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Land Use/Land Cover Changes from 1995 to 2017 in Trang Bang, Southern Vietnam

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Abstract

Trang Bang is the largest agricultural production district of TayNinh province, Vietnam that has a great influence on the socio-economic development of the whole province. This study assessed land use - land cover change in Trang Bang district from 1995 to 2017, the results provide scientific evidence for the safe and effective identification of causes and safeguards for mulch. The study was conducted by an expert classification system and the land use/land cover (LULC) was classified into 6 classes: food-crops, fruit-tree, water, built-up, industry and shrub. The result showed that the LULC there decreased between 1995 and 2017. All the two land cover types (food-crops, fruit-tree) decreased 141.2 km^2 (41.4%) in 2017 compared with 1995, while the area of industrial and urban land (industry, built-up) increased 70.0 km^2 (20.6%). The overall classification accuracies in 1995, 2007, and 2017 were 94.2%, 98.0%, and 96.3% respectively. The overall kappa coefficients for the image classification were 0.90, 0.97, and 0.94 in 1995, 2007, and 2017 respectively. In general, the average classification was above 90%, and this proved that the classification was reliable and acceptable. The result show that the LULC in the study area decreased during 1997-2017 and tended to decrease in recent years.

Keywords

Sai Gon River, Dau Tieng Dam, Land Use/Land Cover, Trang Bang, Classification, Remote Sensing

1. Introduction

Land use/land cover (LULC) change refers to the change of mantle that includes changes in the type of mantle (LULC change conversion) and changes within the mantle itself (LULC change modification). Information about LULC and change of the LULC are essential for proper planning, management and utilization of natural resources, environmental protection. Assessment of the LULC change helps to understand better the relationships between humans and the environment to manage and exploit resources optimally for sustainability. There are many methods and tools for performing classification and evaluation of mantle variation. In particular, the use of multi-temporal remote sensing data provides continuous and accurate information on the status of the mantle. The issue of remote sensing data and GIS application for updating the status and mapping of land cover to better manage natural resources that has been made by scientists from all over the world [1]-[6]. Most of them focused on developing countries (e.g. Thai Land [1], China [2], [3], Africa [4], [5], Indonesia [6]). However, few works were conducted in Vietnam, which is also a developing country with a long history of agriculture and a large population depending on land and its resources for their daily activities.

Trang Bang is a typical agricultural region of southern Vietnam. It is close to Ho Chi Minh City which is the economical center of Vietnam. In recent years, this area has observed rapid urbanization, and many industrial parks have sprung up causing a dramatic decline in agricultural land area, which prolongs dry season and lack of water, threatening agricultural production and people's lives. Because this locality has concentrated on economic development in the direction of industrialization, the area of agricultural land has been reduced dramatically since 1995. Most cultivated land has been changed to built-up and industrial land, which make the land cover change seriously. The dense population and industrial zones have increased rapidly, but there is no scientific basis to conclude that the coating in this area is declining. Therefore, the objective of the current study is to explore the changes of LUCC during the last two decades (1995-2017) using Landsat satellite imageries in Trang Bang, southern Vietnam and identify the main factors driving the changes. The findings are expected to provide valuable information for local government to design appropriate policies for optimal use of land.

2. Data and Methods

2.1. Study Area

Trang Bang (10˚56'N to 11˚15'N and 106˚10'E to 106˚28'E) is located in southern Vietnam and is the most populous district of TayNinh province (**Figure 1**). The study area has a natural area of 340.7 km^2 and population is 160,824 persons (2017) [7].Water resources in Trang Bang are diversified, including two main river systems: Sai Gon and Vam Co Dong rivers and Dau Tieng dam. This is one of the largest dam and has had an impact on Vietnam's agricultural production. This place has a tropical monsoon climate with temperature between 23˚C and 32˚C [8]. There are dry and rainy seasons without wind storms and cold winters. This area has historically been a major production area of rice, vegetable and fruit for TayNinh province and Ho Chi Minh City. However, in recent years

