

**Research Article**

**The comparison analysis of land cover change based on vegetation index and multispectral classification (a case study at Leihitu Peninsula of Ambon City District)**

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**Abstract:** The study utilizes Landsat-7 ETM+ 2001 and Landsat TM5 2009 based on Normalized Differences Vegetation Index (NDVI) and 457 colour composite at the study area located in Leihitu Peninsula, Ambon City District, Ambon Island, Moluccas Province. The classified satellite data under NDVI and 457 colour composite of 2001 and 2009 were used to determine land cover change that have occurred in the study areas. This study attempts to use a comparative change detection analysis in land cover that has occurred in the study area with NDVI and 457 colour composite over 9 year period (2001 to 2009). The results of the present study disclose that total area increased their land cover were bare land and impermeable surface, herbaceous and shrubs, low density vegetation, and medium density vegetation, while high density vegetation is decreasing in both NDVI and 457 colour composite analysis. Overall accuracy was estimated to be around 94.3 % for NDVI and for 457 Colour composites was 84.7%. The study area has experienced a change in its land cover between 2001 and 2009 in both NDVI and 457 false colour composite analyses. The whole land cover types have experienced increased in both methods, except high density vegetation. The transformations of spectral vegetation (NDVI) product more closely with actual land cover compared with 457 colour composite product.

**Keywords:** *change detection, colour composite, land cover, NDVI, vegetation index*

**Introduction**

Land is a basic source of mass and energy throughput in all terrestrial ecosystems (FAO, 2000). Land is a physical environment, which comprises climate, topography, hydrology, and natural vegetation, thus involving ecosystem (Hardjowigeno and Widiatmika, 2007).

Generally, land resources have reached a critical stage due to the increasing of population. When human interaction with the land increases, understanding the changes in the land becomes an integral part of any environmental plan (Perera et al., 2011).

Land-cover refers to the physical characteristics of earth's surface, captured in the distribution of vegetation, water, soil and and/or artificial structures (Ioannis and Meliadis, 2011). Land cover is the observed types of (bio) physical cover on the earth's surface (FAO, 2000). In contrast, land cover, in its narrowest sense, often

designates only the vegetation either natural or man-made, on the earth's surface (Kavitha et al., 2012). Furthermore, it is mentioned that the term land cover lacks the emphasis on economic function that is essential to the concept of land use.

Land use/land-cover analysis provides the baseline data required for proper understanding of how land was being used in the past, what type of changes have occurred and are expected in the future (Mani and Krishnan, 2013). Land use/land cover is an important component in understanding the interactions of the human activities with the environment (Vikhe and Patil, 2014). Knowledge of land cover is important for many planning and management activities concerning the surface of the earth. It is necessary to monitor and detect the land use changes to balance a sustainable environment (Pandian et al., 2014).

Application of remotely sensed data made possible to study the changes in land cover in less

time, at low cost and with better accuracy (Kachhwala, 1985) in association with Geographical Information System (GIS) that provide suitable platform for data analysis, update and retrieval (Star et al. 1997).

Satellite remote sensing capability is to provide near or real-time consistent and promising data that covers large areas through orbiting satellites that have different wavelengths, look angles and resolution (Kwarteng, 1999). The ability to obtain remote sensing data (Sabins, 1996) for vegetation land-cover studies plays major role in developing classification scheme (Lillesand et al., 2004). Change detection using remote sensing techniques that involves the comprehensive analysis of spatio-temporal as well as spectral characteristics of RS dataset so as to derive accurate information of a given changes in landscape (Singh, 1989; Yang and Lo, 2002; Stathakis and Kanellopoulos, 2008).

Change detection techniques are many, for example tasseled cap transformation, image algebraic technique which included principal component analysis, image regression etc. there is also the multi date composite technique, change vector analysis, and post-classification change detection techniques (Morissette, 1997). The use of land-cover change detection tools such as vegetation indices can help to discriminate different areas of land-cover changes that has occurred between different years in an imaging (Lillesand et al., 2004).

Several attempts have been made in developing advanced classification methods towards improving accuracy in NDVI products (Foody, 1996; Aplin et al., 1999; Stuckens et al., 2000; Pal and Mather, 2003). Jensen (1986) explains that the theory of change detection is that the spectral value of cells from datasets covering the same landscape but of different epochs will differ if the physical characteristics have change overtime. Parakash et al. (1998) used a combined method of colour composite, band subtraction, band division and supervised classification to

prepare a land-use map for change detection in a coalmining district in India. They concluded that the supervised classification gives better results for detecting changes.

