Landcover change analysis of besitang watershed, Langkat-North Sumatera

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Abstract. Watershed is an ecosystem area bordered by topographic pattern and serves as a collector, storage and distributor of water, sediments, pollutants and nutrients in the river system and throughout by a single outlet. The high of population growth led to greater land use change. This research aimed to identify land cover classes and land cover change in Besitang watershed between 1990, 2005 and 2015. This research used Landsat 5 imagery in 1990 and 2005, and Landsat 8 imagery in 2015 with supervised classification using method maximum likelihood classifier. The result showed that there were 12 classes of land cover in the Besitang watershed, they were primary forest, secondary forest, mangrove forest, scrub, rubber plantations, oil palm plantations, dry land agriculture, bare land, settlement, fishpond and water body. The largest area of land cover area is primary forest covering an area of 38,542.43 hectares (39.94%) in 1990, 34,279.16 hectares (35.52%) in 2005, and 34,620.41 hectares (35.88%) in 2015. The largest area of land cover change between 1990 until 2005 is mangrove forest to fishpond with covering an area of 2,364.21 hectares change. While the largest area of land cover change between 2005 until 2015 is mangrove forest to oil palm plantation with covering an area of 1,016.82 hectares changes.

1. Introduction
Good perform of watershed can protect and maintain the lower area. Sufficient of vegetation coverage within watershed influence its performance [1]. Unfortunately, vegetation coverage existence was threaten by land occupation and land conversion for cultivation activities. It was occurred in watershed area correspond with many activities that can affect land cover and land use types. Population growth of people who live in watershed area can trigger land use change. People rely on natural resources to fulfill their livelihoods can cause land conversion and land cover change of watershed.

There are many watershed have high population growth and high acceleration of development activities result pressure on watershed performance. In west Java and DKI Jakarta provinces, Ciliwung watershed is example of watershed that get in ecology's pressure from high population growth especially population pressure in upper area of watershed. The amount of land needed by human beings due to the pressure of economic growth resulted in a lot of land use conversion. Landuse change is made to provide economic benefits for humans and also for settlement mostly [2]. However, it will result degrading of ecosystem balance and decreased environment service quality. The watershed encompassed the big city is heading toward watershed degradation as same as Ciliwung watershed if anticipate management is not running well. There is degradation of watershed in the big city such as Ciliwung which needs more attention. As example, watershed covered big city
of North Sumatera province are going on experiencing quality degradation. Besitang watershed as a part of Langkat district-North Sumatra Province has several disturbance of biophysical and anthropogenic factor. Meanwhile the most of Besitang upper stream area is as a part of Gunung Leuser National Park (GLNP) so that it will more secure than other areas. Vegetation structure and composition are still proper with ecosystem needed. The presence of vegetation covered in the upper watershed will improve and maintenance the water quality and quantity that flows through watershed.

Needed of land for cultivation is only provided by land clearing of forest area. The cultivated land extent only can be full filled with using land clearing of bare land, shrub, and other vegetated area. Land conversion and land cover change should be controlled and monitored in order to guarantee carrying capacity of ecosystem and watershed can perform properly. Controlling and monitoring of watershed ecosystem are needed to guarantee the performing of ecosystem function. Identifying and monitoring of land cover periodically are one effort to manage watershed ecosystem. Identification of land cover is to know land cover conditions at different times in the watershed. Study of landcover change was done. The study aimed: 1. to identify the existing land cover class in Besitang River Watershed, and 2. to find out the change of land cover that occurred in the Besitang River Watershed between 1990 - 2005 and 2005 - 2015

2. Method
This research was completed in Besitang watershed, North Sumatera Province. Research was conducted from August to December 2015. This research stages were image data preparation, image interpretation, field check, and mapping of land cover at year 1990, 2005, 2015. All data analysis was done at Forest Inventory Laboratory, Faculty of Forestry, Universitas Sumatera Utara.

2.1. Tool and data
The tool used in this research consists of data’s collection tools and data analysis tools. Field data collecting use tools that are Geographic Positioning System (GPS) and digital cameras. Data analysis tools used are computer hardware and some software that are Microsoft Excel, ENVI 4.7 [3], ERDAS Imagine 8.5 and ArcGIS 10.1. We used Landsat satellite images acquisition 1990, 2005 and 2015 (path 129 row 57), Langkat District administrative map, Besitang watershed boundary map, GLNP boundary map and ground check data.

