Change vegetation density analysis of Sumatran orangutan (Pongo abelii) habitat in Bukit Lawang and Sub-district of Bahorok

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Abstract. Gunung Leuser National Park forest in Bukit Lawang section is the main habitat of Sumatran Orangutan (Pongo abelii) in Sub-district of Bahorok. The condition of wildlife habitat in the region has been fragmented by various human activities which is the major threat to the wildlife survival including Sumatran Orangutan (Pongo abelii). This study was conducted by overlaid some spatial data of the year 2008 and 2018 to obtain data of vegetation density changes and the range of the Normalized Difference Vegetation Index (NDVI) in Section of Bukit Lawang and District of Bahorok. Vegetation analysis was carried out in forest, rubber plantation and mix plantation in District of Bahorok as supporting data. The purposes of this study are to get vegetation density value and analysing the changes of vegetation density of Sumatran Orangutan (P. abelii) habitat in Bukit Lawang and Sub-district of Bahorok year of 2018. The research shows that the largest vegetation density changes was decreased of high dense class which is 47,040.02 hectare or 49.9%. The largest increased was occurred in the highest dense of 43,304.1 hectare or 46.05%.

1. Introduction

Orangutans is the only great ape that lives in Asia, while three of its relatives, namely; gorillas, chimpanzees and bonobos live in Africa. The largest orangutan population in Sumatra is found in West Leuser (2,508 individuals) and East Leuser (1,052 individuals), and Singkil Swamp (1,500 individuals). The current conservation status of Sumatran Orangutans according to the International Union for Conservation of Nature and Natural Resources (IUCN) is critically endangered. Gunung Leuser National Park Forest in Bukit Lawang section is the main habitat of the Sumatran Orangutan (P. abelii) in Sub-district of Bahorok.

Sumatran orangutan (Pongo abelii) can live in a variety of forest types, from dipterocarp forests to mountain forests. Opening of forest areas is one of the biggest threats to the environment because it affects the functioning of the ecosystem that supports life in it. During the 1980-1990 period, Indonesia's forests had been reduced by conversion land to agriculture, plantations and settlements, forest fires, and unsustainable forest exploitation practices [1].

Forest damage which reached 56.6 million ha at a rate of 1.8-2.8 million hectares per year, both caused by human and natural factors affect the habitat of various species of wildlife being reduced and fragmented, such as the habitat of Sumatran Orangutan. Orangutan habitat in Sumatra disappears very quickly. The condition of wildlife habitat in Gunung Leuser National Park area has been fragmented by...
various human activities so that it becomes a major threat to the wildlife survival. According to [2] parts of the Gunung Leuser National Park (GLNP) have been fragmented by palm oil plantations. Bukit Lawang is one of Sumatran Orangutan habitat and also an ecotourism area which a former orangutan rehabilitation station that was officially closed in 1997. (Ministry of Forestry Decree No. 280/kpts II/1995). The area is located in Bukit Lawang section, Sub-district of Bahorok, District of Langkat, North Sumatra Province and within the Gunung Leuser National Park area. In North Sumatra, it is estimated that forest cover has decreased from around 3.1 million hectares in 1985 to 1.6 million hectares in 2007. This proves that there has been a change in forest density area which large in Indonesia, so this research needs to be done to find out changes in vegetation density of Sumatran Orangutan habitat in Bukit Lawang and Sub-district of Bahorok.

The purpose of this study is to obtain vegetation density value of Sumatran Orangutan habitat (P. abelii) in Bukit Lawang and Sub-district of Bahorok in 2018, analyse the changes of vegetation density in Sumatran Orangutan habitat in Bukit Lawang and Sub-district of Bahorok in 2018.

2. Method

2.1. Site research
This research was conducted from October until December 2018. The research location was in Bukit Lawang section and Sub-district of Bahorok, North Sumatra Province. Data processing was carried out at the Integrated Forest Management Laboratory, Forestry Study Program, Faculty of Forestry, University of Sumatera Utara.

2.2. Materials and methods
The tools used in this study consisted of data collection tools and data analysis tools. Field data collection tools include GPS (Global Position system), measuring tape, haga hypsometer, camera, stationery and others. Data analysis tools that will be used are Computer, Excel, ArcGIS 10.3, ERDAS Imagine 9. The data used in this study are primary data, which is ground check, and secondary data which is Landsat 5 and Landsat 8 imagery 2018 as well as administrative maps of Bukit Lawang and Sub-district of Bahorok 2018.

