Change Vector Analysis using Integrated Vegetation Indices for Land Cover Change Detection

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Abstract
The change detection is the process to identify the difference of area between two dates in the same location. The objective of this research is to study the land cover change from satellite image during the years 2007 and 2017 using change vector analysis (CVA). The normalized difference vegetation index (NDVI) and bare soil index (BI) were the parameters considered for land cover change analysis using the CVA. The magnitude and direction of change vectors were used to identify of land cover change. Data collection was conducted by interviewing group leader of 3 sub-districts where considerable land cover changes were observed to evaluate the land cover changes using GIS. The results of the magnitude of change vector have revealed no change 52 % and change 48 %. The results of the direction of change vector found that the moisture change more than 76 %. The land cover change from questionnaire show that Thakhonyang, and Khamriang sub-districts have changed from agriculture area to built-up area, but Makha sub-district did not show changes.

1. Introduction

The study of land use and land cover change is important for the natural resources management and the management at the level of sub-district for the country. It also helps to study the livelihoods of communities or study about identity of the community such as major physical, economic and local lifestyle and the relationship with natural environment or land cover change, etc. In recent years, the use of remote sensing data in classification of land use and land cover has been the most technique for land use mapping. Likewise, the change detection technique has been developed from the remote sensing data which are the primary sources extensively used in recent decades. The change detection technique is the process to identify the differences of time; and it shows the objected or phenomenon change from the activities in the same location and the difference time. For example, the technique of change detection with remote sensing data such as post-classification, image differencing, principle component analysis, vegetation index differencing, and change vector analysis. These techniques have been summarized the change detection techniques (Lu et al., 2004 and Singh and Talwar, 2013).

This paper is based on Change Vector Analysis (CVA) and Normalized Difference Vegetation Index (NDVI). CVA was used for change detection using multi-temporal LANDSAT data (Malina, 1980). The method employs the calculation of spectral change vectors from two different dates, prompting its name change vector analysis (Michalek et al., 1993 and Bovolo et al., 2008). NDVI is the most widely used in the interpretation and classification of land use or land cover on the Landsat (Singh et al., 2016, Jeevalakshmi et al., 2016 and Reddy and Reddy, 2013). Moreover, NDVI can be used for change detection of vegetation monitoring, drought monitoring and assessment (Laosuwan et al., 2016 and Uttaruk and Laosuwan, 2017). This paper was a combination of CVA with NDVI and bare soil index (BI) for land cover change detection. This method was used to classify the threshold to distinguish the pixel change and no-change from the data (Duy and Giang, 2012). The objective of this paper is to study the land cover change using change vector analysis (CVA) in Kantarawichai District, Maha Sarakham Province, Thailand from LANDSAT satellite image with year 2007 and 2017. Additionally, the evaluation of land cover change from CVA methods was the interview from group leader of community in the 3 sub-districts with the most land cover change.

2. Data Usage

Data Preparation: This paper used the data from Landsat 8 OLI and Landsat 5 TM. Parameters of the Landsat images used in the study are shown in the Table 1.

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Table 1: Parameters of the satellite images

Data	Date	Path/Row	Spatial resolution	Used bands
Landsat 5 TM	7/04/2007	128/49	30 m	1-5
Landsat 8 OLI	19/04/2017	128/49	30 m	2-7

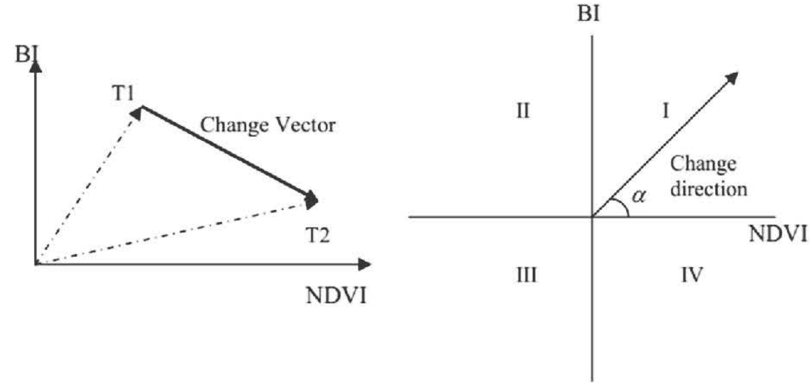

Figure 1: The concept of change vector analysis in two spectral dimensions (Malila, 1980)

3. Methodology

The methodology is divided into 2 steps:

1. Generate the NDVI and Bare Soil Index (BI) of Landsat images to reveal the primary feature of land cover change

2. Classify land cover change using CVA.

3.1 NDVI

Normalized Difference Vegetation Index (NDVI) displays the relationship between the quantity of chlorophyll in leaves with red and near infrared bands 1 (Rouse et al., 1973 and Richardson and Wiegand, 1977) NDVI is defined by equation 1.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Equation 1

Where;

NIR= Near Infrared Band
RED=Red band

The values of NDVI were between -1 to +1. The values of NDVI closest 1 that mean more vegetation and the value near 0 was less vegetation. The water area was shown as negative value in NDVI (Laosuwan et al., 2016).