For effective and sustainable land cover analysis, the use of vegetation index NDVI and Composite Colour should be encouraged, which is adopted in this study. The main objective of the present study is to analyze and identify the nature and extent of land cover changes in Leihitu Archipelago Ambon City, Ambon Island based on Normalized Difference Vegetation Index (NDVI) and image colour composite method.

## Materials and Methods

The study are located at Leihitu Peninsula, Ambon City District, Ambon Island which stretches between 3°34'25"S to 3°42'42"S and 128°03'45"E to 128°15'10"E, covering area 11,838.8 ha (Figure 1). Multitemporal satellite data set observed by LANDSAT-7 Enhanced Thematic Mapper+ (ETM<sup>+</sup>) and LANDSAT TM5 (Thematic Mapper) were used for the analysis are presented in Table 1. The method used are image pre-processing (radiometric correction, and geometric transformation) image cropping, image classification and change detection. Image pre processing is done to derive maximum benefits from satellite imagery, there is the need to eliminate or reduce errors embedded in the data due to atmospheric effects, sensor and illumination effects as well as missed-registration.

Table 1. Image Data Sources

Data	Path Row	Month of Observation	Spatial Resolution
Landsat 7 (ETM+)	109/063	2001 - March	30m
Landsat 5 (TM)	109/062	2009 - November	30m



Figure 1. Location map

In this research, both radiometric and geometric corrections were applied to the RS images used, including applied Landsat-7 ETM<sup>+</sup> 2001 and Landsat TM5 2009 to obtain useful predictive parameters.

$$\rho_{\lambda Pixel, Band} = \left( \frac{L_{\lambda Pixel, Band} \cdot d^2 \cdot \pi}{E_{sun \lambda Band} \cdot \cos(\theta_s)} \right)$$

Radiometric correction is a useful step of conversion of the value of brightness (digital number) into absolute reflectance value. Technically, radiometric correction is conducted using facilities provided by ENVI 4.5 within Basic Tools – Band Math that was calculated by

formula 1. The image of radiometric correction results are presented in Figure 2.

The Landsat TM5 2009 image data was registered using several control points that linked to some identified positions in the topographic (RBI, 1:50.000) map. Landsat Image which has been corrected in geometric is used as a reference to the geometric registration of landsat-7 ETM<sup>+</sup> image. The reason for using the control points is to build a polynomial transformation that will change dataset to spatially correct location from its existing location. The results of geometric correction image is presented in Figure 3.

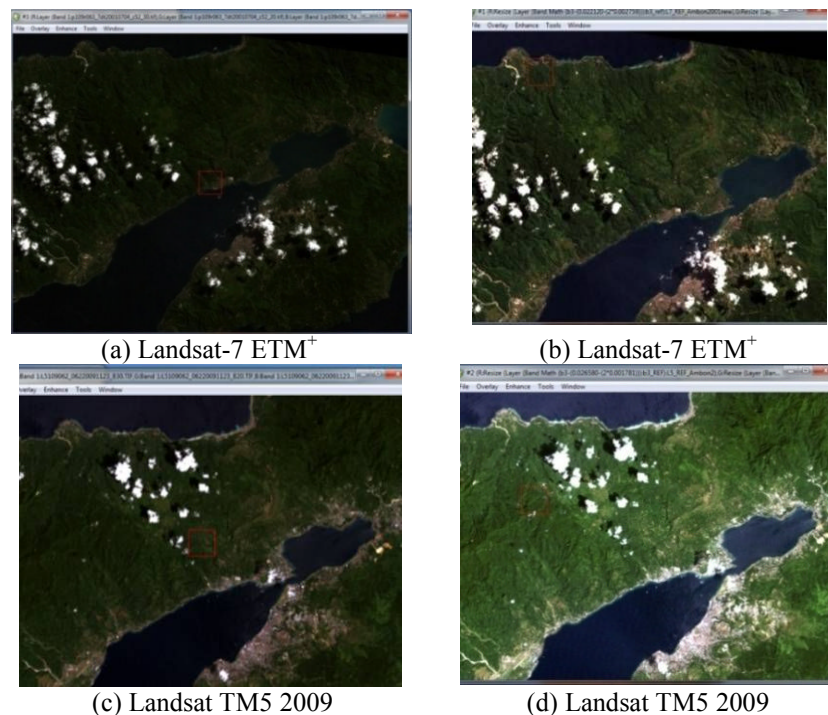


Figure 2. Radiometric Correction Image: before (a, c) and after (b, d)