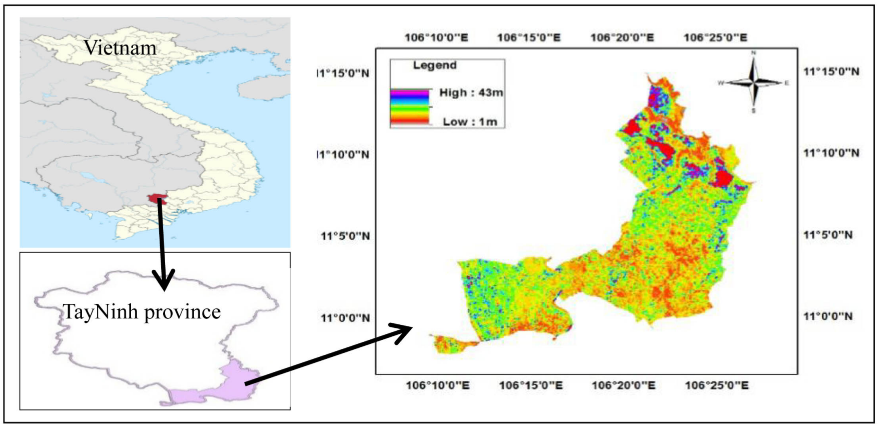

Figure 1. Location and digital elevation map of the study area.

when the economy has developed, the area of agricultural land has reduced sharply, many industrial parks have been operating there, causing the land cover to deteriorate dramatically and threaten drought and quake, severe landslide.

2.2. Data

Because the planning and management of land at provincial and district levels has been synchronized since 1995 in Vietnam, the data for 1995, 2007 and 2017 were used to analyze the (LULC) change over the last two decades (**Table 1**).

In this work, Landsat data were used to investigate the changes of LULC in Trang Bang. Three available cloud-free image scenes (Feb. 2, 1995, Feb. 3, 2007, and Feb. 28, 2017) acquired from the United States Geological Survey (USGS) Erath Resources Observation and Science Data Centre (EROS) [9]. Additionally, the corresponding land use maps (1/50,000) for the three periods were also used to collect training samples and to evaluate classification accuracy.

The Landsat images were geometrically corrected to UTM (Universal Transverse Mercator), Zone 48 North, WGS-1984 (World Geodetic System) based on the land use maps. To do this, the control points were dispersed across each scene and the registration accuracy was less than 0.5 pixels. Supervised classification and visual interpretation methods were applied to land use/land cover types. The interpretative accuracy was 90% and kappa coefficient reached 0.85 after processing. The land use/land cover types over the study area were identified by CORINE [10] and shown in **Table 2**.

2.3. Image Classification and Accuracy Evaluation

Maximum Likelihood algorithm (ML) embedded in ENVI software was applied in this study. It is a widely used supervised image classification method. This algorithm works on the assumption that the statistics for each class in each band follow normal distribution. Then the probability of a given pixel belonging to a certain class is calculated based on the mean and standard deviation of each class obtained from the training samples. In this study, ENVI 5.0 software was used to perform the image classification.

Table 1. Data characteristics and source.

Data type	Year	Resolution	Source
Landsat Image (TM)	1995	30 m × 30 m	NASA[a]
Landsat Image (TM5)	2007	30 m × 30 m	USGS[b], NASRDA[c]
Landsat Image (TM8)	2017	30 m × 30 m	USGS
Maps of the actual land use	1995, 2007, 2017	1/50,000	Survey of study area
Population data	1995, 2000, 2005, 2010-2017		TayNinh Statistical office

[a]: National Aeronautics and Space Administration; [b]: United States Geological Survey; [c]: National Space Research and Development Agency.

Table 2. Classification of land use/land cover of the study area.

Level 1	Level 2
1) Land cover of the water	River, lake, pond, land of the Aquacultural
2) Land cover of the food-crops	Rice, maize, manioc, suger-cane, peanut, sweet potato
3) Land cover of the fruit tree	Fruit tree (durian, rambutan, jackfruit, mango), Rubber, Nacre
4) Land cover of the built-up	Urban, Residential, Traffic
5) Land cover of the industry	Industrial zone, Production business
6) Land cover of the shrub	Shrub, Vegetable, tobacco , grass

Accuracy assessment of the ML classification was determined by means of a confusion matrix (sometimes called error matrix), which compares, on a class by class basis, the relationship between reference data (ground truth) and the corresponding results of a classification [11]. Such matrices are square, with the number of rows and columns equal to the number of classes.

$$\text{Overall accuracy} = \frac{\sum_{i=1}^{m} x_{ii}}{N} 100\% \tag{1}$$

Equation (1) is N and m are the total number of pixels and classes respectively. The minimum acceptable overall accuracy is 85% [12].