3.2 BI

The value of the vegetation index is not so reliable in situations where the vegetation covers less than half of the area. For more reliable estimation of the vegetation status, the new methods include a bare soil index (BI) which is formulated with medium infrared information (Rikimaru and Miyatake, 1997). Bare soil index (BI) helps to identify the difference between agricultural and non-agricultural vegetation, specifically, the identification of bare soil and fallow lands are enhanced when using the *BI* index (Duy and Giang, 2012) defined by equation 2.

$$BI = \frac{(RED + SWIR) - (NIR + BRUE)}{(RED + SWIR) + (NIR + BRUE)} + 1$$

Equation 2

Where;

SWIR= Short-wave infrared Band
NIR= Near Infrared Band
RED=Red Band
BRUE=Brue Band

3.3 Change Vector Analysis Method

Change vector of each pixel includes 2 components NDVI and BI, are 2 axes in Cartesian coordinate system shown in Figure 1. The start points and, finish point of the change vector are the locations of pixel in NDVI and BI space on *T1* and *T2* (*T1*, *T2* the acquisition date of images). The magnitude of vector represents the change intensity (S); the direction of vector represents the change direction (α) (Son et al., 2009; Duy and Giang, 2012).

$$S = \sqrt{(NDVI_2 - NDVI_1)^2 + (BI_2 - BI_1)^2}$$

Equation 3

$$tg\alpha = \frac{BI_2 - BI_1}{NDVI_2 - NDVI_1}$$

Equation 4

Where;

S= the magnitude of change vector (Euclidean distance) is the distance between the initial data with *NDVI* and *BI*

$tg\alpha$ = the direction of change vector is the measure of the angle.

$NDVI_1$ and $NDVI_2$ =*NDVI at date 1 and date 2*

BI_1 and BI_2 = *BI at date 1 and date 2*

3.4 Evaluate of Land Cover Change

The qualitative method used for the study of land cover change was an interview to correct the data from group leader of 3 sub-districts with the most land cover change.

4. Results

4.1 The Results of NDVI and BI

The results of NDVI and BI were evaluated for the 2007 and 2017 of LANDSAT imagery data. The results of NDVI of year 2007 in Figure 2 shows the brightness color that means the high values of vegetation in the study area (red circle). The brightness color of BI shows high bare soil area for the vegetation of year 2007 was dark color (red circle, Figure 2). The brightness color of NDVI year 2017 in the same area was with decreased brightness (yellow circle). The scatterplot showing the relationship between the correlation of NDVI and BI images is presented in the Figure 3. The scatterplot for the year 2007 shows the distribution of NDVI that represents the vegetable distribution area and bare soil higher than the year 2017.

