JOURNAL
of VIETNAMESE
ENVIRONMENT

Application of remote sensing and GIS technique to analyze the land-use change: the case of Phu Giao district, Binh Duong province

Ứng dụng kỹ thuật GIS và Viễn thám để phân tích sự thay đổi đất sử dụng: Trường hợp huyện Phú Giáo, tỉnh Bình Dương

Research articl

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Digital change detection is a helpful technique using multi-temporal satellite image for analyzing landscape exchange. The objective of this study is an attempt to assess the land-use changes in Phu Giao district, Binh Duong province, Vietnam in the period of fifteen years, from 2001 to 2015. Landsat Thematic Mapper (TM) image data files of years from 2001 to 2015 were collected on website of United States Geological Survey (USGS). Then, the images supervised were classified into five classes including perennial plant, annual plant, barren and urban land, and water body using Maximum Likelihood classification method in ENVI 4.7, and mapped using ArcGIS. The results show that during fifteen years, perennial land and urban land have been increased by 39.83% and 10.32%, while annual land and water body have been decreased by 1.37% and 5.35% accordingly, respectively.

Phát hiện thay đổi số hóa là một kỹ thuật hiệu quả sử dụng hình ảnh vệ tinh đa thời gian cho phân tích thay đổi cảnh quan. Bài viết này là một sự cố gắng nhằm đánh giá sự thay đổi đất sử dụng ở huyện Phú Giáo, tỉnh Bình Dương, Việt Nam trong khoảng thời gian mười lăm năm từ năm 2001 đến năm 2015. Các file dữ liệu ảnh Landsat TM của các năm từ 2001 đến 2015 đã được thu thập trên trang web nghiên cứu Địa chất Hoa Kỳ (USGS). Sau đó, các hình ảnh giám sát được phân thành năm lớp bao gồm cả cây trồng lâu năm, cây trồng hàng năm, đất đô thị cằn cỗi và vùng nước sử dụng phương pháp phân loại Maximum Likelihood trong ENVI 4.7, và lập bản đồ bằng sử dụng ArcGIS. Kết quả cho thấy rằng trong suốt mười lăm năm, diện tích đất trồng cây lâu năm, đất đô thị đã được tăng tương ứng là 39,83% và 10,32%, trong khi đất đai hàng năm và vùng nước giảm 1,37% và 5,35%.

Keywords: urban spawl, Landsat image, remote sensing, GIS, land-use exchange

1. Introduction

Land cover is the physical material at the surface of the earth which are captured in the distribution of veg-etation, water, soil and other features of land, including those created by human activities e.g... Land-use has been changed following the way which human has been used it for their activities. According to Ruiz-Luna and Berlanga-Robles (2003) [1], Turner and Ruscher (2004) [2], the change in land-use is a widespread and accelerating process. Information collected from land-use analysis would contribute to understand the change and interaction between human activities and natural phenomenon. Besides, it also helps managers in selection planning, proper land management, decision improvement and implementation of land-use schemes to meet the increase in demands for basic human needs and welfare [3].

Satellite remote sensing has considered an ideal technology in researching because classification, mapping and change detection of land-area cover for large scale [4], [5]. Several improvements in the spatial temporal resolutions have been witnessed by remote sensing., the change in land-use has been analyzed in detail to improve the selection of areas with a design to agricultural, urban or industrial areas of a region based on the invention of remote sensing and Geographical Information System (GIS) techniques [6]. Application of these tools to study the change in land-use is a less time consuming, low cost and better accurate method [7]. Furthermore, the association of two tools provides for data analysis, store, update and retrieval [8]. One of the most important applications of remote sensing is mapping which shows reader the change in land-use visually.

Many studies relating to the land-use exchange have been carried out by many researchers in the world such as studies of Yacouba Diallo et al. (2009) [9], N.H.K.Linh et all (2012) [10], El-Asmar et al. (2013) [11], Butt. A et al. (2015) [[12]2], Phan KD et al. (2015) [13].

Phu Giao is a rural district of Bình Dương Province in the Southeast region of Vietnam. The district covers an area of 53.861 km². It shares the border Tan Uyen district in the southeast, Ben Cat commune in the western and Vinh Cuu (a commune of Dong Nai province) in the eastern (Fig. 1). Population of Phu Giao district was 90.315 in 2013 and approximately eighty-five per cent of population are working in agriculture sector [14].