The Kappa coefficient (K) is a second measure of classification accuracy which incorporates the off-diagonal elements as well as the diagonal terms to give a more robust assessment of accuracy than overall accuracy. It is computed as [13], [14]:

$$K = \frac{N\sum_{i=1}^{m} x_{ii} - \sum_{i=1}^{m}\left(x_{i+}x_{+i}\right)}{N^2 - \sum_{i=1}^{m}\left(x_{i+}x_{+i}\right)} \tag{2}$$

Equation (2) is. x_{+i} and x_{i+}. are column sum and row sum.

To calculate the Land consumption coefficient (LCC) the following formula was used:

Population projected:

$$P(\text{projected}) = P(t_1) + P(t_2 - t_1) \tag{3}$$

Equation (3) is P (projected) is the projected population at present time; $P(t_1)$

is the size of the growing population at initial time; (t_1) is Initial year; (t_2) is Present year; (t_1).

3. Results and Discussion

3.1. Overall LULC Changes

Land use classification results show that the area land of industrial and construction land is increasing, as shown in the land maps of 1995, 2007, 2017 (**Figure 2**).

The results of the land use classification are shown in **Table 3**, LULC has many fluctuations.

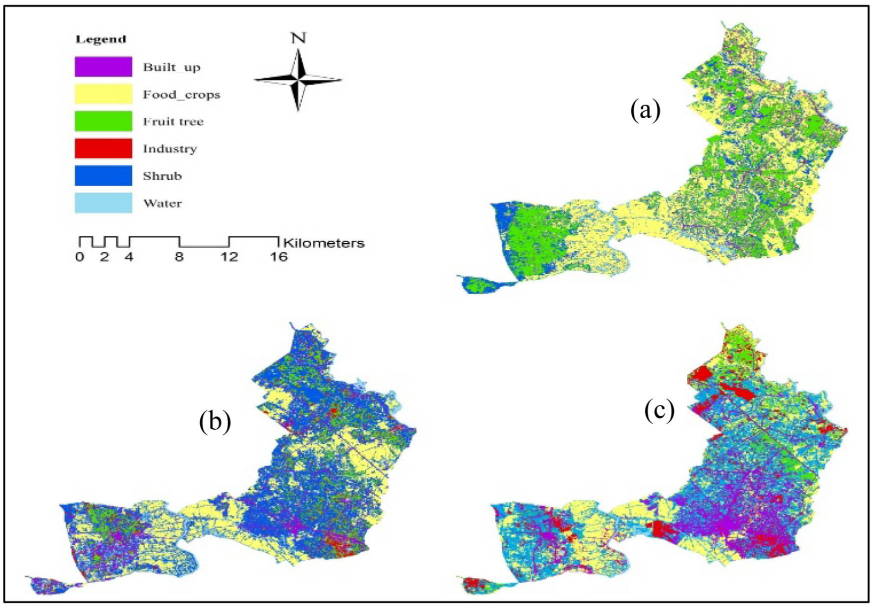

Figure 2. LULC maps (a) 1995; (b) 2007; (c) 2017.

Table 3. LULC area, change differences, classification accuracy, and Kappa statistics.

LULC Classes	Area						Area difference (km^2)		
	1995		2007		2017		1995-2007	2007-2017	1995-2017
	(km^2)	(%)	(km^2)	(%)	(km^2)	(%)			
Food-crops	147.6	43.3	89.3	26.2	83.3	24.4	−58.3	−6.0	−64.3
Fruit-tree	98.3	28.8	42.3	12.4	21.4	6.3	−56.0	−20.9	−6.9
Water	9.4	2.8	16.4	4.8	9.2	2.7	7.0	−7.2	−0.2
Industry	2.1	0.6	10.8	3.2	39.4	11.6	8.7	28.6	37.3
Built-up	20.4	6.0	37.2	10.9	53.1	15.6	16.8	15.9	32.7
Shrub	62.9	18.5	144.7	42.5	134.3	39.4	81.8	−10.4	71.4
TOTAL	340.7	100	340.7	100	340.7	100			
Accuracy (%)	94.2		98.0		96.3				
Kappa (K)	0.90		0.97		0.94				

