Normalized difference vegetation index (ndvi) analysis for land cover types using landsat 8 oli in besitang watershed, Indonesia

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Abstract. Watershed is an ecosystem area confined by topography and has function as a catcher, storage, and supplier of water, sediments, pollutants and nutrients in the river system and exit through a single outlet. Various activities around watershed areas of Besitang have changed the land cover and vegetation index (NDVI) that exist in the region. In order to detect changes in land cover and NDVI quickly and accurately, we used remote sensing technology and geographic information systems (GIS). The study aimed to assess changes in land cover and vegetation density (NDVI) between 2005 and 2015, as well as obtaining the density of vegetation (NDVI) on each of the land cover of 2005 and 2015. The research showed the extensive of forest area of 949.65 Ha and a decline of mangrove forest area covering an area of 2,884.06 Ha. The highest vegetation density reduced 39,714.58 Ha, and rather dense increased 24,410.72 Ha between 2005 and 2015. The land cover that have the highest NDVI value range with very dense vegetation density class is the primary dry forest (0.804 to 0.876), followed by secondary dry forest (0.737 to 0.804) for 2015. In 2015 the land cover has NDVI value range the primary dry forest (0.513 to 0.57), then secondary dry forest (0.456 to 0.513) with dense vegetation density class

1. Introduction
Increasing population always needs land for establishing settlement and cultivation area. Deforestation and lands conversion into settlement have raised in the last decade. By the land use change, vegetation condition also will be changed on each type of land use. Besitang watershed is part of Leuser National Park (LNP). LNP is a one of remained tropical forest and become biosfer heritage in Sumatera. Proper management of Besitang watershed can maintenance LNP function as biosfer heritage. The use of such historical data is important for development of conservation strategy and demonstrated of long term past-antropogenic impact [15] Indonesian government has decided Besitang watershed as a priority watershed. It mean, based on biophysical and social economic characteristic of watershed, Besitang watershed has to be recovered
from suffering disturbance and degraded situation. Biophysical condition, vegetation coverage was vary in dense and its proportion. Vegetation coverage is important related to their role within maintenance land condition and ecosystem balance in watershed area. Detection of vegetation dense can be used as a tool for monitoring dynamics of ecosystem. Therefore, information on degree of forest degradation including forest fragmentation need to be defined to formulate a strategy for habitat and ecosystem management [11]. This information can be obtained from this study. Vegetation dense can be approach by calculating of NDVI (natural vegetation index). NDVI is the most common formula to calculate value of vegetation index (NDVI) give information related to primary production of vegetation [9]. Vegetation index is one of the most useful and used index to quickly identify vegetated areas with the use of multispectral remote sensing data [10].

NDVI has higher sensitivity corresponding with crown density change than other vegetation index. Landsat satellite (Landsat) 8 OLI has band range to determine NDVI. Using red and near infra red band, it can derive NDVI. NDVI calculate vegetation index based on red and near infra red reflectance received by Landsat. Research aimed (1) to obtain land cover in Besitang watershers within 2005-2015, (2) to determine landcover change in Besitang watershed within 2005 - 2015, (3) to examine the change of vegetation dense in Besitang watershed within 2005 - 2015, and (4) To obtain the degree of forest dense for landcover types in Besitang watershed within 2005

2. Material and Method
2.1. Study area
Study was carried out on March – June 2016. Study area cover Besitang watershed located in Langkat district, North Sumatera Province. Geographically, the watershed is situated in 03°45’ – 04°22’44” LU and 97°51’ – 99°17’56” BT (Fig. 1). Material and tool consist of (1) collecting data tool and (2) data analysis tool. Collecting data tool comprise of GPS, compass, camera, and stationary. Meanwhile analyses data tool were Microsoft Excel, ArcGIS 10.1, ERDAS Imagine 8.5 and ENVI 4.7. Some data are needed for completing the study including Landsat image year of 1990, 2005 and 2015 (path 129 row 57), Langkat district map, Besitang watershed map, and also other related research data. Some data were explored and collected by field survey.

2.2. Data collecting
Landsat images acquiring year 2005 and 2015 were downloaded through USGS (United State Geological Survey) web. Besitang watershed situated in path 129 and row 57. Primary data were collected during field survey. Primary data is data set which was obtained from directly field survey for checking the real condition. Ground checking was carried out to verify image classification result. It also to examined what NDVI value met with vegetation dense in the field. The number of samples are 10 poin for each landcover type. Meanwhile, secondary data is supporting data obtained from government agencies related to the study.