2.3. Data collecting
Data collection methods in this study were carried out by downloading Landsat 5 imagery path / row 129/58 in 2008 and Landsat 8 imagery OLI path / row 129/58 in 2018 from the sites www.glovis.usgs.gov and www.eartexplorer.usgs.gov which is needed in accordance with the objectives of analysis. Primary data is data obtained by direct observation to the research location (ground checking) by recording field coordinates observation point from GPS and the conditions around the field point which are equipped with images and analysis of vegetation.

Vegetation analysis using the square line method with a width of 25 meters and a length of 250 meters (area of 6,250 m²). Each lane is made of a sub plot measuring 6 m x 6 m for the seedling level, for the 25 m x 25 m pole level, 12.5 m x 12.5 m for the sapling level, and 50 m x 50 m for the tree level. The number of plots in this study were 45 plots spread over 3 different locations with the plots size larger than usual. As [3] stated that each lane was made of sub-plot with a size of 2 m x 2 m for seedling level, pole level 10 m x 10 m, 5 m x 5 m for sapling level, and 20 m x 20 m for tree level.

The plot size was deliberately made 50 m x 50 m with the aim to exceed the pixel size of the Landsat image that is 30 m x 30 m, so the data obtained would be more representative or accurate when compared to the plot size that is smaller than Landsat image pixel size. Calculation of analysis of tree level vegetation, saplings and seedlings is carried out with the formula [4, 5].

\[
\text{Density per ha} = \frac{\text{total number of number species} \times 10000 \text{ m}^2}{\text{total number of square studied} \times \text{area of quadrat}}
\]  
(1)
\begin{align*}
\text{Relative density} & = \frac{\text{density per ha of a species}}{\text{total number of density all species}} \times 100 \% \\
\text{Frequency of species} & = \frac{\text{total number of quadrat in which species found}}{\text{total number of square studied}} \\
\text{Relative frequency} & = \frac{\text{frequency of a species}}{\text{total number of frequency all species}} \times 100 \% \\
\text{Dominance} & = \frac{\text{basal area of a species}}{\text{total number of square studied}} \\
\text{Relative dominance} & = \frac{\text{dominance of a species}}{\text{total dominance of all species}} \times 100 \% \\
\text{Important Value Index}_{\text{tree}} & = \text{Relative density} + \text{Relative frequency} + \text{Relative dominance}
\end{align*}

2.4. Data analysis

2.4.1. Analysis of Normalized Difference Vegetation Index (NDVI). NDVI transformation is performed using ArcGIS 10.1 software for red and near infrared bands, which are band 3 (Red) and 4 (Near Infrared) for Landsat 5 and bands 4 (Red) and 5 (Near Infrared) for Landsat 8. The working principle of NDVI is by measuring the level of greenness. Values ranging from -1 to +1 resulting from the NDVI transformation have different presentations on land use. According to [5]. The formulas used are:

\[ \text{NDVI} = \frac{\text{IR} - \text{R}}{\text{IR} + \text{R}} \]

IR = infrared band reflectance value (band 4,5),
R = red band reflectance value (3,4).

Classifying NDVI used equal intervals in the ArcGIS software [6]. This classification is shared so that we know the area of Bukit Lawang forest section and Bahorok sub-district. The NDVI value is categorized into 4 classes, namely: lower dense, low dense, moderate dense, dense, and high dense.

2.4.2. Analysis of vegetation density changed. For the analysis purposes, 3 bands/canals were selected according to the spectral characteristics of each canal / band and adjusted for the study purpose. Bands/canals 5, 4, 3 were chosen on Landsat 5 and bands 6, 5, 4 on Landsat 8. Because these bands/canals are sensitive and have high reflection value on vegetation, exposed soil, and water elements. This process is used to find out the results of digitizing the changes in Bukit Lawang and sub-district of Bahorok, with the overlapping process between year of 2008 and 2018.