In this paper, authors tried to build up the map that shows the changes in land-use in Phu Giao, Binh Duong in the period of fifteen years, from 2001 to 2015. Land Administration managers could base on the land-use change map and adjust the land cover so that it is more suitable and sensible with developmental situation of commune.

2. Materials and methods

2.1. Database preparation

Two Landsat images of two years 2001 and 2015 with resolution of 30 m were used to classify land-use changes in this study. The satellite images covering the study area were obtained from earth explore site UGSG system [15]. These data were import to ENVI version 4.7. Specifications of the satellite images acquired for analysis are summarized in Table 1.

Table 1. **Satellite data specifications**

	Landsat 7 TM	**Landsat 8 TM**
Date and Year of acquisition	11/12/2001	23/03/2015
Bands	Multi-spectral	Multi-spectral
Resolution (m)	30	30
Source	USGS glovis	USGS glovis

2.2. Image classification

In this study, authors applied supervised classification technique to classify two dated Landsat images using Maximum Likelihood algorithm in ENVI 4.7. The supervised classification technique is preferred because the availability of data source of study area and author also carried out a field trip to determine the land cover.

According to Wu and Shao (2002) [16], McIver and Friedl (2002) [17] the Maximum Likelihood algorithm is one of the most widely functions used in supervised classification with high accuracy [18,19]. The LULC maps were derived into five classes: 1. Perennial plant, 2. Annual plant, 3. Barren, 4. Urban land and 5. Water body (Table 2).

Figure 1. Geographical location of Phu Giao

2.3. Accuracy assessment

To check the accuracy of the classification, an error matrix was built. The error matrix is an assessment of pre-dicted and observed (field data) by using different waypoints (Fig 2). From the matrix, three standard criteria includ-ing: producer's accuracy, user's accuracy and total accuracy were calculated to assess the accuracy of the classifica-tion. The user's accuracy was proportion of the pixels classified correctly in the total pixels classified in that class.

This criterion indicates the probability that a classified pixel actually represents that category in reality [9]. On in other hand, the overall accuracy has defined as the proportion of total number pixels classified correctly in the total number of reference pixels [20]. In addition, Kappa coefficient also was determined by formula 1.

$$k = \frac{(T - E)}{(1 - E)} \qquad (1)$$

Where T is overall accuracy.

Kappa statistic estimated as K that reflects the difference between actual agreement and the agreement expected by chance. For example, Kappa of 0.85 means there is 85% better agreement than by chance alone.