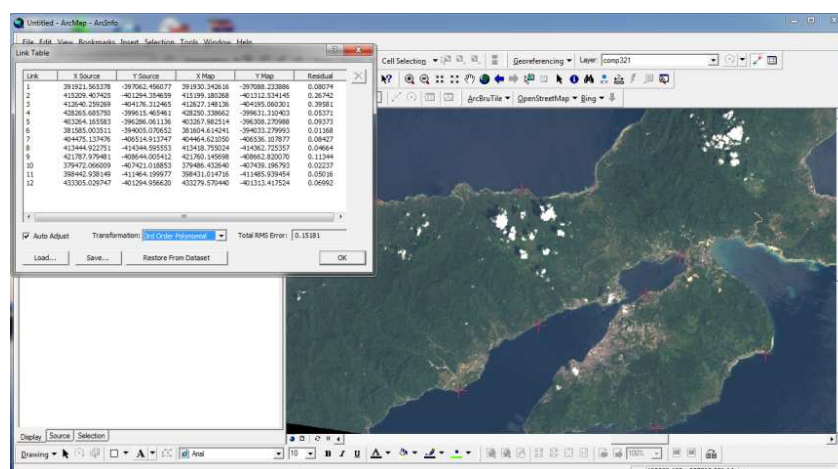


Figure 3. Geometric correction image (Landsat TM5 2009)

Image cropping was done on image that has been corrected in radiometric and geometric. Image cropping was done to find out the image of regions that would analysis. Image cropping was done to simplify the process of digital analysis and reduce memory that is needed to make the process of data processing more accelerated.

#### **Image processing**

An analysis of land cover changes cannot be separated from an analysis of vegetation cover changes. Many methods have been developed to study condition of vegetation both in quantitative and qualitative of satellite images, such as vegetation transformation indices, and colour composite image. Analysis of land cover was conducted using NDVI on vegetation indices transformation and false colour composite, by combing near infrared, middle infrared-I and middle infrared-II which are bands 4, 5, 7 together for both images using ENVI 4.5.

The classification of spectral vegetation value of Landsat-7 ETM and Landsat TM5 image to determine land cover type based on relative calibration approach. While the classification of the spectral range of colour composite image used threshold approach of each image histogram. Index vegetation image of Landsat-7 ETM<sup>+</sup> (2001) and Landsat TM5 (2009) converted into a land cover map (2001 and 2009) in vector format through raster to vector conversion procedure in ENVI 4.5. In the present study, five cover categories were identified namely bare soil and impermeable surface, herbaceous and shrubs, low density vegetation, medium density vegetation, high density vegetation. Description of these land cover classes are presented in Table 2. To assess the accuracy of classification in both NDVI and 457 colour composites, field observation was employed, while to evaluate the land cover map changes for the 2001 to 2009 interval we using crosstab analysis in ArcGIS 9.3.

Table 2. Land cover classification

<b>Land Cover Type</b>	<b>Description</b>
Bare land	Bare land and build up area (residential, transportation, social complexes and services).
Herbaceous and shrubs	Low dense under bush
low density vegetation	A low dense growth plants, and underbrush.
medium density vegetation	A medium dense growth of trees, plants, and underbrush.
high density vegetation	A dense growth of trees, and plants.

## **Result and Discussion**

### ***Land cover analysis in normalized differences vegetation index***

The coverage area of each land-cover type of the study area of the years 2001 and 2009 were produced by using Normalized Differences Vegetation Index is shown in Table 3, while those distribution were presented in Figures 4 and 5.

High density vegetation is the dominant land cover type in the study area, while bare land was the smallest both in 2001 and 2009. According to Landsat imagery of the year 2001 (March Landsat-7 ETM<sup>+</sup>) high density vegetation covered above 90 percent of the study area (Table 3), this has been decreased to 85.0 percent in 2009 (November Landsat TM5) imagery.