3. Result and discussion

3.1. Distribution of NDVI values in Bukit Lawang year of 2008 and 2018

Table 1 and Figure 1a show the area of vegetation density class with the largest NDVI value was high dense class, with NDVI range > 0.45 with area of 31,385.7 ha or 88.29% entire Bukit Lawang Section area of 2008. Whereas in 2018 based on data Table 1 and Figure 1b, the density of dense class was the largest value with NDVI range 0.30 - 0.45 having area of 25,407.46 Ha or 71.45%.
Table 1. Normalized difference vegetation index (NDVI) value in Bukit Lawang year of 2008 and 2018

| No | Vegetation Density Class | NDVI | Area (Ha) Bukit Lawang 2008 | Area (Ha) Bukit Lawang 2018 | Area (Ha) Bahorok 2008 | Area (Ha) Bahorok 2018 |
|----|--------------------------|------|-----------------------------|-----------------------------|------------------------|------------------------|
| 1  | Low dense                | 0 – 0.15 | 112.96                      | 126.80                      | 1,359.88               | 856.51                 |
| 2  | Medium Dense             | 0.15 – 0.30 | 88.47                      | 369.48                      | 1,897.13               | 6,015.59              |
| 3  | Dense                    | 0.30 – 0.45 | 3,962.18                  | 25,407.46                   | 13,033.16              | 56,337.24             |
| 4  | High Dense               | > 0.45   | 31,385.70                   | 9,645.59                    | 77,905.86              | 30,865.84             |
|    | Total                    |          | 35,549.31                   | 35,558.33                   | 94,196.03              | 94,075.18             |

Figure 1. Map of normalized difference vegetation index (NDVI) distribution in Bukit Lawang year of 2008 (a) and 2018 (b)

3.2. Distribution of NDVI values in Sub-district of Bahorok year of 2008 and 2018

Data of Table 1 and Figures 2a and 2b show the largest NDVI value was high dense class, with NDVI range > 0.45 and area of 77,905.86 ha or 82.71% entire sub-district of Bahorok. Whereas in 2018 based on table 1 and figure 2b, the largest NDVI value was dense class with NDVI range 0.30 - 0.45 having area of 56,337.24 hectares or 59.89%.

Figure 2. Map of normalized difference vegetation index (NDVI) distribution in Sub-district of Bahorok year of 2008 (a) and 2018 (b)
3.3. Analysis of vegetation density changes in Bukit Lawang year of 2008 and 2018

The degree of vegetation density based on NDVI values can be used as a basis for predicting in accordance with the dominance of plants in the field. According to [7, 8] vegetation coverage that has range of NDVI 0.1 show grasslands and shrubs, more than 0.1 to 0.8 indicate tropical forests.

Table 2. The changes of vegetation density in Bukit Lawang and Bahorok year of 2008 and 2018

| No | Vegetation Density Class | NDVI | Changes area (ha) | Bukit Lawang | Bahorok |
|----|--------------------------|------|-------------------|-------------|---------|
| 1  | Low dense                | 0 – 0.15 | 13.84 | 503.37* |
| 2  | Medium Dense             | 0.15 – 0.3 | 281.01 | 4,118.46 |
| 3  | Dense                    | 0.3 – 0.45 | 21,445.28 | 4,304.1 |
| 4  | High Dense               | >0.45 | 21,740.11* | 47,040.02* |

(*) = Decrease

Based on the data in Table 2, it is known that there is a change of vegetation density area in each range of NDVI value in 2008 and 2018. Changes in vegetation density area in each range of NDVI value include increasing and reducing the density area according to vegetation density class (Figure 3). The largest changes occurred for high dense class in 2018. This is due to human activities such as land clearing for road construction, settlements and plantations. Forest conversion was triggered due to human activities, population growth and huge local and foreign tourists in the region which then encourage people to convert forests for survival purposes. It is proved by many luxury lodgings located, ecotourism area, busy residential areas and rubber plantations and mixed gardens which are located very close to Gunung Leuser National Park forest in Bukit Lawang Section. Areas with dense populations and abundant human activities and high accessibility can trigger and encourage people to change land use [6]. Occurred of vegetation density change area occur due to changes in land use related to population increase that causes changes in land use into settlements areas, as [9] stated that population growth is one of the main factors in the settlement’s development.

Figure 3. Diagram of Vegetation Density Change in (a) Bahorok, (b) Bukit Lawang year 2008 and 2018