2.2. Image processing
2.2.1. Merging imagery band. Landsat satellite images have several bands and separate each band. Therefore, the satellite imagery bands was merged in order to provide data for classification of land cover processes.

2.2.2. Radiometrics correction. Radiometric correction was done to eliminate disturbances that occurred in the image due to the effect of the atmosphere. Radiometric correction performed in the form of contrast sharpening process or radiometric enhancement. The contrast sharpening process was done with the linear model found in ERDAS Imagine 8.5 software.

2.2.3. Image cropping. Cutting the image was done to get a more specific image area of the research location. Cutting the image was using ArcGIS Software 10.1 using data vector Besitang watershed obtained from Environment and Forestry Ministry office.

2.2.4. Unsupervised classification. Unsupervised classification process was done to classify images based on the number of classes specified by the user. Unsolicited classification helps in determining ground check points for guided classification and test accuracy.

2.2.5. Field checking. Field check was conducted to verify the condition of land cover in the field based on several samples that have been made systematically on the image of unsupervised
classification. Then there was ground check to observe directly the type of land cover found on the site.

2.2.6. Supervised classification. Supervised classification was based on field survey resulted by making polygons or training areas in image. The method used is the maximum likelihood method of ERDAS Imagine 8.5 software. This stage result was land cover map of Besitang watershed.

2.2.7. Classification accuracy. Accuracy of image classification can be obtain by comparing the results of image classification with data obtained in the field. Accuracy calculation is the stage that determines whether the image classification results in accordance with the conditions in the field or not.

Image accuracy usually analyze in a contingency matrix that contains the number of image pixels in the classification, often called error matrix or confusion matrix [4]. Accuracy of image classification used is Kappa accuracy, Kappa Accuracy value must be ≥85%. Mathematically, the formula for calculating the accuracy is as follows:

\[
\text{Kappa Accuracy} = \frac{N \sum_{i=1}^{N} X_{in} \sum_{i=1}^{N} x_{in} - \sum_{i=1}^{N} x_{in} \sum_{i=1}^{N} x_{in}}{N^2 - \sum_{i=1}^{N} x_{in} \sum_{i=1}^{N} x_{in}} \times 100\%
\]

Note:
\(N\): the number of all pixels used for observation
\(N\): number of rows / lanes in the error matrix (equal to number of classes)
\(X_{in}\): \(\sum x_{in}\) (the sum of all columns on the i-th row)
\(X_{ni}\): \(\sum x_{ni}\) (sum of all columns in row n)

3. Result and discussion

3.1. Besitang watershed landscape 1990, 2005 and 2015

The classification of land cover conducted in this study was used Landsat 8 satellite images for 2015 and Landsat 5 satellite images for 1990 and 2005. Some area were cloud and shadows which were unclassified. Some area of images are clouds covering the land below, so there are some areas that are not identified because it was covered by cloud and cloud shadows. Based on training area made were obtained as many as 12 classes of land cover that exist in the Besitang River Watershed. Classification of classified land cover must be tested for its truth level (test of accuracy) [5] and Kieffer, 2010. Testing the accuracy of image classification results in 2015 is done by using multiple samples of field survey data and comparing it with classified land cover map. In this study the number of samples used for the accuracy test of 48 samples, and from 48 samples the number of samples corresponding to the land cover map of the classification were 42 samples. So that the accuracy value of land cover classification in 2015 was 87.50%.

In addition to accuracy tests based on field survey results, there are also Kappa Accuracy scores used to assess the accuracy of the satellite image classification results. The result of Landsat image classification accuracy in 1990 shows the value of Overall Accuracy 97.64% and Kappa Accuracy 96.01%. For the accuracy of Landsat image classification in 2005 obtained the Overall Accuracy value of 94.20% and Kappa Accuracy 92.76%. For 2015 the image used consists of two images due to poor image quality (cloud cover over 10%). Accuracy of Landsat Image Classification in 2015 obtained by Overall Accuracy 93.25% and 90.41%, while Kappa Accuracy value 89.58% and 85.09%. Based on the accuracy value, the result of image classification is acceptable because it has accuracy value more than 85% [6].

