The effect of land cover change to the biomass value in the forest region of West Java province

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Abstract. Due to the issue of climate change as a public concern, information of carbon stock availability play an important role to describe the condition of forest ecosystems in the context of sustainable forest management. This study has the objective to identify land cover change during 2 decades (1996 – 2016) in the forest region and estimate the value of forest carbon stocks in west Java Province using remote sensing imagery. The land cover change information was obtained by visually interpreting the Landsat image, while the estimation of the carbon stock value was performed using the transformation of the NDVI (Normalized Difference Vegetation Index) which extracted from Landsat image. Biomass value is calculated by existing allometric equations. The results of this study shows that the forest area in the forest region of West Java Province have decreased from year to year, and the estimation value of forest carbon stock in the forest region of West Java Province also decreased from year to year.

1. Introduction

Land cover is a fundamental variable that impacts on and links many parts of the human and physical environments [1]. Land cover mapping and monitoring is one of the major application on Earth observing satellite sensor data and is essential for the estimation of land cover change [2].

Climate change is one of global issues that most frequently discussed, and forests play an important role in it. Due to the issue of climate change as a public concern, information of carbon stock availability play an important role to describe the condition of forest ecosystems in the context of sustainable forest management. Forest biomass is an indicator of carbon sequestration, so it can be known how much carbon is lost or accumulated over time [3].

There are several ways to estimate forest biomass, among others sampling by harvesting (destructive), sampling without harvesting (non-destructive), biomass estimation using remote sensing and modeling of biomass estimators [4]. Remote sensing approach can be applied for large extents areas. The advantages of statistical combinations and temporal resolution of remote sensing allows the obtaining of carbon stock information of an area as well as changes over time [5]. Several studies have been done to estimate the value of biomass by using remote sensing data. Roy and Ravan, 1996 suggest approaches for using satellite remote sensing data for regional biomass mapping in Madhav National Park [6], meanwhile, Rakhmawati (2012) found that correlation between NDVI vegetation index and the land cover's biomass was the highest, both of the natural and non natural vegetation covers with R of 60% [7]. Rokhmatullah measured carbon stock based on vegetation (forest) cover derived from

remote sensing. The vegetation cover is then converted to carbon by multiplying with biomass carbon conversion factors [8]. This study has the objective to identify land cover change during 2 decades (1996 – 2016) in the forest region and estimate the value of forest carbon stocks in west Java Province using remote sensing imagery.

2. Methods

2.1. Data
The data used in this study is Landsat 5 mosaic year 1996 and 2006, and also Landsat 8 mosaic year 2016. The Landsat data have 30 m resolution and have been corrected either radiometrically or geometrically (Level 1T). The study area is in the forest region of West Java Province (Figure 1). Acoording to UU No.41 Tahun 1999 tentang Kehutanan [9] and PP No.44 Tahun 2004 tentang Perencanaan Kehutanan [10], forest region in West Java Province has 3 main functions as conservation forest, protection forest and production forest.
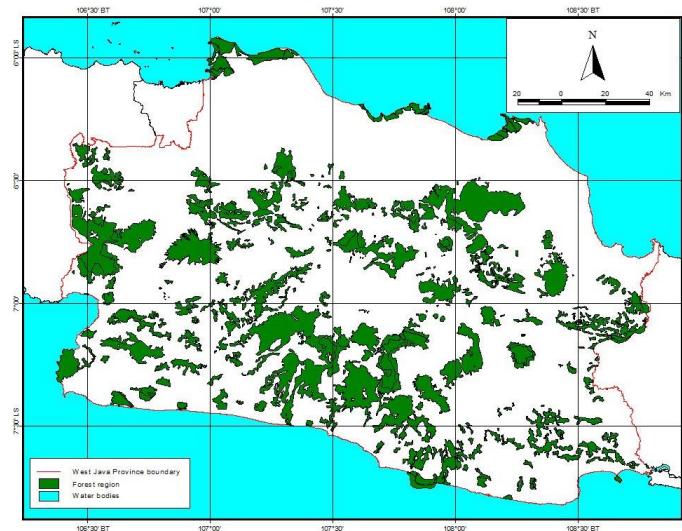

Figure 1. Study area

Field survey were conducted to obtain information needed in estimating biomass value (type of the tree, diameter at breast height, and height of individual tree) and also to validate the result of the land cover classification from Landsat data.