2.3. Image processing
Landsat image has to be composed because it comprised of many band ie. 11 band. Layer stacking was fulfilled to get image with band combination. All process was conducted using Erdas Imagine 8.5. Some corrections have been done to reduce atmosfer effect in the imagine. We used radiometric enhancement. It was conducted using linear model linear. Images was cropped to get a part image fit with watershed boundary. Image cropping was completed using ArcGIS 10.1.

2.4. Image classification
Unsupervised classification gives more working to computer for conducting classification processing. User just determine how many class has to produce. Landcover class was determined about 10 class. Each classes have been verified in the field. Furthermore, Supervised Classification also was done to produce lands cover. It is conducted based on verified result. Supervised classification is one of the most method to detect land use types. Spectral signatures delinate training area. Then, spectral signatures are used to classify all pixels in the image. Training area were made representing landcover types. Supervised classification method is followed by expert knowledge. It is depending on reference maps to improve the accuracy of the classification process [13], [2], [16].

Maximum likelihood were used to classify image base on training area. The satellite images were analysed to produce land cover (use) map. The land use classes (categories) referred to the category of Ministry of Forestry. Field surveys were conducted to verify landcover types and to collect vegetation data. Besides, maps of watershed boundary, river, administration, road, and other thematic maps were also collected.

2.5. Accuracy of classification
Accuracy is determined by comparing image classification result with field data of landcover. Accuracy calculating is stage to determined what classification result met with field situation. Accuracy analyses use contingency matrix which are square matrix comprise the number of pixel classification (error matrix or confusion matrix [1], [6]. Matematically, Kappa accuracy formula to calculate accuracy below:

$$\kappa = \frac{N \sum_{i=1}^{n} x_{ii} - \sum_{i=1}^{n} x_{im} x_{ni}}{N^2 - \sum_{i=1}^{n} x_{im} x_{ni}} \times 100\%$$

(1)

Where, N is the number of pixel observed, n is the number of row and collom on confusion matrix (equal with the number of classes), \(x_{im}\) is \(\sum x_{im}\) (the number of all collom of row-i), \(x_{ni}\) is \(\sum x_{ni}\) (the number of collom on row-n)

2.6. Landcover change
Identification of land cover changes is very important for management and planning watershed. The common change identification including land cover classifications, multi-date classification, vegetation index differencing and change vector analysis [7], [14]. Landcover change analyses compare landcover year 2005 with landcover year 2015. It to identify landcover change occured between 2005 until 2015. Rate of landcover change is stated with percent value with formula below:

$$V = \frac{N_2 - N_1}{N}$$

(2)
Where \( V \) is landcover change (hectare), \( N_2 \) is large area of time 2 (hectares), \( N_1 \) is large area of time 1 (hectares), and \( N \) = total area (hectares) [5].

Furthermore, Supervised Classification also was done to produce.

2.7. Vegetation index

Dense vegetation value is approached using NDVI (Normalized Difference Vegetation Index). NDVI value were calculated on composite image using equation 3. NDVI use band 3 (Red) and 4 (Near Infrared) for Landsat 7, and band 4 (Red) come with band 5 (Near Infrared) for Landsat 8. NDVI approaching calculation of greeness degree. Greenes degree of image corelate with vegetation crown density. NDVI have correlation with chlorofil contain. NDVI spread in range -1 untill +1. More number of NDVI, therefore more number of crown density. NDVI is formulated as below:

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

Where \( IR \) is reflectan value of infra red band (Band 4,5), \( R \) is reflectant value of red band (3,4).

Landsat 8 need to be calibrated by applying a normalization procedure radiance rescaling factors. The metadata file of Landsat providing information to calculate top of atmosphere values (TOA):

\[
L_\lambda = M_\lambda Q_{cal} + A
\]

where: \( L_\lambda \) is TOA spectral radiance (Watts (m-2 srad-1 µm-1)), \( M_\lambda \) is Band-specifics multiplicative rescaling factor from the metadata for each band number), \( A \) is Band-specific additive rescaling factor from the metadata for each band number, \( Q_{cal} \) is Quantized and calibrated standard product pixel values (DN).

2.8. Vegetation index

Crown density was apporched using value of NDVI. Further more, value of NDVI were classified into five class. It is conducted using Equal Interval with software ArcGIS Meanwhile, change of crown density change were obtained by comparing crown density of year 2005 with crown density of year 2015. Therefore, Vegetation density for types land cover 2005 and 2015 was indentified. It can be obtained from overlay land cover 2005 with crown density map 2015. Analyis was conducted to get crown density of aech landcover type with chlorofil contain.