3.4. Analysis of vegetation density changes in Sub-district of Bahorok year of 2008 and 2018

Based on the data in Table 2, it is known that there is a change in vegetation density area of each NDVI range in Sub-district of Bahorok in 2008 and 2018. In 2018, vegetation density area of high dense has decreased by 47,040.02 Ha or around 49.9%. Whereas the dense class increased in 2018 with area of 43,304.1 hectares or about 46.05% (Figure 3b). The occurrence of consistency can be seen in the decline that occurs in the rare class and high dense class between the results of the map overlay Bukit Lawang Section and Sub-district of Bahorok.
The decrease occurred at the same density class on the two administrative maps. The largest changes occurred on high dense class in 2018. It is because limited production forest activity, so there are several plantations and rubber in Sub-district of Bahorok. In accordance with Langkat District Regulation 9/2013 which stated that limited production forest area, with an area of about 56,141 hectares located in Sub-district of Bahorok, Salapian, Kutambaru, Sei Bengai Kuala, Batang Srangan, Seberang Palm, Sei Lepan, Berandan Barat, Besitang, Pangkalan Susu, and Pematang Jaya. Based on these data it can be concluded that area of limited production forests in Sub-district of Bahorok is about 59.6% of total area. In addition, there are also land use for cultivation of wetlands and dry land plants. The development of cultivation areas both in forest management and production aims to improve community welfare. Statistical Center Agency (SCA) Langkat Sub-district of Bahorok (2008) stated that percentage of underprivileged families is 25% of population, while [10] stated that percentage of underprivileged families is only 11%. Figure 9 below is the result of vegetation density changes in Sub-district of Bahorok year of 2008 and 2018.

![Figure 4. Map of vegetation density change in (a) Bukit Lawang Section and (b) Bahorok Sub-district between 2008 and 2018](image)

**Table 3.** Ten main tree species based on IVI in Bukit Lawang section

| No | Species                      | Individual | RD (%) | RF (%) | RDm (%) | IVI  |
|----|------------------------------|------------|--------|--------|---------|------|
| 1  | *Shorea parvifolia*          | 123        | 5.53   | 1.04   | 0.75    | 7.31 |
| 2  | *Cactanopsis tungurut*       | 30         | 4.92   | 1.08   | 0.70    | 6.71 |
| 3  | *Shorea leprosula*           | 72         | 3.23   | 1.04   | 0.79    | 5.06 |
| 4  | *Litsea firma*               | 53         | 2.38   | 1.04   | 1.05    | 4.46 |
| 5  | *Aglaia sp*                  | 49         | 2.22   | 1.04   | 0.76    | 4.14 |
| 6  | *Hopea odorata*              | 49         | 2.20   | 1.04   | 0.76    | 4.00 |
| 7  | *Shorea ovalis*              | 44         | 1.97   | 1.04   | 0.85    | 3.86 |
| 8  | *Actinodaphne angustifolia*  | 38         | 1.96   | 1.05   | 0.59    | 3.59 |
| 9  | *Polyalthia lateriflora*     | 21         | 1.74   | 1.03   | 0.81    | 3.59 |
| 10 | *Endospermum diadenum*       | 26         | 1.74   | 1.04   | 0.58    | 3.36 |

3.5. Vegetation analysis in Gunung Leuser National Park, Bukit Lawang Section

Based on the Table above, the most dominant tree species are from the Dipterocarpaceae family, namely *Shorea parvifolia* with Relative Density (RD) of 5.53%, Relative Frequency (RF) of 1.04%, Relative Dominance (RDm) of 0.75% and Important Value Index (IVI) 7.31. This is in accordance with [11] stated that the most dominant vegetation in the Gunung Leuser National Park Bukit Lawang Section originating from the Dipterocarpaceae family, namely *Shorea parvifolia.*
The dominate type influenced by several factors, including; genetic and environmental factors, competition between existing plants, in this case related to the climate and minerals needed. Climate and minerals needed will support the growth and development of a species, so that the species will be superior and more found in an area [12]. Species with the lowest IVI is *Endospermum diadenum* with Relative Density (RD) 1.74%, Relative Frequency (RF) 1.04%, Relative Dominance (RD) 0.58% and Importance Value Index (IVI) 3.36.

4. Conclusion
The largest vegetation density class of Sumatran Orangutan (*P. abelii*) habitat in Bukit Lawang and Sub-district of Bahorok year of 2018 is dense class with each area respectively 25,407.46 Ha or 71.45% Ha and 56,337.24 or 59.89%. The largest Change of vegetation density class in Sumatran Orangutan (*P. abelii*) habitat in Bukit Lawang and Sub-district of Bahorok is high dense class with a decrease in area of 21,740.11 Ha or 50% and 47,040.02 Ha or 49.9%. Whereas the smallest change of vegetation density class in Sumatran Orangutan (*P. abelii*) habitat in Bukit Lawang and Sub-district of Bahorok is rare class with a decrease in area of 13.84 Ha or 0.03% and 503.37 Ha or 0.53%.

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