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Land Cover Change and Deforestation Characteristics in The Management Section of National Park (MSNP) VI Besitang, Gunung Leuser National Park

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Abstract. Gunung Leuser National Park (GNLP) is one of the world heritage forest located in Indonesia where the Government of Indonesia and International world give serious attention to the condition of that area. Unfortunately, forest area of GNLP significantly decreasing by years due to deforestation. This study aims to determine land cover changes and spatial characteristics of deforestation in MSNP VI Besitang, GNLP. The method used to detect land cover change was post comparison, where the land cover was detected using digital satellite landsat imagery. The results of study showed that remote sensing could be used to detect changes of land cover at MSNP VI Besitang with good accuracy (>85%). Deforestation area that occurred had a positive correlation with population and number of farm households and negative correlation with distance from rivers, roads, settlements, plantations, slopes, and altitude.

Keyword: Deforestation, Driver of Deforestation, Land Cover Change.

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1 Introduction

Population growth causes an increase in need for agricultural land, settlements, industry, and trade. This can cause damage to the forest. One of the factors causing forest destruction is socio-economic problem of community surrounding forest, which ultimately increases of deforestation and forest and land degradation. Deforestation is a change in forest cover to be a non-permanent forest. According to [1] deforestation is conversion of forests to other uses or long-term reduction of canopy closure below 10%. Deforestation has become a national problem because it greatly affects of national economic conditions, community livelihoods, and biodiversity of the world's forests.

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According to [2]-[3] that in 2015-2016 deforestation in North Sumatra reached of 7,907.2 ha. The number has increased quite high compared to deforestation in 2013-2014, which was 4,633.9 ha. Without the right policies, deforestation can threaten the existence of tropical forests in Indonesia. There are two perspectives in viewing deforestation, i.e. time perspective and spatial perspective. A thorough review of deforestation and climate change can be found in the study [4]. In terms of time perspective, deforestation is strongly influenced by the time/season (period) of events. As for spatial perspective, rate of deforestation is strongly influenced by spatial factors, namely location, area, distance, connectivity, and/or contiguity of spatial elements.

Gunung Leuser National Park is one of the world heritage forests in Indonesia. GLNP is a conservation forest that receives serious attention from both Indonesian Government and international community. However, [5] said GLNP Conservation area is one of the forest areas that is experiencing severe degradations. The MSNP VI Besitang is one of damaged regional sections within GLNP. This area is located in Langkat Regency and covering amount of 115,000 ha. Administratively, it is located in Besitang, Sei Lepan, and Batang Serangan Districts. The management of GLNP area at MSNP VI Besitang is facing very complex problems leading to destruction of forest areas.

The use of remote sensing and geographic information systems is possible in forest monitoring activities. Information on changes in land cover and characteristics of deforestation is needed in forest management activities. This study aims to determine land cover changes and the spatial characteristics of deforestation in MSNP VI Besitang of GLNP.

2 Method

This research was conducted at MSNP region VI Besitang of GLNP, located in Langkat Regency, North Sumatra Province (Figure 1).