3. Result and discussion

3.1. Landcover 2005 and 2015

Crown Study classify 12 types of land cover for 2005 and 2015 in Besitang watershed. Those are settlement, dried land primary forest, dried land secondary forest, mixed garden, rubber, palm oil, dried land arable mixed with shrub, ponds, bare land, water, mangrove, shrub, paddy field. Accuracy of classification is 91.83% for 2015 image classification. Meanwhile Kappa accuracy is 87.34% of image 2015 and 92.76% of image 2005. Table 1 show the land cover types and area in Besitang Watershed.
Table 1. Land types of Besitang watershed for 2005 and 2015.

| No. | Land cover types               | Area (Ha)  | % 2005 | % 2015 |
|-----|--------------------------------|------------|--------|--------|
|     |                                | 2005       | 2015   |        |
| 1   | Dry land primary forest        | 34,279.13  | 34,620.41 | 35.52  | 35.88  |
| 2   | Dry land secondary forest      | 631.82     | 1,240.19 | 0.65   | 1.29   |
| 3   | Shrub                         | 1,015.58   | 1,385.81 | 1.05   | 1.44   |
| 4   | Mangrove forest               | 6,729.95   | 3,913.55 | 6.97   | 4.06   |
| 5   | Rubber plantation             | 10,539.29  | 6,615.44 | 10.92  | 6.86   |
| 6   | Palm oil plantation           | 29,943.65  | 30,570.02 | 31.03  | 31.68  |
| 7   | Mixed dry land agriculture    | 1,320.14   | 536.03  | 1.37   | 0.56   |
| 8   | Paddy field                   | 1,731.80   | 1,781.09 | 1.79   | 1.85   |
| 9   | Settlement                    | 843.68     | 3,013.01 | 0.87   | 3.12   |
| 10  | Bare land                     | 1,625.78   | 4,407.11 | 1.68   | 4.57   |
| 11  | Water body                    | 2,563.67   | 1,620.62 | 2.66   | 1.68   |
| 12  | Ponds                         | 3,549.35   | 3,554.90 | 3.68   | 3.68   |
| 13  | Unidentified                  | 1,720.21   | 3,235.95 | 1.78   | 3.35   |
|     | Total                          | 96,494.11  | 96,494.11 | 100.00 | 100.00 |

Based on table 1, study found that the most large of land cover class is primary forest in 2005 as well as in 2015. The forest area is more than 35% of total area. It show Besitang watershed has the forest which enough to maintain the ecosystem condition. It is met with the decree Number 26 Year 2007 regarding to Land Allocation that state at least 30% of watershed area have to be a forest cover. In the up stream of watershed, there is a secondary forest covered 1.29% of total area in 2015. Having the existence of LNP the upstream of watershed need be maintained. Base on data obtained from LNP office, approximately 39,045 Ha or around 40.46% of Besitang area is LNP management area. Unfortunately, a part of LNP is not covered fully by forest in 2015 and 2015. It is caused by illegal logging occurred in LNP area. Therefore, second more large area is palm oil which cover more than 31% of total area. It is in line with population livelihood as farmer and gardener. Study also indentified many estate palm oil belong to company in the watershed area.

3.2. Rate of land cover change of 2005-
Period of 2005 – 2015, rate of landcover change is vary among landcover types (Table 2). Table 3 show primary forest area increasing about 341.28 ha while secondary foresy increase about 608.37 Ha. There is mangrove forest loss 281.64 per year ha along 20015-2015. Bare land area increase 2,781.34 Ha that is the most large area with rate 278.13 Ha/year, followed by mixed garden, palm oil, shrub, paddy field and ponds. The decreased of landcover occured on rubber estate that is about 3,923.84 Ha or 392.38 Ha/year.

Field survey found magrove was converted into palm oil, pond or bare land. There were also found palm oild become forest. Rubber plantation were harvested and established settlement. Log over area of rubber plantation become bare land left without activity.
3.3. NDVI of Besitang watershed
Crown Forest coverage change occurred within period 2005 – 2015 i.e. forest coverage became other landcover as well as other landcover become forest coverage (Table 3). Table 3 show, in 2015, about 283.95 ha of primary forest converted into palm oil plantation, amount 155.79 ha primary forest was logged to be bare land. The other way, palm oil, rubber plantation, and bare land became forest coverage within 2005 – 2015. The new forest coverage was found in the restoration area conducted by LNP, UNESCO and OIC.

