Study on vegetation indices selection and changing detection thresholds selection in Land cover change detection assessment using change vector analysis

Nguyen Ba Duy
Tran Thi Huong Giang
Tong Si Son

Follow this and additional works at: https://scholarsarchive.byu.edu/iemssconference

Duy, Nguyen Ba; Giang, Tran Thi Huong; and Son, Tong Si, "Study on vegetation indices selection and changing detection thresholds selection in Land cover change detection assessment using change vector analysis" (2012). International Congress on Environmental Modelling and Software. 235.
https://scholarsarchive.byu.edu/iemssconference/2012/Stream-B/235

This Event is brought to you for free and open access by the Civil and Environmental Engineering at BYU ScholarsArchive. It has been accepted for inclusion in International Congress on Environmental Modelling and Software by an authorized administrator of BYU ScholarsArchive. For more information, please contact scholarsarchive@byu.edu, ellen_amatangelo@byu.edu.
Study on vegetation indices selection and changing detection thresholds selection in Land cover change detection assessment using change vector analysis

Nguyen Ba Duy, Tran Thi Huong Giang, Tong Si Son

Hanoi University of Mining and Geology, Vietnam
Space Technology Institute, Vietnam

basduy@gmail.com, giangde0912@gmail.com, basduy2309@gmail.com

Abstract: In recent years, the rapidly urbanization and industrialization has caused dramatic changes in land cover. The study on change detection of land cover plays a significant role in making strategy of the managers. Approaches in change detection research using remote sensing and GIS can be categorized into two main groups: post-classification change detection analysis and pre-classification changing spectral determination. The pre-classification approach is further divided into different methods such as: Image Differencing, Multi-date Principal Component Analysis (MPCA); Change Vector Analysis (CVA). Among these, the CVA method is based on two important indices in order to reveal the primary feature of land cover which can be named as vegetation index (NDVI) and barren land index (BI). The ability of applying method of CVA has been indicated by many specialists (Corey Baker et al., 2007; Ding Yuan et al., 1998; Eric F. Lambin et al., 1994). However, the NDVI indices selection and variability threshold haven’t been applied in change detection assessment. This paper proposes application to solve these two problems.

Keywords: Land cover change; Change detection; Change vector analysis

1. INTRODUCTION

Recently, the rapid urbanization has caused the speedy change from agriculture land into industrial one. Furthermore, the uncontrolled deforestation resulted in the problems of environmental degradation and loss of ecological balance. Methods for studying land cover change have been proposed and published worldwide. However, digital change detection methods can be realized in either pre-classification spectral change detection or post-classification change detection methods (Nelson, 1983 and Singh, 1989), figure 1.1.

First method: Post-classification

Second method: Pre-classification

Figure 1.1 Change Detection Methods

In post-classification change detection, two images from different dates are independently classified and labelled. The area of change is then extracted through the direct comparison of the classification results (e.g., Howarth and Wickware, 1981). The advantage of post-classification change detection is that it bypasses the difficulties in change detection associated with the analysis of image acquired at different times of year or by different
The main disadvantage of the post-classification approach is the high dependency of the land cover change results on the individual classification accuracies.

Spectral change detection techniques rely on the principle that land cover changes result in persistent changes in the spectral signature of the affected land surface. These techniques involve the transformation of two original images to a new single-band or multi-band image in which the areas of spectral change are highlighted. The spectral change data must be further processed by other analytic methods, such as a classifier, to produce a labelled land cover change product. Most of the spectral change detection techniques are based on some style of image differencing or image rationing (Weismiller et al., 1977; Toll et al., 1980). It has been shown that image equalization in the data pro-processing stage usually improves the result of change detection (Hall et al., 1991).

Since all spectral change detection methods are based on pixel-wise operations or scene-wise plus pixel-wise operations, accuracy in image registration and co-registration is more critical for these methods than for other methods. The greatest challenge to the successful application of the spectral change detection methods is the discrimination of “change” and “no-change” pixels from the continuous spread of data. When looking at a histogram from a single band there are sharp boundaries separating the value resulting from areas with change from those with no-change (figure 1.2).

From the analysis of the NDVI indices selection and changing detection threshold in changing detection assessment will be highlighted. And the ability of vegetation indices and barren land index will be discussed in order to choose changing detection threshold in changing detection assessment.