2.2. Method
There are three steps of work in this study, The first step is to create land cover classification from Landsat data year 1996, 2006, and 2016 by visual interpretation, the second step is to calculate vegetation index (NDVI) using band Near Infrared and Visible (Red), and the last step is to estimate biomass value in 1996, 2006, and 2016 (Figure 2)
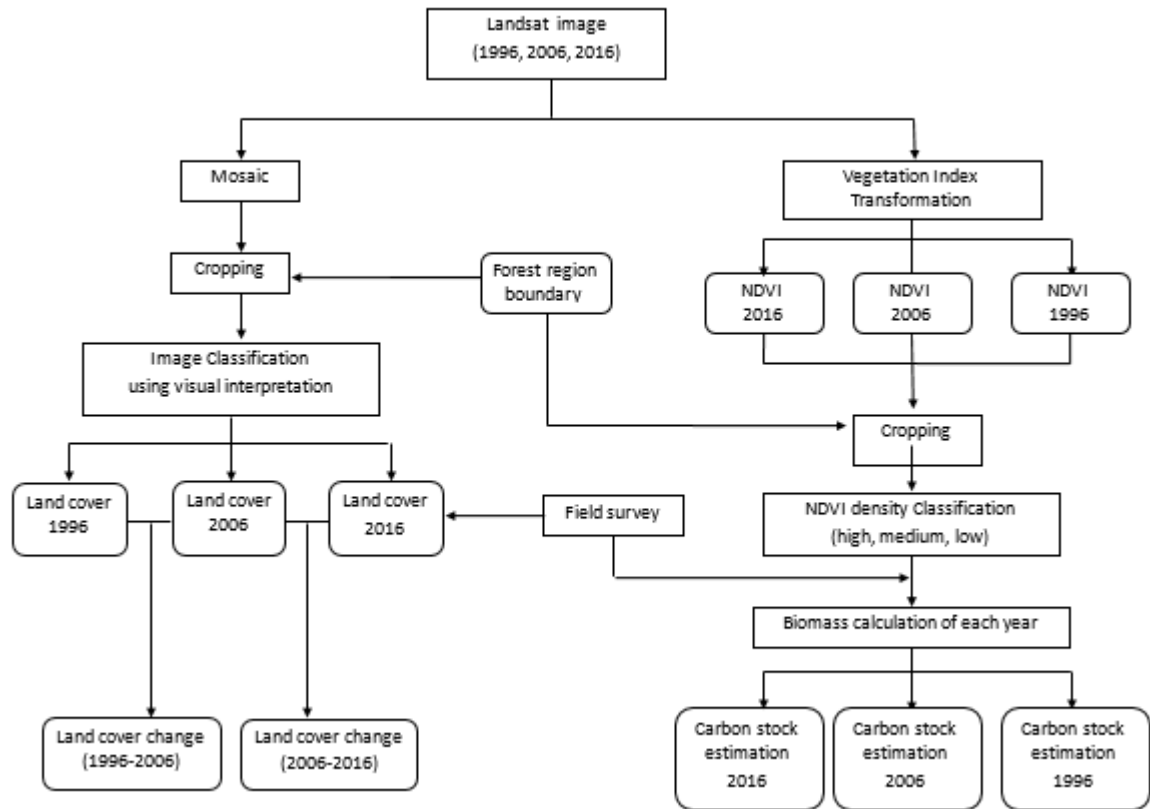
Figure 2. Flowchart of data processing

Land cover classification is done by manually digitizing. Forest classes are separated from other classes including plantation forest. The land cover information was used to calculate land cover change in 1996-2006 and 2006-2016.

NDVI processing is performed on Landsat data. NDVI value is calculated by using reflectant near infrared band and visible band (red). NDVI processing result will be in shapefile format. The shapefile data will be cropped with forest shapefile data so that NDVI in the forest area can be generated. NDVI forest will be grouped into three density classes : high, medium and low density.

The estimation of the biomass at the tree level by using the volume geometric formula is carried out by entering the diameter measurements at breast height, tree height and rod shape figure into the formula [11] :

$$V = 0{,}25\pi \,.\, (D/100)^2 \,.\, H \,.\, F \tag{1}$$

With V being the volume value of the tree, D is the diameter of the tree at chest height, H is the height of the tree, and F is the correction factor, which is calculated from the ratio of actual stem volume to cylinder volume at the same diameter and height. If barcode number information for a specific type of suspected unavailable, a common stem number value of 0.6 can be used.