Analysis results show, in 1995 the area land cover of food-crops was 147.6 km^2 (43.3% of total area), 89.3 km^2 in 2007 (26.2% of total area) and 83.3 km^2 in 2017 (24. 4% of total area). In 1995 the area land cover of fruit-tree was 98.3 km^2 (28.8% of total area), 42.3 km^2 in 2007 (12.4% of total area) and 21.4 km^2 in 2017 (6. 3% of total area). Built-up area in 2017 was 53.1 km^2 (15.6% of total area) (increase 15.9 km^2 compared with 2007 and increase 32.7 km^2 compared with 1995). Industry area in 2017 was 39.4 km^2 (increase 28.6 km^2 compared with 2007 and increase 37.3 km^2 compared with 1995).

Shrub occupies a large area of 63.0 km^2 (1995), 144.7 km^2 (2007) and 134.3 km^2 (2017). This type of mantle is due to the transition to mulch type land cover of food-crops. According to the statistics at the management agency, mainly from land for rice, beans to grass and tobacco. Thus this transformation of the mantle is in the second form, LULC change conversion. Because there is no forest land in the study area, the land for fruit tree is the most stable land. This land will remain 21.4 km^2 by 2017, decreased 76.9 km^2 (22.6% of the total area) in comparison with 1995.

The overall classification accuracies were 94.2%, 98.0%, and 96.3% in 1995, 2007, and 2017 respectively. The overall kappa coefficient of 0.90, 0.97, and 0.94 were also recorded for the image classification of 1995, 2007, and 2017 respectively. This classification results show that the land use coating in the study area is decreasing.

The chart showing the variation of the following mantle types shows the change in land cover over the years 1995, 2007 and 2017. LULC of agriculture tend to decrease, inversely proportional to the population (**Figure 3**).

The chart shows that land use over the years has been declining as built-up of land and industrial land increase. LULC in 1995 the area covered by food-crops of cover decreased 17.1% in 2007 and 18.9% in 2017. While land cover decreased relative to industrial land increased 2.6% in 2007 and 11.0% in 2017, similarly built-up of land increased 5.0% in 2007 and 9.6% in 2017. And agricultural land tends to be inversely proportional to population growth.

3.2. Classification Accuracy

The reliability of the classification results is shown by the accuracy of the classification. Accuracy and Kappa (K) coefficient show that the results of the classification are highly reliable (**Table 4**).

The results of the classification accuracy on each land cover are quite high, the highest is the land cover of food-crops, followed by the land cover of industry. Shrub has the lowest accuracy because this land cover has many similarities.

This classification method produces high overall accuracy were 94.2%, 98.0%, and 96.3% in 1995, 2007, and 2017 respectively. The overall Kappa coefficient of 0.90, 0.97, and 0.94 were also recorded for the image classification of 1995, 2007, and 2017 respectively.