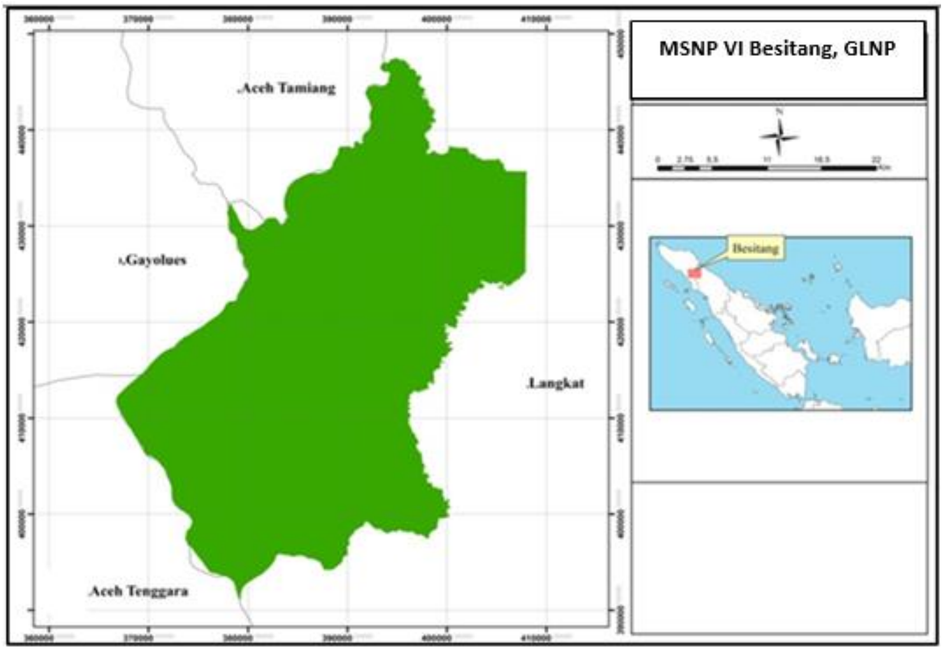

Figure 1 Site Map

The materials used in this study were ground check data of land cover obtained from the field, maps of GLNP area, map of road and river networks, village administration maps, population density data, digital elevation model (DEM) from Shuttle Radar Topographic Mission (SRTM), and Satellite Imagery in 2008 and 2016 (Table 1).

Table 1 The data of Satellite Imagery used in the study

No	Material	Description
1	Satellite Imagery 5 Year of 2008	Path, Row : 129/57, 129/58 Acquisition Date: 18 February 2008
2	Satellite Imagery 8 Year of 2016	Path, Row : 129/57, 129/58 Acquisition Date: 1 July 2016

2.1 The Land Cover Change

Classification method used supervised classification with Maximum Likelihood Classification (MLC) referring to [6]. The post comparison method used to analyze of land cover change. Determination of training area based on ground check sampling point of land cover in the field using GPS.

Kappa Accuracy used to test accuracy of land cover classification results obtained with ground check data. Mathematically, the accuracy of the Kappa Accuracy Formula refers to [7] with the following equation:

$$\text{Kappa Accuracy} = \frac{N\, \Sigma\, Xkk - \Sigma\, Xkt\, Xtk}{N2 - \Sigma\, Xkt\, Xtk} \times 100\% \qquad (1)$$

Description:

Xkk = Diagonal value on row k and column k

Xkt = Number of pixel on column k

Xtk = Number of pixel on row k

N = Number of pixel

2.2 The Spatial Deforestation Characteristic

Analysis of factors triggering deforestation had been conducted to predict and measure how closed or far those factors to forest destruction. Euclidean Distance is distance analysis is a spatial analysis which capable to measure how close the factors to forest destruction [8]. The measured parameters were distance from road, distance from river, distance from settlements, and distance from farm. Euclidean distance of two vectors x and y calculated using following equation:

$$d(x, y) = \left(\sum_i (xi - yi)^2 \right)^{1/2} \quad (2)$$

Pearson Correlation is one of correlation measurements used to measure strength and direction of a linear relationship of two variables. Deforestation size was compared to several variables which could drive deforestation, namely distance from road, distance from river, distance from settlements, distance from farms, slope class, height class, number of residents, and number of farmer households. The drivers of deforestation referred to [9].

3 Result and Discussion

3.1 The Land Cover Change

The land cover classification carried out by analyzing digital images on Landsat 8 satellite images for 2016 and Landsat 5 satellite images for 2008. In both images, there were clouds covering of land below. Therefore, clouds and cloud shadow were classified separately. The results of training area were six land cover classes in MSNP Region VI Besitang area, namely clouds, cloud shadow, forests, dryland mixed agriculture, oil palm, and open land. Spatial distribution of land cover for MSNP Region VI Besitang in 2008 and 2016 was presented in Figure 2.

