Land Cover Change Analysis Using Change Vector Analysis Method in Duy Tien District, Ha Nam Province in Vietnam

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Key words: land cover change, change detection, change vector analysis, land cover dynamics

SUMMARY

Duy Tien district- Ha Nam province is a pure agriculture, in recent times, along with economic development, its land cover changes are diversified rapidly. In such a context, the managers do need not only to know the types of land cover change but also the qualitative characteristics of these changes such as intensity and dimension.

The commonly used method as post-classification change detection can only show the replaced and replacing classes but cannot determine the intensity and dimension of those changes. This paper presents the method to detect the intensity of change and the dimension of change using Change Vector Analysis (CVA) method. A pair of Landsat 7 images acquired almost in the same period of crop calendar of 2000 and 2002 is used to calculate the brightness index and vegetation index, which will be used as the change vector components. The magnitude of vector represents the change intensity and the direction of vector represents the change dimension. The intensity and dimension images are later overlaid to commune administrative map of Duy Tien district to obtain the map of quality change for each commune. The change characteristics produced by this method allow us to have a picture about change dynamics of land cover on the period of 2000-2002 in Duy Tien.

This study is carried out in the framework of the project funded by VNU (Vietnam National University, Hanoi) namely: Study the land use changes and its influences to the waste in rural sector of Duy Tien District based on Remote Sensing and GIS utilization.

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1. INTRODUCTION

Duy Tien district is in the center of Hong river delta with area of 13,765 hectares, include 19 communes and 2 towns. Study area is located from $20^0 32'47.5"$ to $20^0 42'19.4"$ N and from $105^0 53'20.7"$ to $106^0 02'418"$ E.