Table 2. Land-use classification

| Number	Land-use/land cover	Description
1	Perennial plant	Land for less than one-year-old plants
2	Annual plant	Land for more than one-year-old plants
3	Barren	Land area of exposed soil
4	Urban land	Areas with residential, commercial, industrial, transportation and facilities
5	Water body	Areas covered with water such as rivers and lakes, open water, ponds, reservoirs
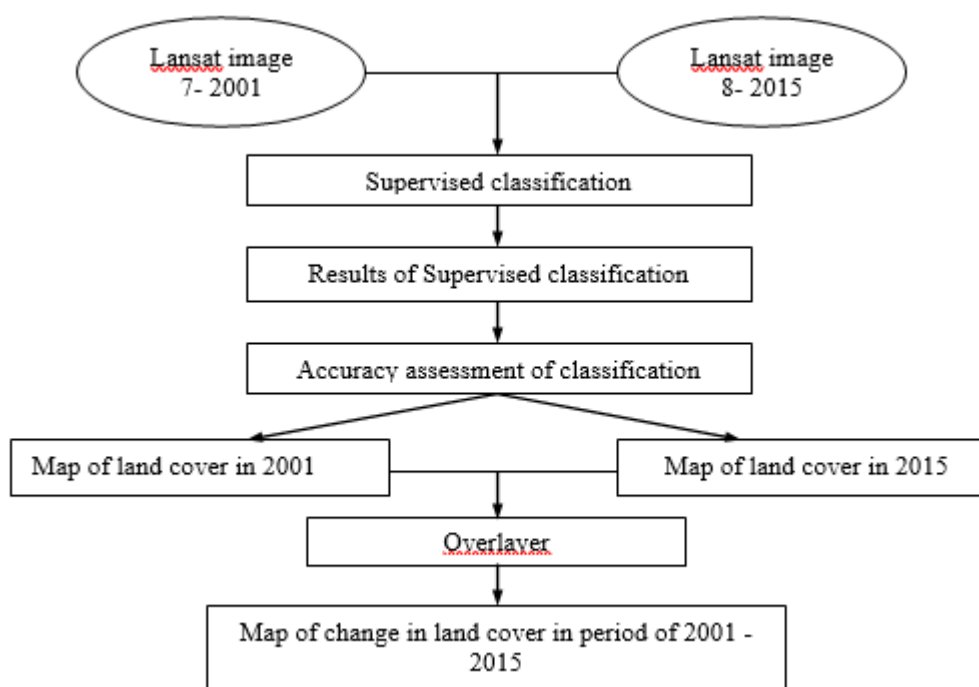
Figure. 2. Process of mapping the change of land cover in period of 15 years from 2001 - 2015
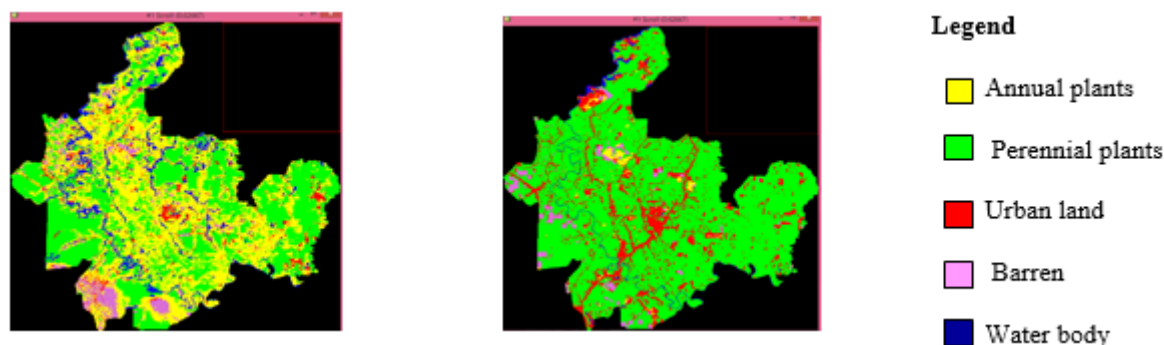

Figure 3. Land cover classification in 2001 (left) and in 2015 (right)

3. Result and discussion

3.1. Result of classification

The classification maps of Phu Giao commune, Binh Duong province, Vietnam of two years 2001 and 2015 were given in Figure 3a and 3b. The overall accuracies of classification are 99.03% and 96.06% and kappa coefficients were 0.9875 and 0.9501 for 2001 and 2015 respectively. These criteria show that there was a high accuracy in classification in the present research because accuracy assessment reporting requires the overall accuracy and kappa coefficient of classification above 90% and 0.9 accordingly [21].

3.2. Calculation of land-use change

The classification for two years 2001 and 2015 were carried out in ArcGIS and the results are summarized in Table 3. It can be seen from the Table 3, Phu Giao was a district

that approximately eighty-five per cent of population is engaged in agriculture activities, farmland covers a large area in 2001.

Table 3. The classification results for 2001 and 2015

Land cover/use classes	Sign	Year 2001		Year 2015	
		Area (ha)	Portion (%)	Area (ha)	Portion (%)
Annual plants	CHN	24585.84	45.04(%)	880.63	1.61(%)
Perennial plants	CLN	21839.82	40.01(%)	43582.50	79.84(%)
Urban land	ĐNO	2271.04	4.16(%)	7905.20	14.48(%)
Barren	CSD	2245.32	4.11(%)	1494.23	2.74(%)
Water body	SON	3646.34	6.68(%)	725.79	1.33(%)
Total		54588.35	100.00(%)	54588.35	100.00(%)