The volume value of the tree is then multiplied by the type and BEF value of the tree type.

$$B = \rho \,.\, V \,.\, BEF_{tree} \tag{2}$$

Estimated biomass is then calculated by summing the individual tree biomass of the constituent tree. The above formula refers to the Guidelines for the Use of Allometric Models for Biomass Assessment and Forest Carbon Stock in Indonesia issued by the Ministry of Forestry and the Environment in 2012[8]. Based on these guidelines, the above formula is the fifth approach used when the allometric model of biomass as well as the allometric model of volume trees developed for a type or type of ecosystem that would otherwise be unavailable, but high data (other than diameter) available from the measurement or inventory of trees.

The 1996 and 2006 biomass values were calculated using the diameter and tree height information in 2016, assuming that NDVI with the same density in 1996, 2006, and 2016 will have the same diameter and tree height information.

3. Result and Discussion

In the period 1996 to 2006 the distribution of unchanged forest land cover is about 167,732.29 Ha (20.85%) of the total forest area (Table 1). While the change of forest cover to non-forest cover is 33923.28 Ha (4.22%), and the change of non-forest cover into forest is 20.53 Ha (0%).

Meanwhile, in the period 2006 to 2016 the distribution of unchanged forest land cover is about 162867.79 Ha (20.25%) of the total forest area. While the change of forest cover to non-forest cover is 4885.02 Ha (0.61%), and the change of non-forest cover into forest is 491.10 Ha (0.06%).

Table 1. Forest Change in the period 1996-2006 and 2006-2016

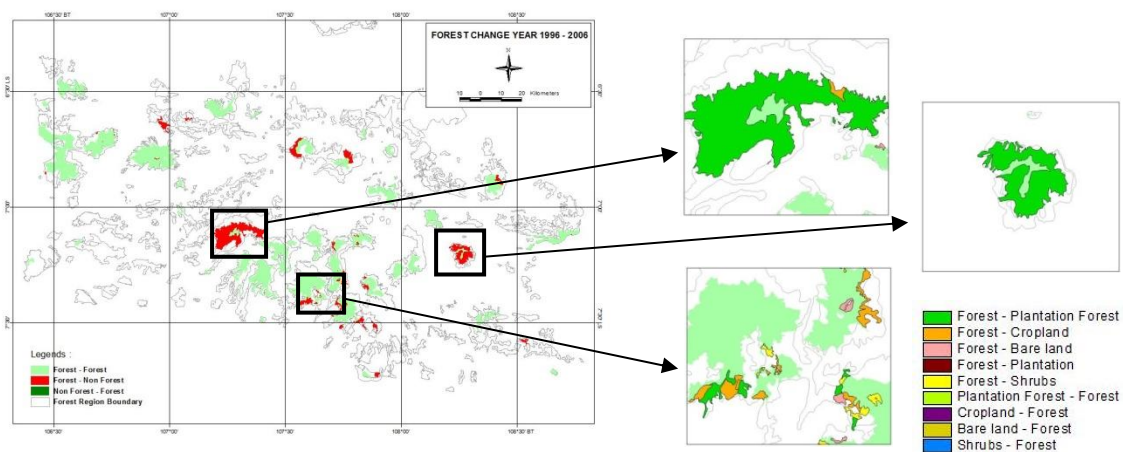| Change	1996-2006		2006-2016	
	Area (Ha)	%	Area (Ha)	%
Forest - Forest	167732.29	20.85	162867.79	20.25
Forest - Non Forest	33923.28	4.22	4885.02	0.61
Non Forest - Forest	20.53	0.00	481.38	0.06
Non Forest - Non Forest	602725.07	74.93	636166.96	79.09
Total	804401.16	100.00	804401.16	100.00

From 1996 to 2006, the change of forest cover to become non-forest cover was dominated by forest conversion into plantation forests of 29,337.34 Ha (3.65%), whereas changes from forest into other classes were less significant (<1%) (Table 2). While the change from cropland into forest is only 16.33 Ha, and the change from plantation into forest is 4.2 Ha.

From 2006 to 2016, the change of forest cover to become non-forest cover was dominated by forest conversion into cropland of 2482.73 Ha (0.31%), and forest conversion into plantation forests of 1763.07 Ha (0.22%), while the change from non-forest into forest was dominated by conversion from shrubs into forest of 199.27 Ha (0.02%).