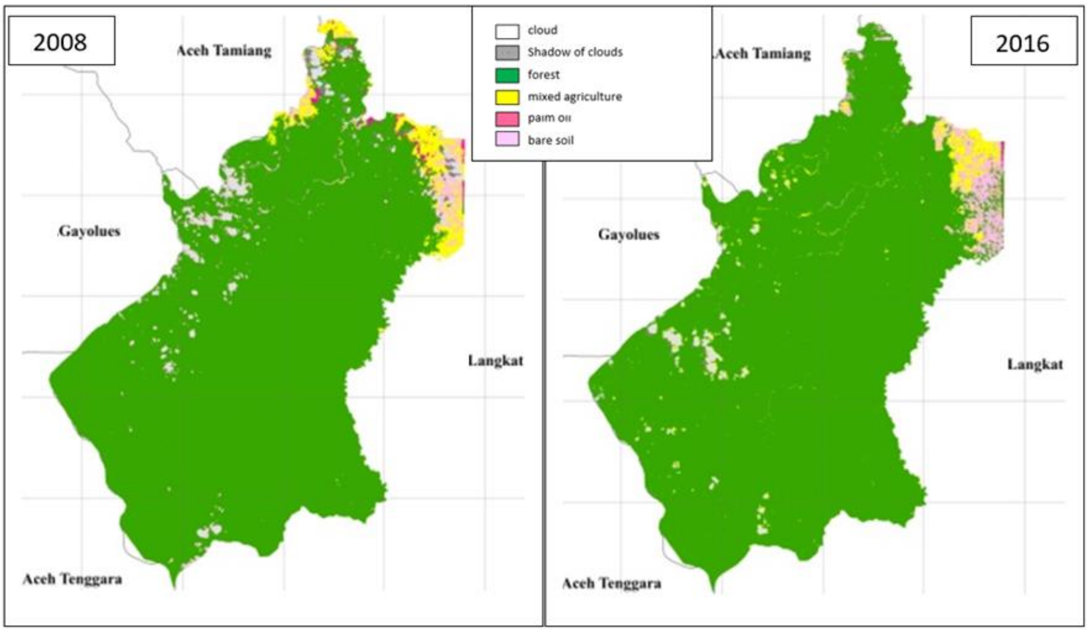

Figure 2 Map of Land Cover MSNP VI Besitang Year 2008 and 2016

Accuracy test resulted in overall accuracy of pixels used as a training area in land cover classification in 2008 and 2016 were 99.8% and 100% respectively, while kappa accuracy values were 99.7% and 100% respectively. The overall result of kappa accuracy on both years considered good because of value was more than 85%, corresponding with provisions set by United States Geological Survey (USGS) [10].

For validation, the land use map year 2016 was tested with field conditions. There was 125 point of ground check determined in study area. The validity test of land cover classification with ground check data resulted of confusion matrix (Table 2).

Table 2 Confusion Matrix of Land Cover Year 2016

	Land Use	Condition on the Field				Total	User Accuracy
		Forest	Dryland Mix Farm	Open Area	Oil Palm		
Land Cover Map Year 2016	Forest	68	0	0	0	68	1
	Dryland Mixed Agriculture	0	15	1	0	16	0.94
	Open Area	0	0	24	0	24	1
	Oil Palm	5	1	0	11	17	0.65
	Total	73	16	25	11	125	
	Producer Accuracy	0.93	0.94	0.96	1		

Overall, Accuracy and Kappa Accuracy value in 2016 land cover classification was 94.4% and 90.9%. Those accuracy value levels were considered quite high and qualified. USGS stated that interpretation accuracy more than 85% is acceptable and can be used for various purposes.

The result of Landsat digital images analysis of land cover in MSNP VI Besitang GLNP was presented in Table 3.