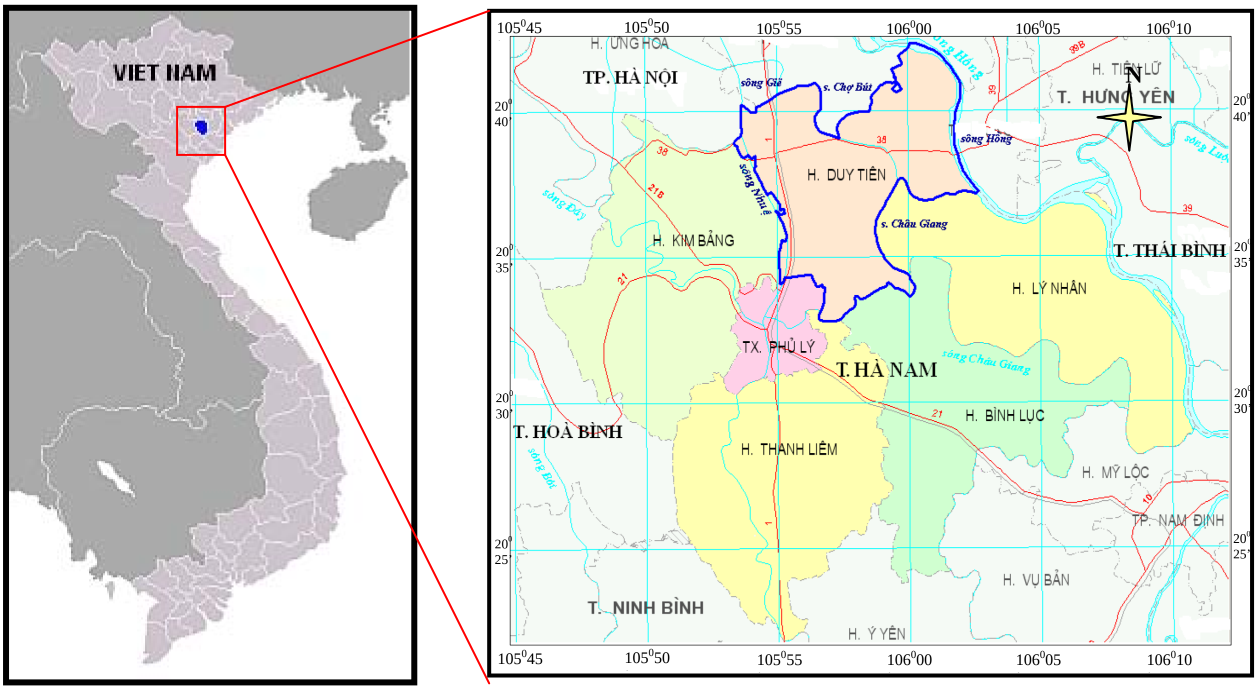

Figure 1: Study area map of Duy Tien district

Ten years up to now, Duy Tien has lost annual a lot of the area of land for agriculture, due to the urbanization and specially, industrial zones expansion and dependent services. This land use change is the main causes of land cover change. Remote sensing and GIS technology has been an importance tool for monitoring environment specially, for large area and demanding resource information multi temporal as Duy Tien. The CVA method is the effective tool to research change dynamics of land cover, but there is not a specific application of the CVA method in Viet Nam. The main objective of this study is to apply the CVA technique for studying land cover dynamics, using ETM+ Landsat data from years 2000 and 2002.

2. METHODOLOGY

2.1 Data source

Satellite image data for this research is collected through CARGIS center, faculty of Geography, Ha Noi University of Science. Topographic map is provided by Department of Survey and Mapping Viet Nam.

Table 1: Satellite Image and Topographic map data

Data	Date	Resolution
Topographic map	1989	1/25000
Landsat ETM +	24/09/2000	30m
Landsat ETM +	29/9/2002	30m

On the whole, the satellite images is clear, no cloud. The land cover is almost rice in the making seed time, so the color tone of images is quite identical. Before using for analysis, the images are corrected geometric. At the geometric correction, control points are detected on the topographic map and the images with the RMS errors are estimated below 0.5 pixel. The images are registered on UTM projection, datum WGS84, zone 48 Northern Hemisphere.

2.2 Indexes are used in study

Normalized Difference Vegetation Index (NDVI) displays the relationship between the quantity of chlorophyll in leaves with red and near infared wavelength, so that NDVI image is used to research vegetation as estimating biomass, plant productivity, fractional vegetation cover (Rouse 1974; Richardson 1977).

$NDVI = \frac{(\rho_{Nir} - \rho_{\mathrm{Re}d})}{(\rho_{Nir} + \rho_{\mathrm{Re}d})}$ Where $\rho_{Nir}, \rho_{\mathrm{Re}d}$ are the spectral reflectance measurements acquired in the near-infrared and red regions.

Bare soil index (BI) is calculated to distinguish agricultural land and non-agricultural land (Jamalabad 2004).

$BI = \frac{(\rho_{Swir} + \rho_{\mathrm{Re}d}) - (\rho_{Nir} + \rho_{Blue})}{(\rho_{Swir} + \rho_{\mathrm{Re}d}) + (\rho_{Nir} + \rho_{Blue})}$ (Jamalabad 2004) Where $\rho_{Nir}, \rho_{\mathrm{Re}d}, \rho_{Swir}, \rho_{Blue}$ are the spectral reflectance measurements acquired in the near-infrared, red, short wave infrared, blue regions (band 4, 3, 5, 1 in Landsat ETM+ image).

NDVI and BI index are used in CVA method to stress the vegetable class and bare soil class that are the main classes of land covers of natural surface.

2.3 Change vector analysis method

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 and the direction of vector represents the change dimension.

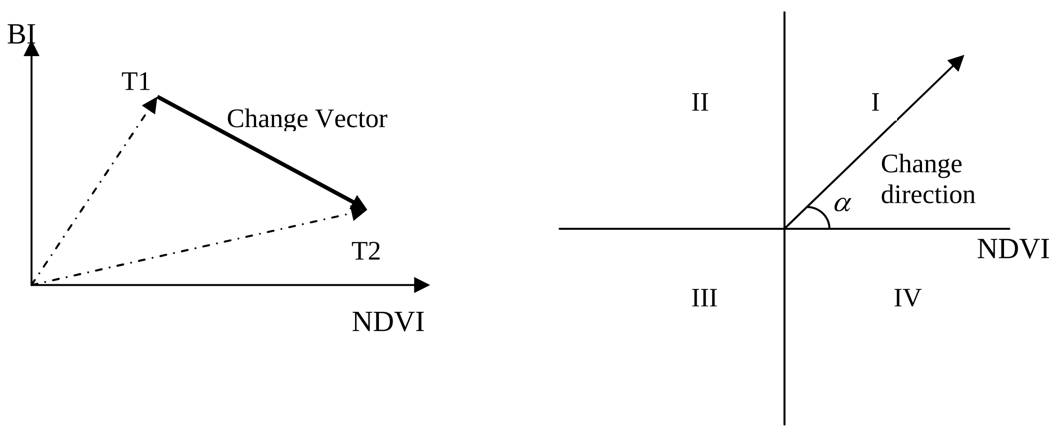

Figure 2: The concept of Change Vector Analysis in two spectral dimensions (Malila,1980)