After classification of land cover class, then calculate the area of each land cover class. Calculation of land cover area is done by calculate geometry in attribute table. The extensive data of each class of land cover in the Besitang Watershed can be seen in Table 1.
Table 1. Landover change of Besitang watershed at year 1990, 2005 and 2015

| No. | Landover types               | Year 1990 | Year 2005 | Year 2015 |
|-----|------------------------------|-----------|-----------|-----------|
|     | Area (Ha)                    | Area (%)  | Area (Ha) | Area (%)  |
| 1.  | Primary dry land forest      | 38,542.43 | 34,729.16 | 34,620.41 |
|     | 2.  | Secondary dry land forest    | 372.68    | 631.82    | 1,240.19  |
| 3.  | Mangrove forest              | 11,083.13 | 6,729.98  | 3,913.47  |
| 4.  | Shrub                        | 4,083.47  | 1,015.58  | 1,385.81  |
| 5.  | Rubber estate                | 22,563.17 | 10,539.29 | 6,615.36  |
| 6.  | Palm estate                  | 9,832.13  | 29,943.65 | 30,569.94 |
| 7.  | Mixed dry land agriculture   | 1,015.91  | 1,320.14  | 535.95    |
| 8.  | Paddy field                  | 1,237.22  | 1,731.80  | 1,781.01  |
| 9.  | Settlement                   | 541.52    | 843.68    | 3,012.93  |
| 10. | Water body                   | 1,338.20  | 2,563.67  | 1,620.54  |
| 11. | Bare lands                   | 3,596.84  | 1,625.78  | 4,407.03  |
| 12. | Ponds                        | 1,224.44  | 3,549.35  | 3,554.82  |
| 13. | Unidentified                 | 1,062.97  | 1,720.21  | 3,236.65  |
|     | Total                        | 96,494.11 | 96,494.11 | 96,494.11 |

Based on the data in Table 1 it can be seen that more than 35% of the total area of the Besitang Watershed has a land cover in the form of primary dry land forest. The forest is located in the upper watershed of Besitang and in the area of is the Gunung Leuser National Park Area. The presence of forest vegetation in the upper watershed greatly affects the balance of the watershed ecosystem. According to Law no. 41 of 1999 on Forestry, the area of forest that must be maintained at least 30% of the area of the watershed watershed and or the island with a proportional distribution. Under the law, Besitang Watershed still meets the minimum extent of forest that must be defended in a watershed. By 2015, 35.88% of Besitang River Watershed land cover is primary dry land forest. However, the management of forests in the Besitang River Watershed must be kept in mind, given the reduction of forest area that occurred in the Besitang River Watershed.

Land cover data at three different year show that there was is decreased forest land cover from 1990 to 2005 and 2015. Forest coverage decreased found along edge forest that bordered with community land cultivation. There were land encroachment and land clearing for cultivation activities. It corresponds with population growth of Langkat district. Population growth of Langkat district increased along 1990-2000, move from 1.04 % per year to 1.14 % per year [7]. This condition supported by livelihood of Besitang community, that the most of community is as farmer. Farmer was estimated 85.79 % of population in Besitang sub district. Farmer population was also increase so it will increase land requirement for cultivation [7].

The similar land use change pattern was also occurred in National Park of Gunung Gede, Batang Toru ecosystem, and natural forest reserve of Kamojang. Forest coverage change was caused by land occupation surrounded of national park area and other forest area. In Gunung Gede National Park, within period of 2000 – 2010, there are decreased forest coverage of 5.55 %, which is triggered by population density factor [8]. Therefore, Batang Toru ecosystem is also experienced forest landscape fragmentation beside decreased of forest coverage area [9, 10]. It also found out in Kamojang-West Java, socio economics factor as well as low income was triggered forest conversion into other landuse type [11].

3.2. Landcover change of Besitang watershed landscape 1990-2005
In 1990 - 2005 there was large change on each class of land cover. The proportion change of land cover area between 1990 - 2005 was presented in Figure 2.
Figure 1. Area distribution of land cover change in Besitang watershed 1990 and 2005 year

Table 2. Landcover change in besitang wastersheds 1990 and 2005 year

| No. | Land cover type          | Area change (Ha) |
|-----|-------------------------|------------------|
| 1.  | Primary dry land forest | 33,047.91        |
| 2.  | Primary dry land forest | 1,806.03         |
| 3.  | Primary dry land forest | 784.35           |
| 4.  | Primary dry land forest | 694.71           |
| 5.  | Primary dry land forest | 475.74           |
| 6.  | Primary dry land forest | 216.27           |
| 7.  | Secondary dry land forest | 222.03      |
| 8.  | Mangrove forest         | 5,969.52         |
| 9.  | Mangrove forest         | 2,364.21         |
| 10. | Mangrove forest         | 919.17           |
| 11. | Mangrove forest         | 815.58           |
| 12. | Mangrove forest         | 360.09           |
| 13. | Mangrove forest         | 192.78           |
| 14. | Ponds                   | 199.62           |
| 15. | Bare land               | 102.33           |
|     | Others                   | 50,538.04        |
|     | Total                    | 96,494.11        |

