcoal.

The information of the existence of vegetation in the coastal area is needed to give an overview of the condition of its land cover. Information on vegetation density along the coast can become one point to be considered for coastal management planning including protection and rehabilitation.

The research has two objectives. Objectives of the research are to find out the vegetation density along the coastal area of Langkat in the year 2006 and 2016 and to analyze the change of vegetation density along the coast of Langkat between the year 2006 and 2016.
2. Materials and method

2.1. Time and place
The research was conducted from December 2016 to March 2017. Location of the research was in the coastal area of Langkat Regency of North Sumatera, Indonesia. Data processing and analysis were done in Forest Management Laboratory of Faculty of Forestry, University of Sumatera Utara.

![Figure 1. Research site.](image)

2.2. Equipment and data
Equipment used in the research included equipment for data collection and analysis (see table 1). Those were GPS (Global Positioning System), compass and camera. Data analysis used software including Microsoft Excel, ArcGis 10.1 and ERDAS Imagine 8.5.

| No  | Type of data                  | Source                     | Year |
|-----|-------------------------------|----------------------------|------|
| 1   | Field data                    | Ground check               | 2016 |
| 2   | Landsat 5 image path 129 row 57 | www.glovis.usgs.gov       | 2006 |
| 3   | Landsat 8 OLI image           | www.earthexplorer.usgs.gov | 2016 |
| 4   | Administration map of Langkat  | BPKH Medan                 | 2016 |

2.3. Research method

2.3.1. Satellite image preparation. Landsat image was downloaded from earthexplorer.usgs.gov. Stacking was conducted to have one file of band combination of the image. The correction was one step to minimize any disturbance in the image including atmospheric effect and visual enhancement. ERDAS Imagine 8.5 was used for this step.

Image cropping was done to have the image of the site area which is the coastal area of Langkat using ArcGis 10.1. The administration map used was the map from Balai Pemantapan Kawasan Hutan (Forest Area Stabilization Agency).

2.3.2. NDVI analysis. NDVI processing and analysis were conducted using software ArcGis 10.1. Red and near infrared bands were used, Band 3 (Red) and 4 (Near Infrared) for Landsat 5 and Band 4 (Red) and 5 (Near Infrared) for Landsat 8.

The principal of NDVI was the measurement of greenness level of vegetation. The greenness intensity in the image was correlated to vegetation density level and detection of greenness by the chlorophyll of leaves. The range of NDVI values is between -1 and +1. The higher the value of NDVI, the higher the vegetation density. The formula of NDVI is:
\[
\text{NDVI} = \frac{\text{NIR} - \text{R}}{\text{NIR} + \text{R}}
\]

NDVI = reflectance value of infra red band (band 4,5)
R = reflectance value of red band (3,4)

Classification of NDVI values into vegetation density classes were done by dividing values into five classes. An equal interval was given for the rank. All steps were done using ArcGIS 10.1.

Vegetation density along the coast of Langkat was classified based on the rank from the lowest to the highest values of NDVI. Those classes were non-vegetation, rare, slightly dense, dense and very dense.

3. Results and discussion

3.1. NDVI distribution of coastal area of Langkat year 2006 and 2016

NDVI employs the Multi-Spectral Remote Sensing data technique to find vegetation index, land cover classification, vegetation, water bodies, open area, scrub area, hilly areas, agricultural area, thick forest, thin forest with few band combinations of the remote-sensed data. Remote sensing, especially Landsat 8 and geographic information systems (GIS), was used to obtain information about the appearance on the earth surface [4].

Vegetation density index was used to measure the level of vegetation density in the research area. Image processing of 2006 and 2016 using NDVI analysis gave information on NDVI values distribution along the research area. Table 2 shows the vegetation density class and rank of NDVI values in the area in 2006.

| No  | Vegetation density | NDVI   | Extent (Ha) | Percentage (%) |
|-----|--------------------|--------|-------------|----------------|
| 1   | Non vegetation     | <0     | 4,825.40    | 4.41           |
| 2   | Rare               | 0 – 0.18 | 9,046.89 | 8.26          |
| 3   | Slightly dense     | 0.18 – 0.36 | 21,363.65 | 19.51        |
| 4   | Dense              | 0.36 – 0.54 | 33,354.95 | 30.45        |
| 5   | Very dense         | > 0.54  | 40,936.69   | 37.38         |
| Total|                    |        | 10,9527.56  | 100.00       |

Table 2. The area of vegetation density of Langkat year 2006.

| No  | Vegetation density | NDVI   | Extent (Ha) | Percentage (%) |
|-----|--------------------|--------|-------------|----------------|
| 1   | Non vegetation     | <0     | 2809.20     | 2.58           |
| 2   | Rare               | 0 – 0.18 | 8329.10 | 7.61          |
| 3   | Slightly dense     | 0.18 – 0.36 | 21304.62 | 19.45        |
| 4   | Dense              | 0.36 – 0.54 | 41854.62 | 38.21        |
| 5   | Very dense         | 0.54 – 0.71 | 35230.02 | 32.16        |
| Total|                    |        | 109527.56   | 100.00        |

Table 3. The area of vegetation density of Langkat year 2016.

NDVI analysis shows that there is NDVI value of less than 0 and the highest is 0.71. Those values were classified into vegetation density classes. Those classes were non-vegetation, rare, slightly dense, dense and very dense. In the year 2006, the highest vegetation density was very dense with 4,0936.69 Ha or 37% of the total. While in 2016 the highest vegetation density was dense with 41,854.62 Ha or 38.21% of total coastal area. According to Wardana et al. [5], the difference of area of each vegetation density is due to the difference of how each land cover class absorbs and reflects red and infrared light.