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

S: The magnitude of change vector (Euclidean distance)
α: The direction of change vector
$NDVI_1$, $NDVI_2$, BI_1, BI_2: NDVI and BI index at date 1 and date 2

3. RESULTS AND DISCUSSION

3.1 Change intensity image and change dimension image

The results of this study are calculated by using Band Math tool in ENVI 4.2 software. The histogram of change intensity image is analyzed to detect change or no change threshold. The change dimensions are built following the 4 directions (4 corners) on trigonometric circle as figure 2.

Figure 3a: Image of change intensity (2000-2002)
(*The more brightness the high level change*)

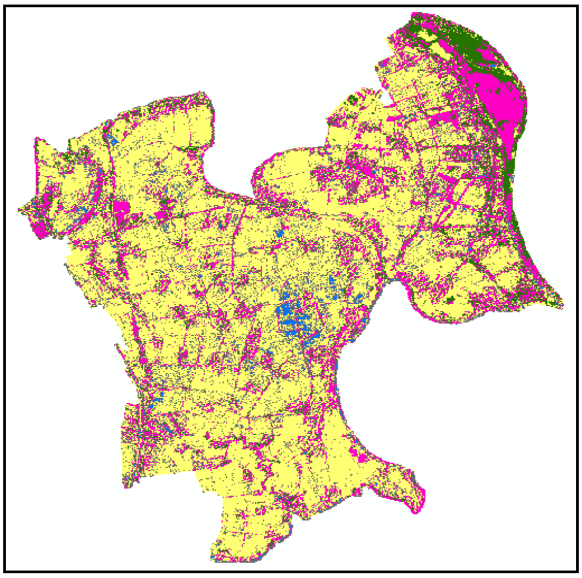

Figure 3b: The image of change dimension (2000-2002)

The dimension of change	BI index	NDVI index	Description
III	-	-	Water or high moisture land
II	+	-	Bare soil expansion
IV	-	+	Chlorophyll Increase
I	+	+	Moisture reduction

Table 2: The description of change dimension

The dimension I shows the increase in both of the NDVI and BI index. The cause of this phenomenon is the moisture reduction between dates. In fact, there is no replacement of classes of land cover. Conversely, the decrease in both of the NDVI and BI index in the dimension III shows the water or high moisture land. Comparing the change intensity image with the change dimension image, we can see the location of the dimension II area similar to the location of high level change area. In the field, these areas are the replacement of rice to construction or bare soil. The most popular in study area is the areas of the dimension IV. Rice at the date of image 2002 grew more than image 2000, so the quantity of chlorophyll of rice is more than too. That is the reason of the NDVI increase and the BI decrease in dimension IV.

The change/no-change threshold detection

The CVA detection technique required consider ation of some ecological and spectral conditions in regard to threshold selection and overall change sensitivity. A lower change threshold value would allow inclusion of slightly changed wetlands into the change analyses, while a high threshold value would only include the locations of significantly changed areas.(Corey Baker 2007). The change detection threshold, therefore, was determined using the remote sensing analyst's expert knowledge of the study area, similarly to many remote sensing techniques such as an unsupervised classification where expert known-edge of land cover classes within the study area is required to relate spectral clusters to land cover types (Jano et al. 1998). In this research, we determined the change threshold base on the histogram of Change intensity image combining with knowledge of the study area and divide the Change intensity image into 3 classes as *Figure 4.*

Level	Name	Description
I	No change	Spectral No-change
II	Low level change	Spectral change
III	High level change	Land cover change