Table 3. Landuse change in Besitang watershed year 2005 – 2015.

| No. | Landcover types | Year 2005 | Year 2015 | Area change (Ha) |
|-----|-----------------|-----------|-----------|------------------|
| 1.  | Dry land primary forest | 34,279.13 | 34,620.41 | 341.28           |
| 2.  | Dry land secondary forest | 631.82   | 1,240.19  | 608.37           |
| 3.  | Shrub | 1,015.58 | 1,385.81  | 370.23           |
| 4.  | Mangrove forest | 6,729.95 | 3,913.55  | 2,816.40         |
| 5.  | Rubber plantation | 10,539.29 | 6,615.44  | 3,923.85         |
| 6.  | Palm oil plantation | 29,943.65 | 30,570.02 | 626.37           |
| 7.  | Mixed dry land agriculture | 1,320.14 | 536.03    | 784.11           |
| 8.  | Paddy field | 1,731.80 | 1,781.09  | 49.29            |
| 9.  | Settlement | 843.68   | 3,013.01  | 2,169.33         |
| 10. | Bare land | 1,625.78 | 4,407.11  | 2,781.33         |
| 11. | Water body | 2,563.67 | 1,620.62  | 943.05           |
| 12. | Ponds | 3,549.35 | 3,554.90  | 5.55             |
| 13. | Unidentified | 1,720.21 | 3,235.95  | 1,515.72         |

Table 2. Increased and decreased of landcover period 2005-2015.

| No. | Landcover | Area (Ha) | Area (Ha) | Rate (Ha/year) |
|-----|-----------|-----------|-----------|----------------|
| 1.  | Dry land primary forest | 34,279.13 | 34,620.41 | 341.28          |
| 2.  | Dry land secondary forest | 631.82   | 1,240.19  | 608.37          |
| 3.  | Shrub | 1,015.58 | 1,385.81  | 370.23          |
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Degradation of mangrove forest occurred in 2005-2015. Forest mangrove convert into settlement, ponds, palm oil plantation, bare land and rubber plantation. Amount 1.016,82 ha of Palm oil give more economics benefit for community although ecologically it will invite natural disaster which mangrove forest convert into palm oil plantation while approximately 868,50 ha of mangrove forest convert into ponds. It is triggered by land needed for cultivation land especially in coastal area. The community create new income from forest conversion. New income can be obtained from palm oil plantation.

3.4. NDVI Besitang watershed 2005-2015

Vegetation is biomass and carbon storage potency. Presence of vegetation indicate how many carbon and biomass stock. NDVI can represent attended of vegetation. In 2005, studi found NDVI range from 0,422 to 0,737. It increase range from -0,11 to 0,876 in 2015. It indicate crown/vegetation density is more dense. Base on categorized, NDVI comprise of 6 class that are non vegetation, lowest dense, lower dense, moderate dense, dense, and highest dense (Table 4).

Table 6 shows the most area of watershed cover by higher dense vegetation. It is located in upstream of watershed and small part is LNP protected area. The vegetation are rubber plantation and palm oil. Meanwhile primary natural forest is found in part of LNP area. It is steepy and highly area. According to [17] forest landscape tend to be clustered in hill and mountain area. Forest in steepy area and difficult accessibility area have less human disturbance [3]. Remaining forests in Besitang watershed have relatively high elevation and undisturbed, while forests in relatively low elevation were more disturbance.

Lower and lowest dense were found along coastal and settlement. It is area with dense population and more human activites. High acessibilities is also found there so it can trigger and drive human converting land use and land cover. The road attracts human for changing land use and land cover. Human will convert forest to agricultural land triggering land use changes. Closer to the road, forests fragmentation and deforestation increase due to the relationship between forest and human home is easier [8]. Development of new road will change forest landscape [4].

| No. | Dense class   | NDVI       | 2005 Area (ha) | %  | 2015 Area (ha) | %  |
|-----|---------------|------------|----------------|----|----------------|----|
| 1   | Non vegetatiom| < 0        | 2,422.43       | 2.51| 520.67         | 0.54 |
| 2   | Lowest dense  | 0-0.15     | 2,436.59       | 2.53| 2,127.03       | 2.20 |
| 3   | Lower dense   | 0.15-0.3   | 3,993.28       | 4.14| 7,926.93       | 8.21 |
| 4   | Dense         | 0.3-0.45   | 9,874.65       | 10.23| 35,874.02     | 37.18 |
| 5   | Higher dense  | 0.45-0.6   | 44,913.72      | 46.55| 5,985,21      | 6.20 |
| 6   | Highest dense | > 0.6      | 32,853.44      | 34.05| 44,060.24     | 45.66 |
|     | Total         |            | 96,494.11      | 100 | 96,494.09     | 100.00 |