2. **APPLICABILITY OF VEGETATION INDICES AND BARE SOIL INDEX IN THE STUDY OF CHANGES IN LAND COVER BY MEANS OF CVA**

2.1 **Vegetation Index (VI) and Bare Soil Index (BI)**

Vegetation Indices (VIs) are combinations of Digital Numbers (DNs) or surface reflectance at two or more wavelengths designed to highlight a particular property of vegetation. Each of the VIs is designed to accentuate a particular vegetation property. Analyzing vegetation using remotely sensed data requires knowledge of the structure and function of vegetation and its reflectance properties. This knowledge enables the linking of vegetative structures and their condition to their reflectance behavior in an ecological system of interest.

In current research, three VIs was computed: the simple Ratio Vegetation Index (RVI), Normalized Difference Vegetation Index (NDVI), the SAVI (Soil Adjusted Vegetation Index - computes the ratio between red and near infrared spectral region with some added terms to adjust for different brightness of background soil) (Huete, 1988). These indices are used to
estimate the correlation with bare soil index. Then, the most suitable index will be selected for land cover change detection. These indices are defined as follows:

\[ RVI = \frac{\rho_{\text{red}}}{\rho_{\text{nir}}} \]  

(1)

\[ NDVI = \frac{\rho_{\text{red}} - \rho_{\text{nir}}}{\rho_{\text{red}} + \rho_{\text{nir}}} \]  

(2)

\[ SAVI = \left[ \frac{\rho_{\text{red}} - \rho_{\text{nir}} + L}{\rho_{\text{red}} + \rho_{\text{nir}}} \right] \times (1 + L) + 1 \]  

(3)

Where: \( \rho \) is the reflectance, \( L \approx 0.5 \)

**Bare Soil Index (BI)** was also computed to identify difference between agricultural and non-agricultural vegetation. The bare soil, fallow lands, and vegetation (with marked background response) are enhanced when using the BI index (Jamalabad and Abkar, 2004).

\[ BI = \left[ \frac{\rho_{\text{red}} + \rho_{\text{nir}}}{\rho_{\text{red}} + \rho_{\text{nir}} + \rho_{\text{blue}}} \right] + 1 \]  

(4)

### 2.2 Change vector analysis algorithm (CVA)

Change vector of each pixel includes 2 components NDVI and BI, which are 2 axes in Cartesian coordinate system. The start point and finish point of the change vector are the locations of pixel in NDVI-BI space on T1 and T2 (T1, T2 are the acquisition date of images). The magnitude of vector represents the change intensity (S); the direction of vector represents the change direction (\( \alpha \)).

**Figure 2.1:** The concept of Change Vector Analysis in two spectral dimensions (Malila, 1980)

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

(5)

\[ \tan \alpha = \frac{BI_2 - BI_1}{NDVI_2 - NDVI_1} \]  

(6)

S: The magnitude of change vector (Euclidean distance)

\( \alpha \): The direction of change vector

\( \text{VI}_1, \text{VI}_2, \text{BI}_1, \text{BI}_2 \): Vegetation Indices and Bare Soil Indices at date 1 and date 2

### 3. STUDY AREA AND DATA SOURCE

#### 3.1. Study area

Study area includes Tanh Linh district, Ham Thuan district, Ham Thuan Bac, Duc Linh (Binh Thuan province), Bao Loc town, Bao Lam district, Di Linh, Cat Tien (Lam Dong province), Tan Phu district, Dinh Quan, Xuan Loc (Dong Nai province). Geographic coordinates: 10°56’55.4” to 11°50’57.7” North latitude; 107°10’4.9” to 108°09’22.7” East longitude.
3.2. Data source

A pair of LANDSAT images which have parameters on the number of spectral bands, wavelengths, spatial resolution and image acquisition time presented in table 3.1. LANDSAT ETM+ image has numbered positions p124-r052 taken on 01/05/2002 and on 13/01/2005 with width (180x180) km² covers the study area and the surrounding area (Figure 3.1). Can be seen clearly changes in land cover on the image of the False Color Composite (Red: Channel 4, Green: Channel 3, Blue: channel 2) taken on 01/13/2005 in comparison with photos on 05/01/2002 (yellow ellipse circled areas).

Table 3.1: Satellite Image

<table>
<thead>
<tr>
<th>Data</th>
<th>Spectral Bands : Wavelengths(µm)/Resolution (m)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat ETM⁺</td>
<td>Band 1: (0.450-0.515) / 30</td>
<td>January, 5th, 2002</td>
</tr>
<tr>
<td></td>
<td>Band 2: (0.525-0.605) / 30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Band 3: (0.630-0.690) / 30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Band 4: (0.750-0.900) / 30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Band 5: (1.550-1.750) / 30</td>
<td>January, 13th, 2005</td>
</tr>
<tr>
<td></td>
<td>Band 6: (10.40-12.50) / 60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Band 7: (2.090-2.350) / 30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Band 8: (0.520-0.900) / 15</td>
<td></td>
</tr>
</tbody>
</table>

The collected images are quite clear, not affected by cloud, fog and other weather disturbances, which reduce false fluctuations during the volatility coating research. All the images were corrected geometric. During the geometric correction process, control points were detected on the topographic map with the RMS errors less than 0.5 pixel. The images were registered on UTM projection, datum WGS84, zone 48 Northern Hemisphere.
3. Study to select vegetation index and appropriate threshold change for assessing the land cover change.