Table 3. Area under NDVI and land cover type

<b>NDVI Value</b>	<b>Land Cover Type</b>	<b>Area</b>			
		<b>March 2001(ETM<sup>+</sup>)</b>		<b>November2009 (TM5)</b>	
		<b>ha</b>	<b>%</b>	<b>ha</b>	<b>%</b>
0.03 – 0.25	Bare land	29.6	0.3	46.0	0.4
0.25 – 0.41	Herbaceous and shrubs	59.8	0.5	171.0	1.4
0.41 – 0.58	Low density vegetation	203.2	1.8	460.1	3.7
0.58 – 0.74	Medium density vegetation	817.1	7.0	1183.0	9.5
0.74 – 0.99	High density vegetation	10729.1	90.5	9978.7	85.0
	Total	11838.8	100.0	11838.8	100.0



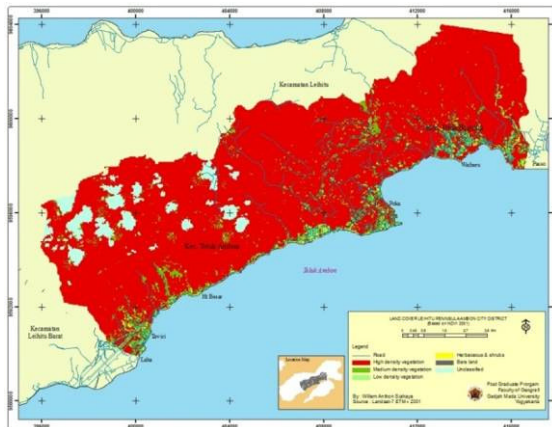


Figure 4. Land cover under NDVI using Landsat-7 ETM<sup>+</sup>2001

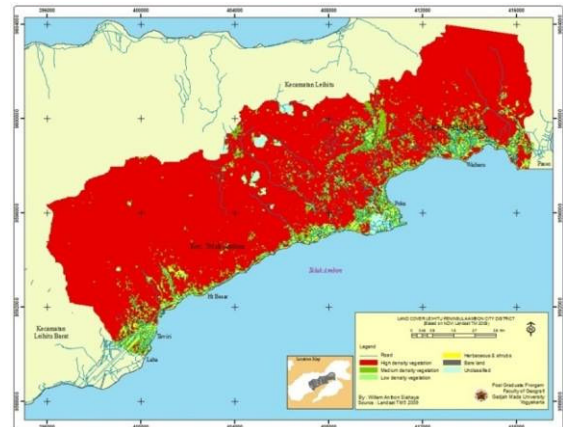


Figure 5. Land cover under NDVI using Landsat TM5 2009

#### ***Land cover under 457 colour composites analysis***

The land-cover maps of 2001 and 2009 were produced by using supervised image classification technique based on the Maximum Likelihood Classifier (MLC) and 534 training samples. Land cover area under 457 colour composites is shown in Table 4. Figures 6 and 7 present the distribution of each land cover type of the study area of the

years 2001 and 2009. High density vegetation is the dominant land cover type in the study area, while bare land was the smallest both in 2001 and 2009. According to Landsat imagery of the year 2001 (March Landsat-7 ETM<sup>+</sup>) high density vegetation covered above 77 percent of the study area (Table 4), this has been decreased to 58.0 percent in 2009 (November Landsat TM5) imagery.