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Table 2. Land Cover Change Classes in the period 1996-2006 and 2006-2016

Land Cover Change Classes	1996-2006		2006-2016	
	Area (Ha)	%	Area (Ha)	%
Fixed Classes (F-F, NF-NF)	770457.36	95.78	799034.76	99.33
Forest - Plantation Forest	29337.34	3.65	1763.07	0.22
Forest - Cropland	2564.35	0.32	2482.73	0.31
Forest - Bare Land	884.09	0.11	356.92	0.04
Forest - Plantation	0.00	0.00	117.44	0.01
Forest - Settlement	49.62	0.01	19.21	0.00
Forest - Shrubs	1087.87	0.14	137.55	0.02
Forest - Mining	0.00	0.00	8.10	0.00
Plantation Forest - Forest	0.00	0.00	118.48	0.01
Cropland - Forest	16.33	0.00	119.71	0.01
Bare Land - Forest	0.00	0.00	43.92	0.01
Shrubs - Forest	0.00	0.00	199.27	0.02
Plantation - Forest	4.20	0.00	0.00	0.00
Total	**804401.16**	**100.00**	**804401.16**	**100.00**

Figure 3 and Figure 4 illustrate the spatial distribution of land cover changes for the period 1996-2006 and 2006-2016.

Figure 3. Spatial distribution of land cover changes for the period 1996-2006
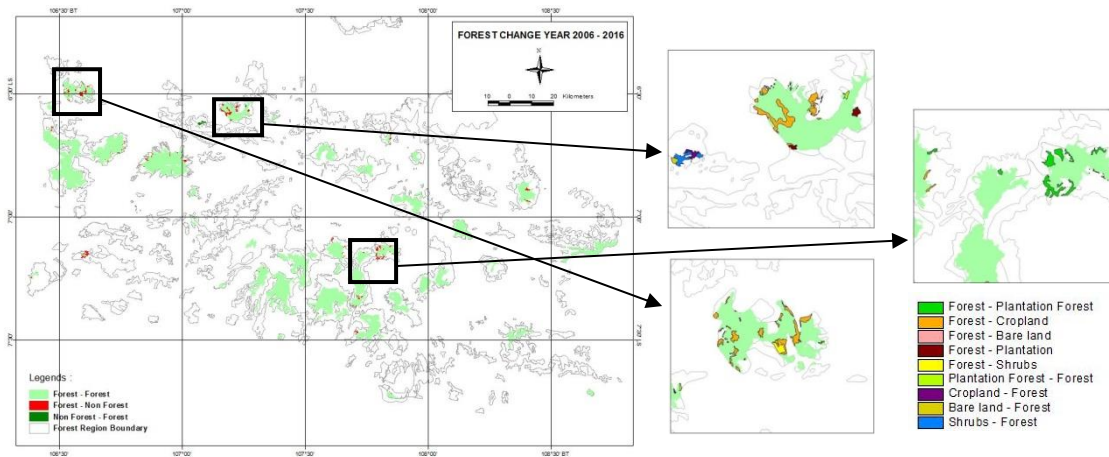
Figure 4. Spatial distribution of land cover changes for the period 2006-2016

Table 3 presents estimation of carbon stock in forest region of West Java province. Total estimation of forest carbon stock in 1996 was 28,154,912.48 ton C/Ha, and in 2006 total forest carbon stock was reduced to 20,677,898.44 ton C/Ha, while in 2016 the total value of forest carbon stock has decreased into 19,925,748.74 ton C/Ha.

Table 3. Estimation of Forest Carbon Stock year 1996, 2006, and 2006

Year	NDVI	Forest	
		Area (Ha)	C (ton C/Ha)
1996	High	159,021.96	25,181,876.62
	Medium	36,609.80	2,729,989.35
	Low	6,023.81	243,046.50
Total		**201,655.57**	**28,154,912.48**
2006	High	100,166.73	15,861,873.65
	Medium	61,044.63	4,552,092.34
	Low	6,541.46	263,932.46
Total		**167,752.82**	**20,677,898.44**
2016	High	98,576.58	15,610,065.90
	Medium	48,069.64	3,584,548.55
	Low	18,120.87	731,134.30
Total		**164,767.09**	**19,925,748.74**

4. Conclusion
During the period 1996 - 2006 the forest area has decreased by 33,923.28 Ha, while the change of non-forest land cover to forest is only 20.53 Ha. Meanwhile, during period 2006 – 2016 the forest area has

increased by 491.101 Ha, while the change of forest land cover to non forest is only 4885.021 Ha. However, the forest area in the forest region of West Java Province have decreased from year to year.

The estimation value of forest carbon stock in the forest region of West Java Province also decreased from year to year. In 1996 the value of carbon stocks was 28,154,912.48 ton C/Ha, in 2006 the value of carbon stock was reduced to 20,677,898.44 ton C/Ha, and in 2016 the value of carbon stock became 19,925,748.74 ton C/Ha.

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