Table 5 show increased and decreased the level of vegetation density in Besitang watershed between 2005 and 2015. Higher dense loss about 38,928,51 ha. It indicates forest and vegetated area have been degraded or converted into other landuse. Based on field verification, study found the young palm oil plantation, new bare land and new settlement. Therefore, decreasing of dense vegetation also indicate the change of vegetation that dense old vegetation become young vegetation through replanting i.e. youn palm oil and young rubber plantation. Meanwhile, [12] state more higher the NDVI, it indicate old vegetation and health vegetation. In other way, young vegetation and lowest dense of vegetation have lower chorophyl so the reflectance greeness plant is lower.

Dense vegetation found more wide in 2015 than vegetation dense. Approximately, 25,999,37 ha is new dense vegetation class in 2015. It was predicted degraded forest, young vegetated area,
and young palm oil plantation. The situation is supported by data showing restoration activity and reforestation in this area.

Table 5. Increased and decreased vegetation density Besitang watershed period 2005-2015

| No. | Dense of vegetation | Area (Ha) | Change (Ha) |
|-----|---------------------|-----------|-------------|
|     |                     | 2005      | 2015        | Increased | Decreased |
| 1   | Non vegetation      | 2,422.43  | 520.67      | -         | 1,901.76  |
| 2   | Lowest dense        | 2,436.59  | 2,127.03    | -         | 309.56    |
| 3   | Lower dense         | 3,993.28  | 7,926.93    | 3,933.65  | -         |
| 4   | Dense               | 9,874.65  | 35,874.02   | 25,999.37 | -         |
| 5   | Higher dense        | 44,913.72 | 5,985.21    | -         | 38,928.51 |
| 6   | Highest dense       | 32,853.44 | 44,060.24   | 11,206.80 | -         |

3.5. NDVI and landcover type of Besitang watershed in 2005 and 2015

NDVI range of landcover type on different years can indicate landcover change and situation. Study show primary forest have the highest NDVI class range 0.804 to 0.876 in 2015 (Table 6). Secondary forest have NDVI in range 0.456 to 0.513; while primary forest have NDVI in range 0.513 to 0.57 in 2005. It shows forest coverage and forest density increase during 2005 – 2015. Furthermore, ponds have the lowest NDVI range from 0.057 to 0.114 in year 2005. It indicates mangrove forest degraded especially in ponds area. Forest coverage have NDVI higher than other land cover indicated by highest crown density. NDVI calculation representing chlorophyll result NDVI high value especially in forest coverage. Vegetation coverage dense is recognized by spectral reflectance. Base on value of spectral reflectance, it indicates the density of vegetation.

Table 6. Crown density of landcover type based on NDVI value in 2005 and 2015 year

| No. | Land cover             | Range of NDVI | Crown density |
|-----|------------------------|---------------|---------------|
| 1   | Dry land primary forest| 0.513-0.57    | 0.804-0.876   | dense        | Highest dense |
| 2   | Dry land secondary forest| 0.456-0.513 | 0.737-0.804   | dense        | Highest dense |
| 3   | Shrub                  | 0.456-0.513   | 0.67-0.737    | dense        | Highest dense |
| 4   | Mangrove forest        | 0.456-0.513   | 0.335-0.402   | dense        | Quite dense   |
| 5   | Rubber plantation      | 0.513-0.57    | 0.335-0.402   | dense        | Quite dense   |
| 6   | Palm oil plantation    | 0.513-0.57    | 0.335-0.402   | dense        | Quite dense   |
| 7   | Mixed dry land agriculture | 0.456-0.513 | 0.335-0.402   | dense        | Quite dense   |

4. Conclusion

Crown density was approached using value of NDVI. Further more, value of NDVI were classified into primary forest coverage have the highest NDVI range from 0.804 to 0.876, followed secondary forest range from 0.737 to 0.804 in year 2015. It is higher than NDVI value 2005. Bare land and settlement increase more extensive in Besitang watershed within 2005 – 2015. Mangrove forest loss about 2,816.40 Ha in the same period. The wide of highest vegetation dense increase quite large, lower dense of vegetation dense loss 39,714.58 ha approximately. Population growth cause lossed forest coverage meanwhile restoration can increase the wide of vegetated area in Besitang watershed.

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