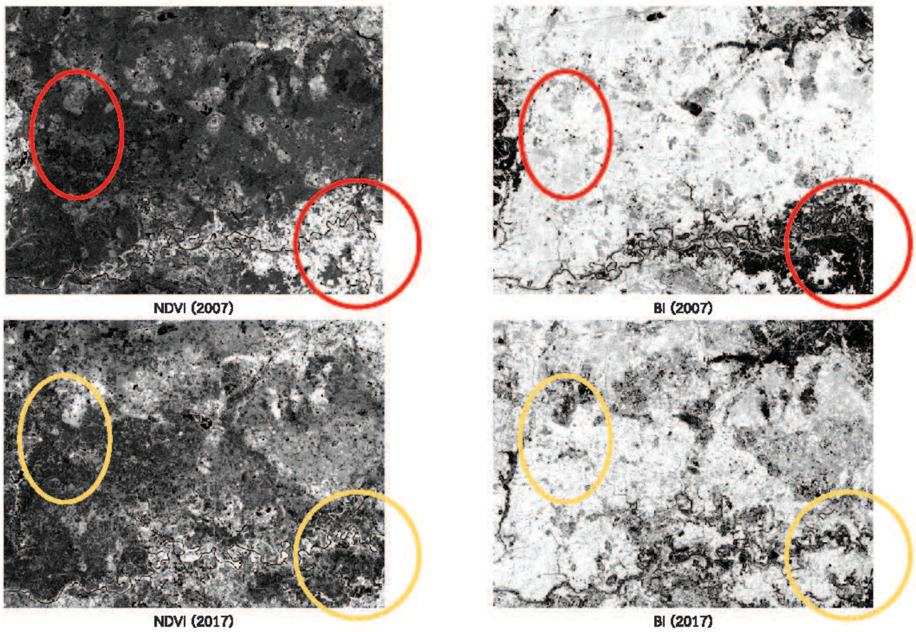

Figure 2: The NDVI and BI images of year 2007 and 2017

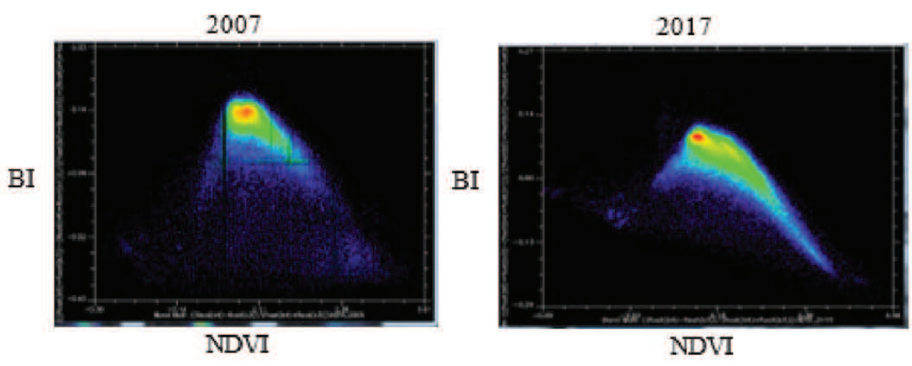

Figure 3: The scatterplot of correlation between NDVI and BI of year 2007 and 2017

Table 2: Statistical values: maximum (max) and minimum (min) and mean and standard deviation (STD) data of NDVI and BI for years 2007 and 2017

Statistic value	NDVI		BI	
	2007	2017	2007	2017
Min	-0.393	-0.244	0.562	0.711
Max	0.631	0.584	1.326	1.316
Mean	0.129	0.212	1.043	1.018
STD	0.114	0.080	0.134	0.072

Table 3: An area of land cover change after threshold divided

Classified Data	Area change (km^2)
No-change	356.007
Low level change	265.922
High level change	56.440

Table 4: Change direction class of α from greenness and brightness component

Class color	brightness (BI)	greenness (NDVI)	Classes
	-	-	Water or high moisture land
	+	-	Bare soil expansion
	-	+	Chlorophyll Increase
	+	+	Moisture reduction

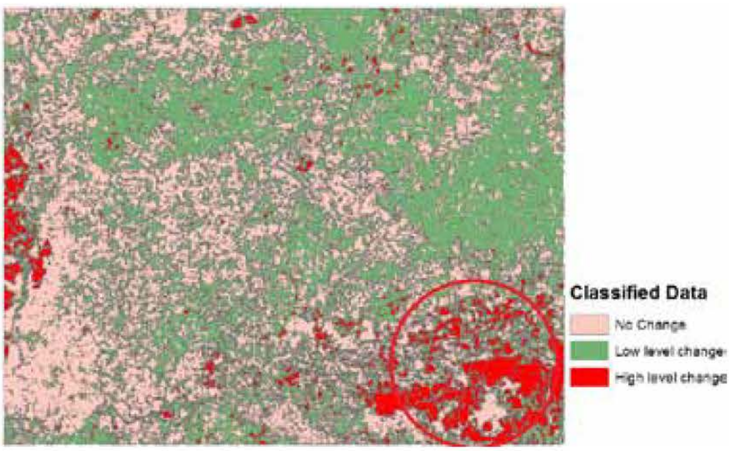

Figure 4: The classified data of land cover change from magnitude vector change

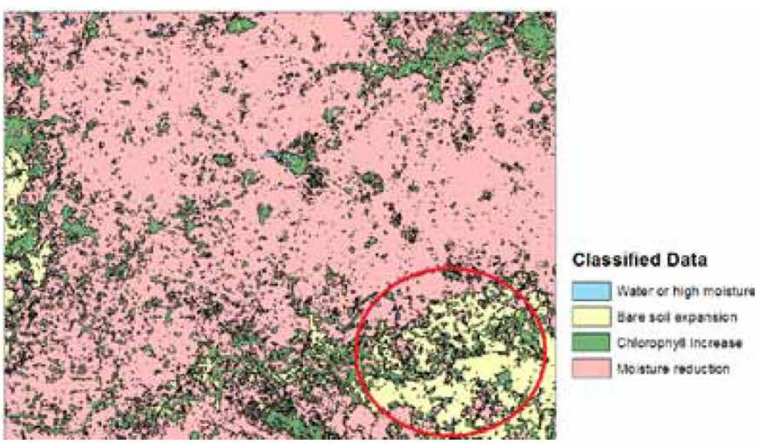

Figure 5: The classified data of land cover change from change direction

The statistical analysis of NDVI and BI are listed in the Table 2. The results of statistics values of NDVI and BI are as follows: max NDVI and BI values of 2007 was higher than 2017, the mean NDVI value of 2017 were higher than 2007, mean BI value of 2007 was higher than 2017, min NDVI and BI values of 2007 were less than 2017, and the STD NDVI and BI values were higher than 2017.