The representation of NDVI value to vegetation and soil relation in land cover was mentioned by [6]. Very low value of NDVI (0.1 and below) corresponds to barren areas of rock, sand, or snow. Moderate value represents shrub and grassland (0.2 to 0.3), while high value indicates temperate and tropical rainforests (0.6 to 0.8). Bare soil is represented with NDVI values, which are closest to 0 and water bodies are represented with negative NDVI values.
In addition, Wardana et al. [5], also mention that absorption of red light by chlorophyll and reflectance of infrared by mesophyl in leaves will create big difference of brightness value received by satellite censor. Non vegetation including water bodies, bare land and area with low vegetation will show low ratio.

In the coastal area of Langkat, we found mangrove, oil palm plantation, settlement, paddy field, bare land and fishpond. According to Statistical data of Langkat 2014, there was an increase in fish pond area and oil palm plantation. The population also increased [7].

![Figure 2. NDVI map of Langkat year 2006.](image1)

![Figure 3. NDVI map of Langkat of the year 2016.](image2)

Onrizal [8] has mentioned that the forest damage of coastal area in Langkat was due to conversion to fishpond, plantation, settlement and agricultural area. The mangrove area also decreased due to abrasion as the impact of conversion and logging.

### 3.2. The change of vegetation density of coastal area of Langkat in 2006 and 2016

The change of vegetation density was established by overlaying vegetation density map of the year 2006 and 2016. The change can be seen in the table below.

| No | Vegetation density | Extent (Ha) | (%)  | Extent (Ha) | (%)  | Extent (Ha) | (%)  |
|----|-------------------|------------|------|------------|------|------------|------|
| 1  | Non-vegetation    | 4,825.40   | 4.41 | 2,809.20   | 2.58 | 2016.2     | 1.83 |
| 2  | Rare              | 9,046.89   | 8.26 | 8,329.10   | 7.61 | 717.79     | 0.65 |
| 3  | Slightly dense    | 21,363.65  | 19.51| 21,304.62  | 19.45| 59.03      | 0.06 |
| 4  | Dense             | 33,354.95  | 30.45| 41,854.62  | 38.21| 8499.67    | 7.76 |
| 5  | Very dense        | 40,936.69  | 37.38| 35,230.02  | 32.16| 5706.67    | 5.22 |
| 6  | Total             | 109,526.56 | 100% | 109,525.56 | 100% |            |      |

Note : (*) Decreasing area
The change of vegetation density area includes the increase and decrease of area of each vegetation density classes. The highest extent of the year 2006 was very dense with 40,936.69 Ha or 37.38%. In 2016, very dense class decreased 5,706.67 Ha or 5.22% to 35,230.02 Ha. Dense vegetation density class was 33,354.95 or 30.45% in 2006. This class decreased 8,499.67 Ha or 7.76% to 41,854.62 Ha. The change of vegetation density class is related to the change of land use in the coastal area.

Based on the change analysis of vegetation density between the year 2006 and 2016, there was information on the type of change of each class. The change of each class can be seen in table 5.

**Table 5. Change of coastal vegetation density of Langkat between 2006 and 2016.**

| Vegetation density of 2006 | Vegetation density of 2016 |
|---------------------------|---------------------------|
| Non-vegetation            | Non-vegetation            |
| Rare                      | Rare                      |
| Slightly dense            | Slightly dense            |
| Dense                     | Dense                     |
| Very dense                | Very dense                |
| Total                     | Total                     |
| Non-vegetation            | 2,085.23                 |
| Rare                      | 507.08                    |
| Slightly Dense            | 113.52                    |
| Dense                     | 91.52                     |
| Very Dense                | 11.85                     |
| Total                     | 2,809.20                  |

Table 5 shows that there are changes in vegetation density in 2006 and 2016 in the coastal area of Langkat. There was an increase and a decrease of area of each class. Dense class in the year 2016 remained the same in the area of 16,521.64 Ha. The remaining areas were very dense of 14,254.44 Ha, slightly dense of 8,322.92 Ha, rare of 2,193.74 Ha, and non-vegetation of 561.68 Ha. Very dense class in the year 2016 was from dense class of 8,672.66 Ha, slightly dense of 2,009.02 Ha, rare of 352.36 Ha and non-vegetation of 352.39 Ha.

**Figure 4. Vegetation density change of coastal area of Langkat between 2006 and 2016.**
Zaitunah, et al. [9] did research on coastal area of Sibolga. They mentioned that the highest percentage of coastal area of Sibolga had low NDVI value. It indicates that the area has less vegetation. The field check showed that the coastal area had a dense settlement with less vegetation. Most of the coastal area of Sibolga had a very low value of NDVI which was less than 0.1. It is relevant to the field observation along the coastal area covered by building mainly settlement. Higher value can be seen more in the mainland.

Based on the ground check data, the vegetation of very dense class was mangrove area and oil palm plantation. The dense class of vegetation density was shrub in the field. Settlement belonged to rare or less vegetation density. Waterbody and fishpond were included in non-vegetation.

Physical efforts are aimed at decreasing the energy of tsunami wave that comes to the beach, which can be divided into physical and natural efforts. Those efforts are complementary, depending on the condition of the area. Naturally, it can be done by having a greenbelt in the form of coastal forest and mangrove. Mangrove has a strong and unique root system with a dense canopy. Mangrove is ideal to protect the beach naturally [10].

4. Conclusion
The research found that the highest area in the coastal of Langkat in year 2006 was under very dense class with 37.38%. In 2016, the highest area covering coastal of Langkat was dense class with 38.21%. The decrease area found from very dense class to dense class for 34.06%.

Remarks
The research on land cover and land use using remote sensing analysis is needed for more comprehensive study in the coastal area. The information on vegetation density and land cover can lead to a good recommendation for better management and planning in the coastal area.

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