Analysis of vegetation changes in Cidanau watershed, Indonesia

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Abstract. Vegetation change detection is needed for conserve of quality and water cycle in Cidanau watershed. The NDVI was applied to quantify the vegetation changes of Cidanau watershed for three different years 1989, 2001, and 2015. Using NDVI we mapped the reflectance from chlorophyll and distinguished varying amounts of vegetation at the pixel level by index. In the present study, as a preliminary study, we proposed a vegetation change detection analysis based on the NDVI from 1989 through 2015. Multi-temporal satellite data i.e. Landsat imagery with 30 m spatial resolution are used in the present study. It is reported that agroforestry land exhibited the greatest reductions in highly dense vegetation class in 1989-2001 and also moderate vegetation class in 2001-2015. It's mean that amount of vegetation present in agroforestry land is getting lower year by year.

1. Introduction

Cidanau watershed is one of the priority watersheds in Indonesia. A rare ecosystems and the only one natural wetland that existing in Indonesia which appear in the mountain region, included nature reserve that contains the last lowland swamp forest in Java Island. The Rawa Danau reserve also plays an important role as a water catchment for the Cidanau River [1]. Vegetation change has played an important role in quality and water cycle condition which Cidanau watershed is the only one sources of freshwater supplies for domestic and industrial water in Banten Province, Indonesia.

Vegetation change detection can be done by remote sensing data through a process called change detection. It can simply be defined as the process of identifying differences in vegetation or land cover over time [2]. Variation in spectral response involves situations where the spectral characteristics of the vegetation in a given location change over time [3]. [4] Mentioned that the change detection approach by the temporal dynamics of vegetation over a long period is able to detect changes in the earth's surface, either the gradual change caused by the extreme climatic variations or changes dramatically due to human or natural. Some researchers also noted that human activities, especially some ecological construction projects, greatly influence vegetation change [5-9]. Quantitatively, NDVI will generally show the proper sense of change in greenness at the pixel level by index. NDVI is one of the most successful indices for simple and quick identification of vegetated areas and their condition [10]. Therefore, the aim of this study was to detect the vegetation changes based on the NDVI for three different years 1989, 2001, and 2015.

2. Methods

2.1. Study Area

Cidanau watershed is located in Serang District and Pandeglang District, Banten Province, Indonesia (060 07’ 30”-060 18’ 00” S and 1050 49’ 00”-1060 04’ 00” E). Cidanau watershed covers an area of 22620 Ha. [11]. As mostly in Indonesian islands, the Cidanau watershed has tropical climate with two seasons; dry and rainy seasons. In the dry season, rainfall is only 50-87 mm, which happens in June to October. In this season, relative humidity is 77.60-81.40% and shining intensity is 60.20-78.60%, and temperature is 26.14 ^{o}C-27.00 ^{o}C and wind speed is around 4.80-5.40 knot per hour. In the rainy season, rainfall is 133-346 mm, which happens in November to May. In the same season, the relative humidity is 79.60-84 % and shining intensity is 31.60-68.20 %, and temperature is 26.04-27.10 ^{0}C with wind speed 5.00-5.90 knot per hour [12]. Figure 1 shows the location of Cidanau watershed.