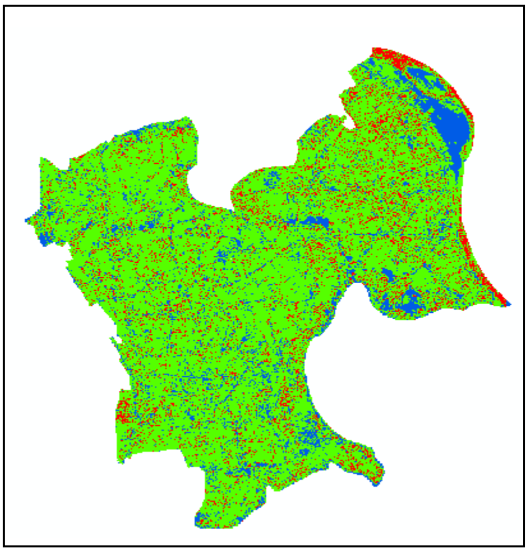

Figure 4: The change intensity image after threshold divided.

Level I is the areas, which changes spectral at very little level, so it can be ignored and consider as no change in the study period. The areas in level I are water or firm construction. Level II is spectral change areas but it doesn't show classes replacement. Level II stands for the change of quality inside each class of land cover. The replacement a class by another class is showed in Level II that is changes at high level.

3.2 Combining change images with GIS

Change intensity image and change dimension image are overlaid to commune administrative map of Duy Tien district to obtain the quality of change of each commune through the relation between change intensity and change dimension.

	I	II	III	IV
High level change (ha)	154.73	519.35	145.64	872.44
Low level change (ha)	1546.85	1572.27	808.43	6686.44
No change (ha)	387.52	332.13	330.18	477.85

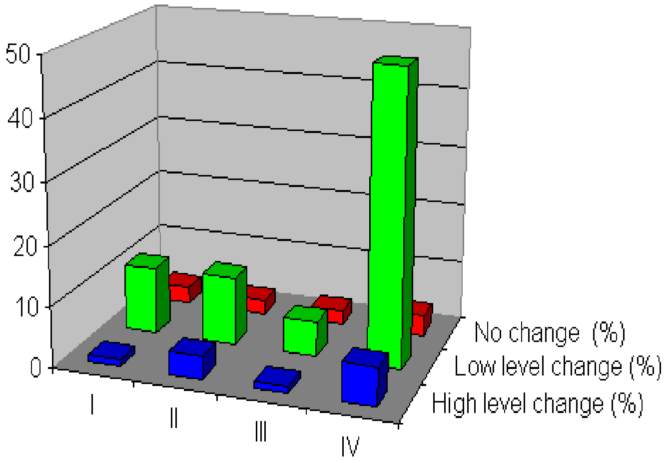

Figure 5: The relation between change intensity and change dimension.

Figure 5 shows that: At the date of 2000, some of alluvial grounds along the Hong river in Moc Bac commune are bare soil, but at the date of 2002 those ones are replaced by vegetable. So that 6.31% of study area in the high level change and following the dimension IV. At the same time, 3.75% of study area rice is replaced by industrial zone expansion in Dong Van town and along the highway one. The

Because Duy Tien is pure agricultural district, cultivates rice only, the land cover is usually not change at the same time in years, so the most area is the low lever change areas (Level 2) with 10,624 ha (76% of study area), in that 43% of change area following the dimension IV.

The no change area is distributed equally among 4 dimensions. On the change intensity image, the no change areas are ponds, clean rivers. The change of reflectance spectral value is usually disturbances in remote sensing technology.

4. CONCLUSION

Change vector includes 2 components (NDVI and BI index) is an effective tool in assessing land cover/ land use change. The CVA method does not only exploit the intensity element but also the dimension element of change (the nature of change) from remote sensing data.

The research shows that, CVA method using NDVI and BI index is fully suitable for Lansat ETM+ image and for pure agricultural area such as Duy Tien district. The nature of CVA method is using original spectral bands therefore, the accuracy of method depend on the quality of image, geometric correction and the accuracy of change or no change threshold detection, that the reason the CVA method will not be applied for cloudy image or foggy image.

With the ability of studying the level of change of land cover, the CVA method can study the development of a specific species of plant through the periods of growth by using multi temporal image. Since then, we can estimate the quantity of crop and support the farmers, which is very necessary for an agricultural country as Viet Nam.

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