4.2 Change Vector Analysis

The results of change vector analysis have two parameters - the magnitude of change vector and the direction of change vector. The magnitude of vectors was calculated from the Euclidean distance between the difference in positions of the NDVI and BI in the same pixel from year 2007 and 2017 can be calculated by equation 1. The results of magnitude vector can be represented by the length of the vector to compare the land cover change. The threshold of magnitude was used to classify the change or no-change land cover. A lower change threshold value would allow inclusion of slightly change into the change analyses, while a high threshold value would only include the locations of significantly changed areas (Baker et al., 2007). The results of the magnitude of change vector were shown in Table 3 and change images of magnitude vector (Figure 4). The land cover change area of no-change class was 356.007 km^2, low level change was 265.922 km^2, and high level change was 56.440 km^2. In the magnitude vector change image the area has change and no-change, and the red color was the high level change. The green color showed the low level change and pink color indicated no-change area. The direction of change vector indicated the change direction classes from greenness (NDVI) and brightness (BI) component and related types of change. The direction of change vector (α) were found to indicate the type of land cover changes that occurred from year 2007 and 2017 shown in Table 4 and the result of α images show in Figure 5. The areas of land cover changes are listed in the Table 5. The results of the magnitude vector change displayed the maximum land cover changes in 3 sub-districts: Makha, Thakhonyang, and Khamriang. After that, the qualitative data were collected using interviews from the group leader of community of 3 sub-districts to correct the data about changes in land use and land cover in the study area. The results of interviewed show that. In general the land cover change analysis marked "no change" because the people in this area made the integrated farming based on the traditions using mixed or multiple cropping systems. The most area of land cover was agricultural land and in particular the multiple cropping system contained parallels to naturally occurring plant communities. The questions about the land cover of moisture reduction in (Figure 5) from year 2007 and 2017, the results from interview about the impact of moisture reduction. The results shown that actually the land cover no more change to the moisture reduction. The change of land cover was mainly in the paddy fields than to multiple crop fields. Integrated farming depended on the condition of the weather. The impact of natural disasters also had a great impact on the land cover changes and lifestyles of the community, including droughts and floods.

In the parts of 3 sub-districts that most of the land covers change the results following: Makha sub-district has the low level of land cover change because the majority of the occupations in the community is farming and the patterns of land cover are agricultural. Thakhonyang, and Khamriang sub-districts have the high level of land cover change. Both sub-districts are the location of Maha Sarakham University; it has rapid growth of the built-up. The land covers change from vegetables area to built-up areas. Figure 4 and Figure 5 show that the red circles are the locations of Thakhonyang, and Khamriang sub-districts the land cover change was of higher level than the changes for bare soil expansion.

5. Conclusion

This work employed integrated NDVI and BI combination with the change vector analysis to land cover change detection. The results of the magnitude vector change were found to reveal the land cover changes using the thresholds from statistical data between greenness and brightness for years 2007 and 2017.

Table 5: Area of land cover change from direction of change vector from greenness (NDVI) and brightness (BI) component

Classes	Area change (km^2)
Water or high moisture land	7.618
Bare soil expansion	77.202
Chlorophyll Increase	79.256
Moisture reduction	514.293

The results indicated the change of land cover as no-change was higher compared to the lower levels and high levels changes respectively. The directions of change vector were considered from direction of change from greenness and brightness following 4 directions in term of the trigonometric circle. By using interpretation classes as follow: water or high moisture land was decrease of both greenness and brightness, bare soil expansion was brightness increase and greenness decrease, chlorophyll increase was brightness decrease and greenness increase, and moisture reduction was increased of both greenness and brightness. The relationship of the magnitude vector change and the direction change were also described which brought out the areas with higher levels of land cover changes and also the land cover change towards bare soil expansion was also found. The evaluation of the land cover change from the interviews from the group leader of 3 sub-districts revealed and confirmed the areas with high level changes. The lands cover changes from the vegetation area to urban area (bare soil expansion). This area is located around Maha Sarakham University, Khamriang Campus. The importance of the CVA method is excellent for classifying the vegetation and bare soil changes, but not appropriate for classifying of the complex types of land cover changes in cultivation plant.

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