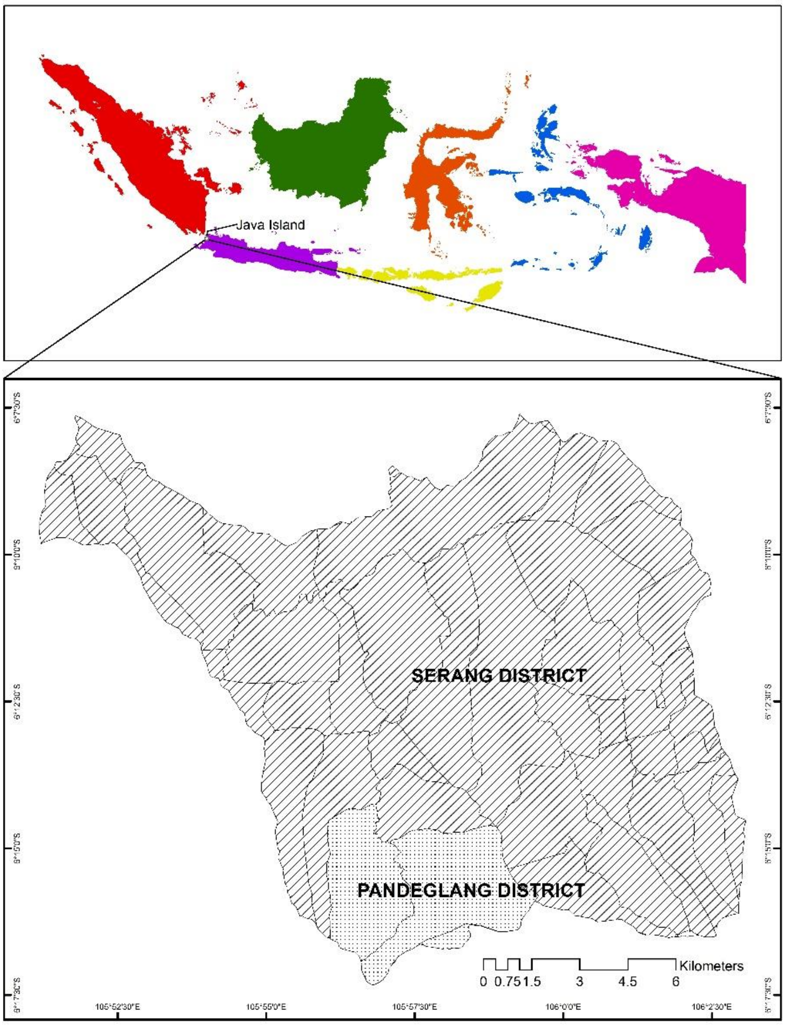

Figure 1. The map of study area.

2.2. Satellite image datasets

In order to quantitatively our predictions of vegetation change, we used Multi-temporal satellite data i.e. Landsat imagery with 30 m spatial resolution. The characteristics of Landsat imagery data that used in the present study are shown in Table 1. Cloud cover is a major problem in working with optical remotely sensed data sets in humid tropical forest environments such as Indonesia and Brazil [13-15]. Unlike Brazil, for example, Indonesia doesn’t have a seasonally cloud-free window, requiring more data intensive methods to overcome persistent cloud cover [16].

Table 1. Acquired satellite remote sensing data.

Satellite sensor	Date of Acquisition	Spatial Resolution	Clouds Cover	Spectral Resolution
Landsat 5 TM	July 29, 1989	30 m	0.00%	Band 5,4,3
Landsat 7 ETM+	July 6, 2001	30 m	10.00%	Band 5,4,3
Landsat 8 OLI TIRS	July 5, 2015	30 m	2.66%	Band 6,5,4

*https://earthexplorer.usgs.gov/ (downloaded 2017)

2.3. Image processing

Before using data for detecting vegetation changes, pre-processing operations were performed on three images including geometric correction, atmospheric correction, cloud and shadow masking. The Dark object subtraction (DOS) method for atmospheric correction, was applied using QGIS software for digital image processing, remote sensing and GIS based software (ERDAS Imagine 9.1 and ArcGIS 10) were used for image processing, classification, analysis to achieve the objectives of the study. ERDAS Imagine is used to calculate NDVI for all of the three images (1989, 2001 and 2015). Then three individual NDVI was applied to detect areas of vegetation changes and derived quantitative data were generated and summarized using ERDAS Imagine, GIS software and spreadsheet. The NDVI derived map of 1989, 2001 and 2015 were crossed to generate the change map of vegetation in the study area. Very low values of NDVI (minus one (-1.00) to 0.10) correspond to non-vegetated surface likes barren areas of rock or sand, shrub and grassland (0.20 to 0.30), while high values indicate temperate and tropical rainforests (0.60 to 0.80) [17]. Based on this information, the three date NDVI images were classified into six ranges by fixing the thresholds for NDVI classification and the method used is equal interval (Table 2).

Table 2. Classification for vegetation coverage.