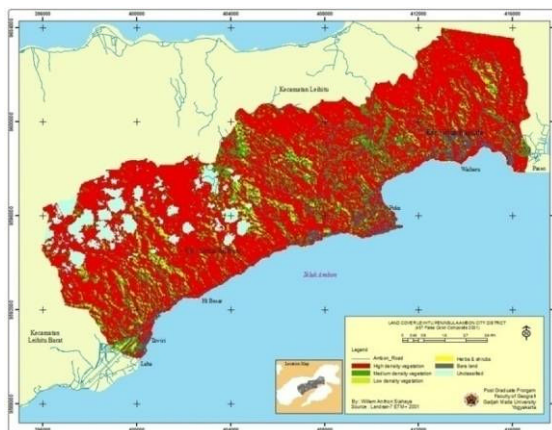


Figure 6. 457 2001

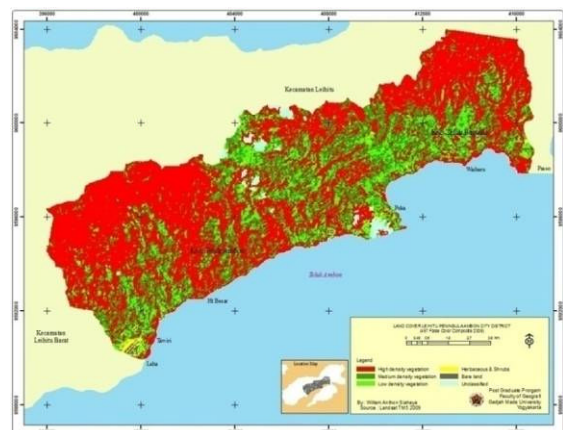


Figure 7. 457 2009

Bare land area includes settlements, government and social facilities, transportation and recreation places. Generally, the growth and development of bare land areas was along the coastal area. The vegetation found in herbaceous and shrubs were reeds, centrosema, crotalaria, and various species of shrubs. There was also found the agricultural crops such as tubers, nuts, vegetables, corn, banana, papaya, pineapple, and chili. Besides that, there was also found saplings level of mahogany, lenggua, and crops of fruit as langsat, gandaria, mango, rambutan, cashew, and jackfruit. The vegetations found in low density were jabon,

seigon, herbaceous and grass. In addition, there was also found fruit trees such as langsat, mangosteen, mango, parkia, jackfruits, breadfruit, bouea macrophylla, and salaca and plantation such as clove, nutmeg, and coconut. The vegetations found on this land had low density in cover. In this area, there is also found several type of agricultural crops such as corn, tubers (yams, cassava, sweet potato) nuts, vegetables, spices (ginger, saffron, chili), pineapple, bananas, etc. The vegetations found in medium density were jabon, ulin, angšana, candlenut, rattan, sago, herbaceous and grass.

Table 4. Land cover type area under 457 colour composite

ROI	Land Cover Type	Area			
		March 2001(ETM <sup>+</sup> )		November 2009 (TM5)	
		ha	%	ha	%
I	Bare land	16.1	0.1	35.4	0.3
II	Herbaceous and shrubs	43.1	0.4	106.0	0.8
III	Low density vegetation	514.1	4.4	1508.5	12.2
IV	Medium density vegetation	2051.3	17.2	3471.2	28.3
V	High density vegetation	9214.1	77.9	6717.7	58.4
	Total	11838.8	100.0	11838.8	100.0

In addition, there was also found fruit trees such as duren, walnut, langsat, duku, mangosteen, parkia, jackfruits, and bouea macrophylla, salaca, and banana, and plantation such as clove, nutmeg, and coconut. The vegetations e found on this land had medium density in cover. In this area, there was also some kind of agriculture crops such as that has been described above by the spread sporadically. The vegetations found in high density were agathis, matos, angsana, black belo tree, wood of iron, calophyllum, jabon, ulin, candlenut, gopasa, sago, jeunjing, rattan, sago, nypa, mangrove, herbaceous, and grass. In addition, there were also found fruit trees such as duren, walnut, langsat, duku, mangosteen, parkia, jackfruit and bouea macrophylla; and plantation

such as clove and nutmeg. The vegetations found on this land had high density in cover. The final analysis shows the classified Figures 3-6 in relation to the verification of the land cover, put NDVI and 457 colour composite as the method for discriminating land cover, hence used as the reference in this discussion. Not only in NDVI but also in 457 colour composite analysis, bare land, herbaceous and shrubs, low density vegetation, and medium density vegetation are increasing in trend, and high density vegetation is decreasing in trend from 2001 to 2009, while high density vegetation is decreasing. Nevertheless broad area of medium density vegetation and high-density vegetation based on NDVI transformation was less than 457 colour composite method (Table 5).

Table 5. Changes in Land Cover 2009-2001

No.	Land Cover Types	NDVI			457 ColourComposite		
		2001	2009	Changes in 2009- 2001	2001	2009	Changes in 2009-2001
1	Bare land	0.3	0.4	0.1	0.1	0.3	0.2
2	Herbaceous and shrubs	0.5	1.4	0.9	0.4	0.8	0.5
3	Low density vegetation	1.8	3.7	1.9	4.4	12.2	7.8
4	Medium density vegetation	7.0	9.5	2.6	17.2	28.3	11.1
5	High density vegetation	90.5	85.0	-5.5	77.9	58.4	-19.5
		100.0	100.0		100.0	100.0	

Figures 8 and 9 represent graphically the above changes. The graphic showed that between 1986 and 2008 the amount of bare land, herbaceous and shrubs, low-density vegetation and medium density vegetation increased in both NDVI and 457 colour composite while high density vegetation was decrease. Overall accuracy averaged 94.3 % in NDVI product, while the averaged overall accuracy in 457 Colour Composite product was 84.7%.