Table 3 Land Cover in MSNP VI Besitang in 2008 and 2016

No.	Land Cover	Land Cover Area (ha)	
		Year of 2008	Year of 2016
1	Cloud	2,489.17	1,600.12
2	Cloud Shadow	643.30	111.76
3	Forest	104,741.15	107,336.03
4	Dryland Mixed Agriculture	3,690.40	2.498.53
5	Oil Palm	526.96	88.40
6	Open Area	3,116.80	3,572.93
	Total	115,207.78	115,207.78

The cloud obstructed trend of extensive forest cover to describe of actual forest condition. Cloud and shadow significantly influenced the resulted of Landsat data and image quality. Cloud also had an impact on classification result. One of disadvantage Landsat imagery lies in the passive sensor [11]. The quality of data produced by Landsat sensors is highly dependent on atmospheric conditions at the time of recording. The presence of clouds, fog, and smoke or other atmospheric disturbances will result in a decrease of data quality produced especially in the tropics surrounding of equator, where cloud cover is high and evenly distributed throughout the year.

Interpretation of digital satellite imagery used in this study depended on single digital number pixel value of image. This method only extracts spectral information from images without considering spatial information, in contrast to visual interpretation methods where classification carry out directly by including things that are visible in satellite imagery. It can affect the results obtained in each land cover area, especially in forest and oil palm land cover, where digital number value was almost similar. Similar digital numbers value causing of images classification was less accurate on both land cover, especially of point where ground check was not carried out. It resulted in possibility a wider area of oil palm cover compared to classification result obtained.

Due to the incapability of Landsat imagery to read objects under clouds or cloud shadows, the alterations of cloud into forest or vice versa, clouds become non-forest or vice versa, cloud shadows become forest or vice versa, cloud shadows become non-forest, or vice versa, and clouds become non-cloud or vice versa could not be classified into deforestation or reforestation. Those alterations were classified into no data.