Classes	Value Intensity
No Vegetation	value < 0.19
Less Vegetation	value >0.20 and value <0.34
Less Moderate Vegetation	value >0.35 and value <0.49
Moderate Vegetation	value >0.50 and value <0.64
Dense Vegetation	value >0.65 and value <0.79
Highly Dense Vegetation	value >0.80 and value <0.94

Supervised classification has been widely used to detect land use types. In supervised classification, spectral signatures are collected from specified locations in the image by digitizing various polygons overlaying different land use types. Classes of the resulting image were recoded into 10 land-use classes. The accuracy of the classified land use was assessed using high resolution images Google Earth. The overall accuracy was computed by dividing the total correct by the total number of pixels in the error matrix. Another discrete multivariate technique of use in accuracy assessment is called Kappa [18].

3. Results

The NDVI is used in the present study to detect vegetation changes. The NDVI images representing the amount of vegetation present at each time in Figure 2, areas with healthy vegetation is white to grey, and the area where no vegetation is black. The white area which represents vegetated areas has stronger near-infrared reflectance. Conversely, negative NDVI values were recorded in a dark area. This is as a result of the fact that features reflect more in the visible band than they do in the near-infrared band, indicating regions of low vegetation, typical water, cloud, bare soil and rock [19]. The mean of NDVI for overall watershed were 0.75 (1989), 0.45 (2001) and 0.35 (2015). It shows that amount of vegetation present in 1989, getting lower in 2001 and also 2015. The mean NDVI between 1989, 2001 and 2015 is characterized by a general decrease.

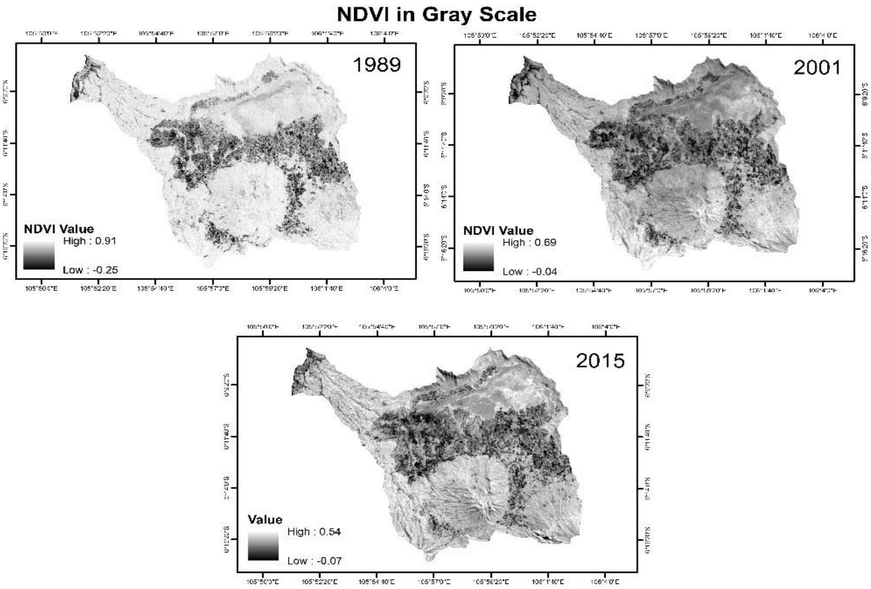

Figure 2. NDVI map for three different years (1989, 2001, and 2015).