For the evaluation of the accuracy of classification, a matrix of changes has been used (Table 6 and 7) for the image 2009 and the field observation. The accuracy of vegetation spectral transformation (NDVI) product was higher than the accuracy of 457composite colour product. This means the transformation of spectral vegetation (NDVI) product more closely with actual land cover compared with 457 colour composite product.

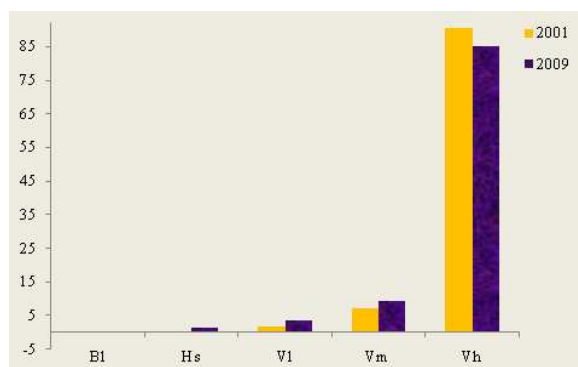


Figure 8. Changes in the land cover categories for NDVI between 2001 & 2009.

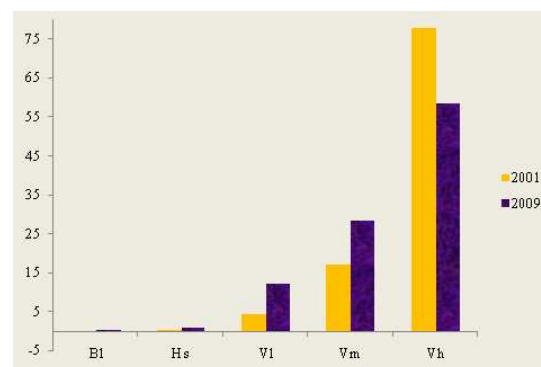


Figure 9. Changes in the land cover categories for 457 Colour Composites between 2001 & 2009

Remarks: Bl = Bare land, Hs = Herbaceous and shrubs, Vl = Low density vegetation, Vm = Medium density vegetation, Vh = High density vegetation

Table 6. Accuracy of NDVI 2009

Classification	Land Cover	Field Check					TOTAL	User Accuracy	Error Commission
		Bl	Hs	Vl	Vm	Vh			
	BL	49	2	0	0	0	51	96.1	3.9
	Hs	2	50	2	0	0	54	92.6	3.7
	Vl	0	2	45	2	0	49	91.8	8.2
	Vm	0	1	1	75	2	79	94.9	5.1
	Vh	0	0	1	2	60	63	95.2	4.8
	TOTAL	51	55	49	79	62	296		

Overall accuracy = 94.3

Remarks: Bl = Bare land, Hs = Herbaceous and shrubs, Vl = Low density vegetation, Vm = Medium density vegetation, Vh = High density vegetation

Table 7. Accuracy of 457 colour composites

Classification	Land Cover	Field Check					TOTAL	User Accuracy	Error Commission
		Bl	Hs	Vl	Vm	Vh			
	Bl	43	8	1	0	0	52	82.7	17.3
	Hs	2	37	3	0	0	42	88.1	7.1
	Vl	0	3	46	7	0	56	82.1	17.9
	Vm	0	1	5	35	1	42	83.3	16.7
	Vh	0	0	3	2	38	43	88.4	11.6
	TOTAL	45	49	58	44	39	235		

Overall accuracy = 84.7

Remarks: Bl = Bare land, Hs = Herbaceous and shrubs, Vl = Low density vegetation, Vm = Medium density vegetation, Vh = High density vegetation

## Conclusion

Overall accuracy was estimated to be around 94.3 % for NDVI and 84.7% for 457 colour composites. The study area has experienced a change in its land cover between 2001 and 2009 in both NDVI and 457 false colour composite

analysis. The whole land cover types have experienced increased in both methods, except high density vegetation. The transformation of spectral vegetation (NDVI) product more closely with actual land cover compared with 457 colour composite product.

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