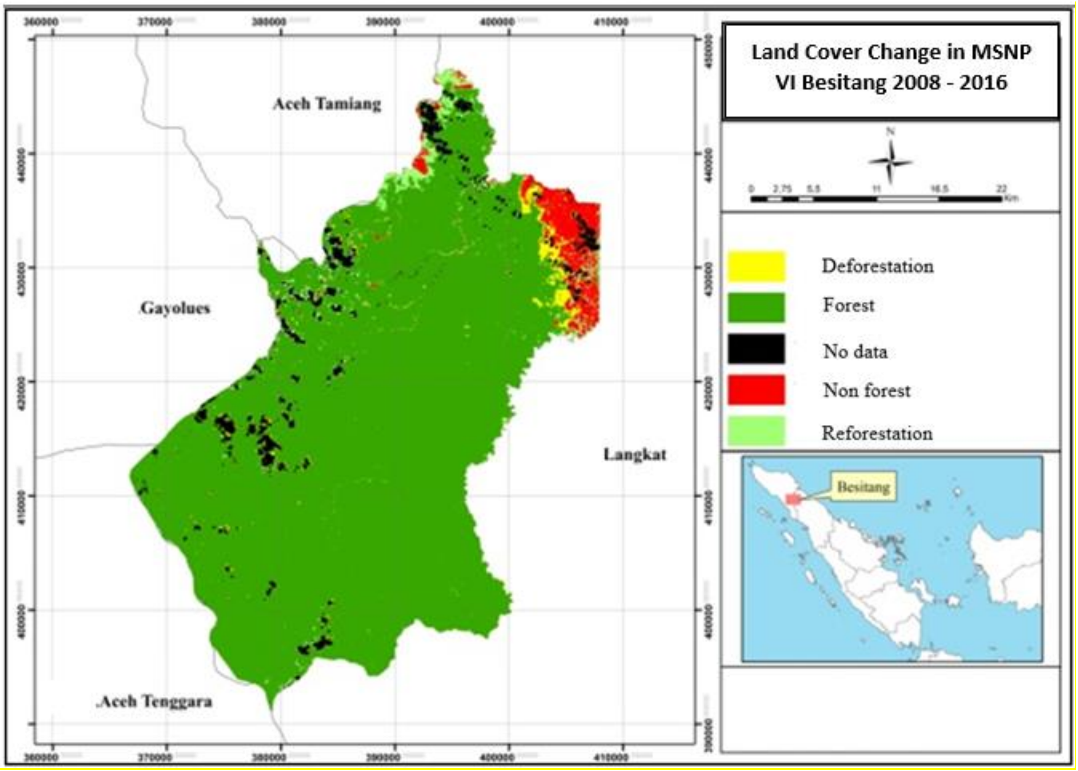

Figure 1 Map of Land Cover Change in MSNP VI Besitang Year of 2008 to 2016

3.2 The Spatial Deforestation Characteristic

The driving forces are factors as trigger for deforestation, which does not directly occurrence affect of deforestation. The drivers of deforestation in this study were identified through exploratory analysis based on initial (apriori), literature studies, and data availability used as the basis for selecting several variables from a large number of variables that be used. The selection based on the initial guess, then tested using statistical methods to determine of appropriate variables used in spatial modeling of deforestation.

Population growth is one of main factors causing deforestation increment area every year, especially people who work as farmers, they need more forest areas to meet their needs. This was in accordance to [12], who stated that population density of a region will influence of potential for environmental damage. The higher population density, the higher of community's needs for land availability.

In addition to increasing population, the road network was one of the driving factors of deforestation. The existence of a road network surrounding or inside a forest area provides access for community to explore the forest. River network functions as water sources, however in some locations, it acts as a road network. According to [13] that deforestation and forest degradation occurred because of proximity the forest areas to river networks. Both road and river network were included in accessibility factor.

The altitude was also a factor affecting deforestation. It was assumpted that the higher of forest area then chances of deforestation will increase. This was related to several research results, which stated that altitude factors were inversely proportional to deforestation events [14].

According to [15], on low to medium slope levels, forest quality was highly declining compared to steep slopes. This area was used for agriculture, horticulture, agroforestry, and grazing by community. The slope is related to biophysical conditions of land. Forest areas with increasingly steep slopes are likely to be deforested. According to [14], opportunity of deforestation will increase in relatively sloping areas. The characteristics of deforestation that occurred in MSNP Region VI Besitang GLNP was presented in Table 4.

Table 4 Statistical Value of Deforestation in MSNP VI Besitang

	Rd	Rvr	Stmt	Frm	Hgt	Cmty	Hhd	Slope	Area
Min	00	00	22,653.77	330	00	00	00	00-8	00
Max	28,060.8	33,756.23	446,688.1	336,355.6	22,601	66,750	11,148	>>45	551.75
Mean	88,426.94	6608.48	221,942.86	111,741.87	7713	55,587.56	8881.55	88-15	00.76

Description:

Min : Minimum Value

Max : Maximum Value

Rd : Distance from the road (m)

Rvr : Distance from the river (m)

Stmt : Distance from the settlement (m)

Frm : Distance from the farms (m)

Htg : Height (m)

Cmty : Number of Community (person)

Hhd : Number of farmer households (person)

Slope : Slope class (%)

Area : Deforestation Area (ha)

Pearson correlation analysis showed that deforestation area had a positive correlation with the population and number of farm households. This indicated that population growth and increase in the number of farmer households can trigger deforestation. The outcomes of this study strengthen the results of study [9] and [16].

Pearson correlation test results indicated of deforestation area had an inverse relationship with distance from road (-0.095), distance from river (-0.025), distance from settlement (-0.108), distance from farm (-0.101), slope class (-0.064) and altitude class (-0.069). Deforestation in extensive patches occurred mostly in areas far from roads, rivers, settlements, farms, flat areas, and areas with low topography. We assumed the patches of forest that close to the centers of human activities were narrowing. Therefore, deforestation in extensive patches of forest likely occurred in areas far from human activities. In addition, forest clearing for oil palm plantation which were often found in the field was easier to carry out in flat and low altitude areas.