Based on the data in Table 2, the largest change of forest cover type is mangrove forest into ponds with a change of 2,364.21 Ha. In addition, considerable forest changes also occur in primary dry land forests into oil palm plantations with a change of 1,806.03 hectare. In December 2006 there was huge flooding in Langkat district. A total of 12 districts were directly affected by the hug flooding event, one of them is Besitang Sub-district. [12] stated that upstream watershed has a conservation function to maintain the condition of the watershed so as not to be degraded, one of the indicators is land cover conditions. Based on the data in Table 2, in 2005 the change in primary forest land that occurred quite large. So that the big flash floods occurred in 2006, also caused by beside it was caused by high rainfall, and trigged by the massive of forest conversion in upstream of watershed. The most of forest conversion is forest converted into land cultivation such as oil palm and ponds.

3.3. Besitang watershed landscape landcover change 2005-2015
Changes in land cover from time to time continue to occur, in addition to economic growth is also caused by social and ecological factors. Changes in land cover for the years 2005 - 2015 are shown in Figure 3.
Figure 2. Percentage change of land cover area of Besitang Watershed in 2005 – 2015

Based on the data in Figure 2, there was an increased about 257.12% of residential area within 10 years. It shows that the population in the Besitang watershed is increasing so that the need for settlement is also getting bigger. An enormous increase of population can lead to forest destruction and forest conversion. Therefore, community empowerment efforts need to be conducted intensively in order to maintain the preservation of forests. [13] stated that community forestry is one of the priority programs for forestry development in the context of community empowerment. Forest changes occurring period 2005 - 2015 vary, not only forest land has changed function but there is some land cover that turns into forests. Land cover change data for 2005-2015 is presented in Table 3.

Table 3. Changes in land cover types in the Besitang watershed 2005 – 2015

| No. | Landcover type          | Landuse change area (Ha) |
|-----|-------------------------|--------------------------|
|     | Year 2005                | Year 2015                |
| 1   | Primary dry land forest  | 32,945,13                |
| 2   | Primary dry land forest  | 283,95                   |
| 3   | Primary dry land forest  | 196,38                   |
| 4   | Primary dry land forest  | 155,79                   |
| 5   | Secondary dry land forest| 466,74                   |
| 6   | Secondary dry land forest| 107,55                   |
| 7   | Mangrove forest          | 2,985,75                 |
| 8   | Mangrove forest          | 1,016,82                 |
| 9   | Mangrove forest          | 868,50                   |
| 10  | Mangrove forest          | 770,58                   |
| 11  | Mangrove forest          | 417,87                   |
| 12  | Ponds                   | 404,91                   |
| 13  | Palm estate              | 294,75                   |
| 14  | Water body               | 218,52                   |
| 15  | Bare lands               | 182,52                   |
| 16  | Other changes            | 55,396,87                |
|     | Total                    | 96,494,11                |

In Table 3 it can be seen that there were a change of oil palm and open land into secondary dry land forest. The change was due to a restoration program carried out by TNGL Center and OIC (Orangutan Information Center) which began in 2008. [14] states that forest cover in a region of its condition is gradually reduced to its lowest point. At that point due to improved economic and public awareness, there was a reversal of forest conditions where forest cover conditions gradually recovered.
Changes in the largest land cover types in 2005 - 2015 also occurred in mangrove forests. An area of 1,016.82 Ha of mangrove forest is converted into oil palm plantations. To earn the income of coastal communities many convert mangrove forests into ponds as a source of their income. In proportion to the increase of pond area, the increase of oil palm plantation area is also influenced by the economic needs of the community in the Besitang River Watershed. From an economic point of view, oil palms provide greater benefits that many communities and companies that grow oil palm crops.

4. Conclusion
The land cover in the Besitang watershed have 12 classes which were primary dry land forest, secondary dry land forest, shrubs, settlements, rice fields, and ponds, mangrove forests, mixed dry land farming, oil palm plantations, rubber gardens, and open land and water bodies. The largest land cover area in 2015 are the primary dry land forest area of 34,620.41 Ha (35.88%). The largest land cover change in the years 1990 - 2005 is mangrove forests into ponds with a change of 2,364.21 Ha. While the largest land cover change in the year 2005 - 2015 is mangrove forest into oil palm plantation with a wide change of 1,016.82 Ha.

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