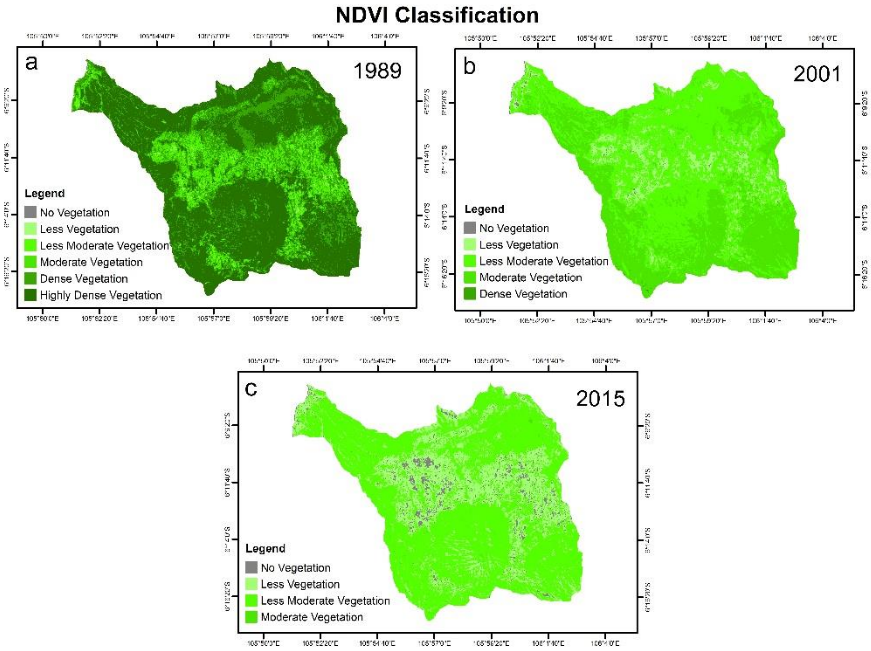

Figure 3. (a,b,c) NDVI derived classified map of study areas different years (1989, 2001, and 2015).

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The change detection technique, which was employed in this study, was the post-classification comparison. In 1989, the site was dominated by 59.01% highly dense vegetation class. In 2001, it was dominated by 53.68% less moderate vegetation class. Meanwhile, in 2015 it was dominated by less moderate vegetation also about 67.00%. In 2001 and 2015, there are no site was categorized into classes highly dense vegetation. Are presented in Table 3&4 and Figure 3. The obvious difference was the area of highly dense vegetation class was high in 1989 but then disappeared in 2001 and 2015.

Table 3. Vegetation changes from 1989 to 2001.

Area Covered in 1989 (Hectare)	Area Covered in 2001 (Hectare)					
	No Vegetation	Less Vegetation	Less Moderate Vegetation	Moderate Vegetation	Dense Vegetation	Grand Total
No Vegetation	6.35	4.57	2.95	0.19	0.00	14.05
Less Vegetation	8.84	71.27	55.87	4.53	0.06	140.58
Less Moderate Vegetation	18.64	413.66	417.00	22.32	0.05	871.67
Moderate Vegetation	16.72	964.79	1381.35	82.16	0.24	2445.27
Dense Vegetation	8.76	831.12	4071.39	889.29	0.39	5800.95
Highly Dense Vegetation	1.84	131.99	6213.14	6993.31	7.19	13347.47
Grand Total	61.14	2417.41	12141.70	7991.80	7.95	22620.00

Table 4. Vegetation changes from 2001 to 2015.

Area Covered in 2001 (Hectare)	Area Covered in 2015 (Hectare)				
	No Vegetation	Less Vegetation	Less Moderate Vegetation	Moderate Vegetation	Grand Total
No Vegetation	26.52	29.84	4.78	0.00	61.14
Less Vegetation	350.06	1678.00	389.23	0.12	2417.41
Less Moderate Vegetation	325.52	4602.41	7210.38	3.39	12141.70
Moderate Vegetation	16.01	383.73	7552.68	39.38	7991.80
Dense Vegetation	0.00	0.00	7.35	0.60	7.95
Grand Total	718.11	6693.98	15164.42	43.49	22620.00

To explain this, we tried to observe the distribution with the land use of Cidanau watershed to find out the location of changes. The pattern of the land use changes for three different years, 1989, 2001 and 2015 are presented in Table 5 and Figure 4. It is reported that agroforestry land exhibited the greatest reductions in highly dense vegetation class in 1989-2001 and also moderate vegetation class in 2001-2015. It's mean that amount of vegetation present in agroforestry land is getting lower year by year. The economic crisis in Indonesia may induced on vegetation changes rapidly in 1989-2001. Many people who depend on natural resources for subsistence, by cutting down trees in the private landowners or illegal area. The lack of government monitoring, caused to the amount of vegetation present continues to decreased dramatically. [20] Explains that the economic crisis, has induced an unstable population flow between urban area and rural area. There are not enough lands to develop for new cultivation. These implies illegal activities by poor farmers and strangers (refugees) from other place.