4 Conclusion

The land cover changes had occurred since 2008 to 2016 in MSNP Region VI Besitang GLNP. The deforestation rate that occurred since 2008 to 2016 on MSNP Region VI Besitang GLNP was 221.14 ha/year. The deforestation area that occurred had a positive correlation with population and number of farmer households and negative correlation with distance from rivers, roads, settlement, farm, slope, and altitude.

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REFERENCES

[1] FAO [Food and Agriculture Organization]. (2011). REDD in Copenhagen Accord. http://agroindonesia.co.id/2010/01/12/redd-didalam-copenhagen-accord/.[20 March 2017].

[2] Ministry of Environment and Forestry. 2017. 2016. Environment and Forestry Statistics in 2016. Ministry of Environment and Forestry Data and Information Center.

[3] Ministry of Environment and Forestry. 2016. 2015 Environmental and Forestry Statistics Data and Information Center for the Ministry of Environment and Forestry.

[4] Moutinho P, Schwartzman S. 2005. Tropical deforestation and climate change. environmental defense. Amazon Institute for Environmental Research.

[5] Gunung Leuser Nasional Park, 2007. Leuser Trail Bulletin, Stepping on Nature Conservation with GLNP. Vol.3 No.8. ISSN 1858-4268.

[6] Sulistiyono et al., 2015. Detection of Deforestation Using Low-Resolution Satellite Images in the Islands of Sumatra 2000-2012. International Journal of Sciences: Basic and Applied Research (IJSBAR) (2015) Volume 24, No 1, pp 350-366

[7] Jaya, N. 2010. Digital Image Analysis: The Remote Sensing Perspective for Natural Resource Management. IPB. Bogor

[8] Ball, K. 1990. Eigenvalues of Euclidean Distance Matrices. Department Mathematics, Texas A & M University, College Station, Texas 77843, and Trinity College, Cambridge, England

[9] Sulistiyono et al., 2015. Spatial Model of Deforestation in Sumatra Islands Using Typological Approach. JMHT Vol. 21, (3): 99-109. Bogor.

[10] Sampurno, R M. and Thoriq, A. 2016. Land Cover Classification using Landsat 8 Operational Land Imager (OLI) Imagery in Sumedang Regency. Teknotan Journal Vol. 10 No. 2. Padjadjaran University. Bandung.

[11] Ekadinata, A., Zulkarnain MT., Widayati A., Dewi S., Rahman S., and VanNoordwijk M. 2012. Changes in Land Use and Cover in Indonesia in 1990, 2000 and 2005. World Agroforestry Center - ICRAF. Bogor. Indonesia

[12] Entwisle B, Rindfuss RR, Walsh SJ, Page PH. 2008. Population Growth and Its Spatial Distribution as Factors in the Deforestation of Nang Rong, Thailand. Geoforum; journal of physical, human, and regional geosciences. 39(2):879-897.

[13] Chen G, Powers RP, de Carvalho LMT, Mora B. 2015. Spatiotemporal patterns of tropical deforestation and forest degradation in response to the operation of the Tucuruí hydroelectric dam in the Amazon basin. Applied Geography. 63:1–8.

[14] Kumar R, Nandy S, Agarwal R, Kushwaha SPS. 2014. Forest cover dynamics analysis and prediction modeling using logistic regression model. Ecological Indicators. 45:444–455.

[15] Nandy S, Kushwaha SPS, Dadhwal VK. 2011. Forest degradation assessment in the upper catchment of the river tons using remote sensing and GIS. Ecological Indicators. 11: 509-513.

[16] Prasetyo LB, Kartodihardjo H, Okarda B, Adiwibowo S, Setiawan Y. 2009. Spatial model approach on deforestation of Java Island, Indonesia. JIFS. 6**:** 37 - 44.