Table 4. Change matrix for the change in land cover 2001 – 2015 (Unit: hectares)

| Land cover	Sign	Area 2001	Change in land cover 2015					Change increase (+), decrease (-) (-)	Area 2015
			Annual crops	Perennial crops		Barren	Water body		
Total area		54,588.35							54588.35
Annual crops	CHN	24,585.84	371.25	19,523	4121.3	367.18	203.12	-23,705.24	880.63
Perennial crops	CLN	21,839.82	340.27	1,8074.6	2395.15	943.17	86.6	21,742.71	43582.5
Urban land	ĐNƠ	2,271.04	33.99	1,725.87	467.03	33.35	10.8	5,624.16	7905.2
Barren	CSD	2,245.31	114.49	1,602.16	396.69	129.32	2.65	-751.09	1494.23
Water body	SON	3,646.34	20.61	2,656.87	525.03	21.2	422.62	-2,920.55	725.19
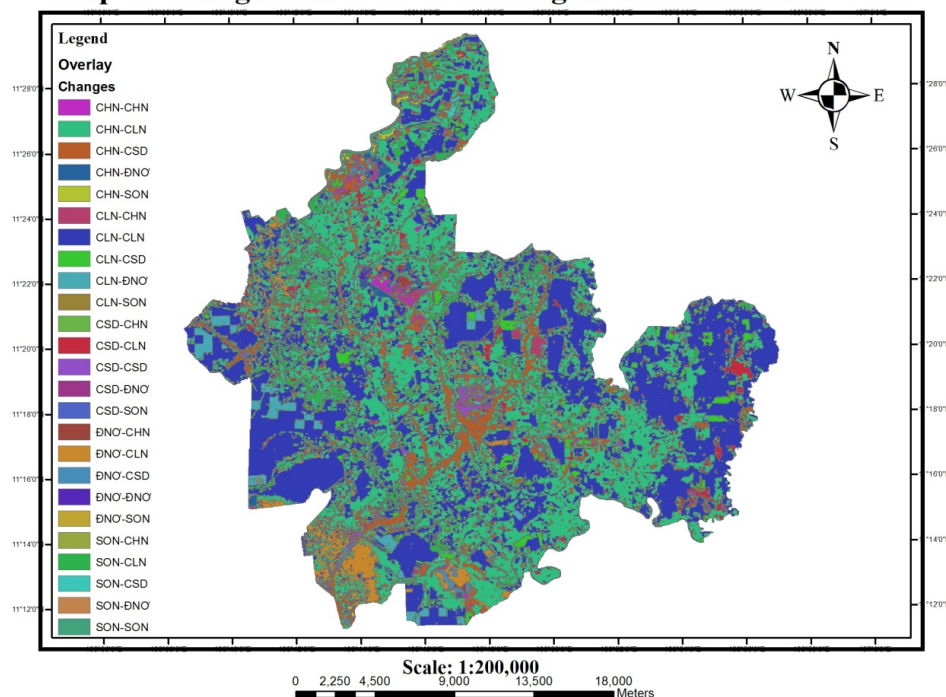
Figure 4. A map of the change in land- use from 2001 to 2015

In particular, the area for perennial crops, and annual crops were 21,839.82 ha; and 24,585.84 ha respectively. Urban area was still very little occupying (2271.04 ha). Unused land (barren) occupied area of 2245.32 ha).
In 2015, due to the process of industrialization and modernization, there was a change in land-use. The perennial crops with high economic value increase by approximately double in 2015.

Moreover, urban land, which was the least area covering class in 2001, increased in 2015 from 4.16% to 14.48%. Besides, 2015 witnessed a decrease in barren and water

body by 1.37% and 5.35% accordingly. To understand land encroachment for different land categories in the period of fifteen years from 2001 to 2015, a change matrix was built (Table 4). Finally, a map of the change in land- use was established (Figure 4).

4. Conclusion

Satellite remote sensing and GIS are useful technology to analysis the land use and land cover change. Therefore, this application would be less time-consuming, cost effective, few limitations methods and better results to support for decision makers. This study is successful in classifying the land covers in Phu Giao with Kappa coefficients are 0.9875 and 0.9501 for 2001 and 2015 respectively. The overall accuracies of classification are 99.03% for 2001 and 96.06% for 2015. As we can be seen from the results, there is a consistent increase in annual crops and urban area in Phu Giao commune from 2001 to 2015. Urban area is predicted to grow much higher in future because of industrialization and population growth while the area of water body has downward tendency. Land Administration managers should have corrections that are suitable and sensible with developmental situation of commune.

5. References

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