Table 5. Land use derived changes statistics of the study area for three different years (1989, 2001, and 2015).

Land Use	Area (Hectare) in 1989	Area (Hectare) in 2001	Area (Hectare) in 2015
Secondary forest	925.27	899.98	927.20
Swamp forest	1110.22	955.57	946.47
Agroforestry	11839.19	12025.28	12300.08
Forest plantations	354.15	366.77	368.43
Shrubs	68.27	33.96	47.32
Grass marshes	1418.31	804.73	829.55
Paddy fields	6192.88	6814.60	6482.76
Open land	1.11	2.10	1.05
Housing	627.96	628.01	627.52
Water bodies	82.63	89.00	89.61
Total	22620.00	22620.00	22620.00

Land use changes in Table 5 above statistics shows that in each year agroforestry land and paddy fields dominated the area Cidanau watershed. According to [21], this is as a result of socio-economic conditions in the region Cidanau watershed communities who depend on agriculture and plantation sector. According to data from DAS Communications Forum Cidanau in 2013, the livelihoods of residents in the watershed Cidanau 33% are in the agricultural sector.

Table 6. Overall classification and kappa accuracy.

Accuracy Assesment	in 1989	in 2001	in 2015
Overall classification accuracy	89.00%	89.00%	92.73%
Overall kappa index	0.88	0.87	0.91

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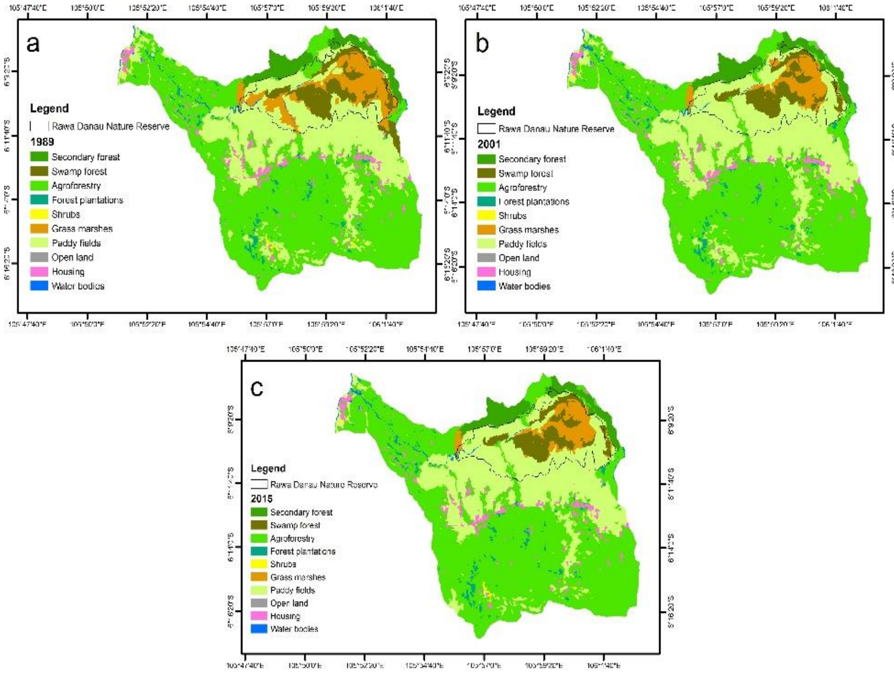

Figure 4. (a, b, c) Land use cover change map for three different years (1989, 2001, and 2015).

4. Conclusion

The study highlights was to try to understand the changes in vegetation by looking the land use distribution. It is reported that agroforestry land exhibited the greatest reductions in highly dense vegetation class in 1989-2001 and also moderate vegetation class in 2001-2015. It’s mean that amount of vegetation present in agroforestry land is getting lower year by year.

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