3.1 Selecting suitable index vegetation

Images were analyzed and processed by ENVI 4.5 software. All the images indices: Vegetation index (RVI, NDVI, SAVI) were calculated by using the formula (1), (2) and (3); bare soil index (BI) was calculated by formula (4) which was presented in figure 3.2.

![Vegetation index (NDVI) Images](image)

![Bare soil index (BI) Images](image)

Figure 3.3 The Images Index (Vegetation and Bare soil)

The correlation between vegetation index and bare soil index is evaluated and the results can be seen in figure 3.4. Figure 3.4 reveals the inverse correlation between vegetation index and the bare soil index, in which the highest and clearest inverse correlation is shown on vegetation index (NDVI) and bare soil index (BI). That is why the NDVI and BI are chosen to study the land cover change in this paper.

![Correlation between NDVI & BI, RVI & BI, SAVI & BI](image)
3.2 Selection of appropriate change threshold.

A challenge in change spectrum determination method is to distinguish the pixel change and no-change from chain of incoherent data. The change and no-change area cannot be distinguished when having a look at the distribution graph of single image (Ding Yuan 1998). Also in this paper, Ding Yuan offered change threshold method as in figure 1.2.

Change detection analysis techniques require the consideration of the ecological and spectrum conditions in order to select, classify threshold intensity change. If the threshold value is low, the land cover change detection is low and vice versa (Corey Baker 2007). Determining threshold change by using expert knowledge of the study area is similar to many classification techniques have tested, using experiential knowledge to build relations between the group of spectral values are relatively consistent with the types of land cover (Jano 1998).

In this paper, the method of Ding Yuan is used to classify the threshold changes. However, the implementation result does not reflect real changes. Based on the research results combining with the understanding of the studied area the graph is divided under the standard deviation in order to identify the threshold intensity changes. The classification of threshold intensity change shown in the table below. Intensity change image is built according to the assign threshold value (table 3.2).

<table>
<thead>
<tr>
<th>Period</th>
<th>(max)</th>
<th>(min)</th>
<th>(mean)</th>
<th>(stdev)</th>
<th>No change</th>
<th>Low level change</th>
<th>High level change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002-2005</td>
<td>1.652</td>
<td>0.0007</td>
<td>0.2651</td>
<td>0.175259</td>
<td>0.0007-0.0899</td>
<td>0.0899-0.4404</td>
<td>0.4404-1.652</td>
</tr>
</tbody>
</table>

4. RESULTS AND CONCLUSION

4.1 Results

Based on the results shown in figure 4.1 we can see that:

During the period of 2002-2005, the low change detection area occupied the largest area which accounted for 67.91% of the research area. Of those, 32.25% of the area change in direction II (reduced vegetation index and increased level of lighting). In 2005, there was a dramatic decrease in forest and cultivation land area due to the uncontrolled deforestation, illegal logging as well as speedy urbanization. As the result, vegetation index reduced and bare soil index increased between two periods of time.

The high change detection area (which is able to swap land cover) changed mainly in the direction II (bare soil index increases and vegetation index decreases) which accounted for 12.28%. As can be seen from figure 2.8 the change areas mainly happened in two districts: Tanh Linh and Ham Thuan Bac. This is because of the deforestation and illegal logging in
Tanh Linh and speedy urbanization in Ham Thuan Bac. As the result, the cultivated land turned into industrial and residential area.

**4.2 Conclusion**

To sum up, the remote sensing data along with the studied land cover features makes vegetation index NDVI and bare soil index (BI) the most appropriate to calculate the pairs of LANDSAT image appropriate with research objectives.

In this paper, the intensity change is classified into 3 levels with different types and change quality using Ding Yuan’s method of the threshold reviewed to 4 directions I, II, III and IV according to the correlated change between the bare soil index and vegetation index.

The accuracy of the method based on many factors with each level of processing such as: level of consistency, the appropriation of data image and using indices; the accuracy during
image preprocessing, in which rectification images at different times on the same coordinate system plays important role, the suitable classify threshold method which classifies the level of change under the users’ purposes.

REFERENCES