The accuracy between producer's and user's difference is not high in every

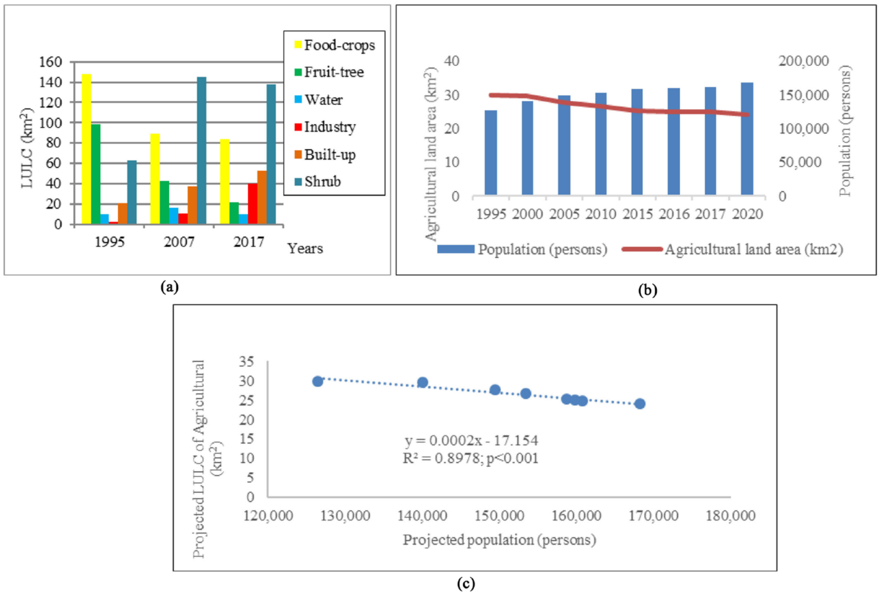

Figure 3. Summary of statistical analysis of the study area (a) comparative chart of land cover types and (b), (c) relationship between LULC of agricultural and Population.

Table 4. Producer's and user's image classification accuracies and Kappa coefficient.

LULC Classes	Classification accuracies (%) and Kappa coefficient					
	1995		2007		2017	
	Producer's	User's	Producer's	User's	Producer's	User's
Food-crops	95.2	98.1	99.7	100.0	97.5	100.0
Fruit-tree	92.7	98.3	94.7	95.6	100.0	93.1
Water	88.8	93.7	91.9	100.0	90.9	100.0
Industry	100.0	85.7	98.4	98.0	95.9	98.8
Built-up	96.3	88.1	98.5	97.0	98.4	85.3
Shrub	97.8	79.7	100.0	93.1	90.6	70.0
Accuracy (%)	94.2	93.9	98.0	97.5	96.3	96.1
Kappa (K)	0.90	0.87	0.97	0.95	0.94	0.92

group, the highest is 100% and the lowest is 70.0%. However, overall accuracy is over 85% so this result is acceptable.

3.3. Discussion

As a result of the analysis, the coverage area decreased sharply from 1995 to 2017 in all three types of land use: food-crops of land, fruit-tree of land and shrub of land. In particular, land for fruit-tree has the most stable coverage, because the study area has no forest so this kind of land use is considered as a perennial plant with stable coverage and plant structure less change. From 1995 to 2017 the area of fruit-tree decreased 76.9 km^2, mainly to built-up of land and industry of land, the evidence is that other types of land cover also decrease. Map of land cover classification in 1995-2017 for matrices of changes in mulch cover over the years 1995-2017 (**Table 5**). This area change matrix shows that the LULC change results in **Table 3** are reliable.

This study analyzes the remote sensing data in an objective and highly accurate analysis. Land use classification in 1995 was 94.2, 98.0 in 2007 and 96.3 in 2017. The Kappa coefficients in 1995, 2007 and 2017 were 0.90; 0.97 and 0.94. Accuracy of analysis over the years is not the same because of the process of locating samples based on local statistics and land classification. And because of the structure of crops in the land of rice, vegetable and grass land is unstable. These types vary from one rice crop, two rice crop, and vegetable, which makes it difficult for statistical work. It leads to a definite sample set for the unstable classification between the two land use types: food-crops of land and shrub of land. However, according to the analysis, the accuracy of the above 90 and the Kappa coefficients above 0.9 are quite acceptable.

The above results show that the process of socio-economic development of the area along the Saigon River has a large fluctuation in LULC. For more than 2 decades (from 1995 to 2017), 141.4 km^2 of land cover was lost (accounting for 41.5%). Of which, 18.9% is reduced to food crops and 22.6% of fruit land area is reduced. Meanwhile, construction and industrial land area increased by 70 km^2 (accounting for 20.5%). In addition, the land cover in the study area is unstable (fluctuating in seasons and dependent on irrigation water, often reducing coverage in the dry season).

Because this area has no forest, this type of land use is considered to have the most stable coverage. However, the identification is also difficult due to unstable land use patterns. For example, 1-crop rice and vegetable land use only 3 to 6 months per year. The data collected is covered but the remote sensing image is vacant land. Therefore, the author classifies these into a group of shrub land, data analysis at different time is accurate.

Table 5. Cross-tabulation matrix of LULC classes between 1995-2017.

	Class	1995						
		Food-crops	Fruit-tree	Water	Industry	Built-up	Shrub	Total
2017	Food-crops	49.7	11.0	3.1	14.3	17.7	52.1	147.9
	Fruit-tree	14.7	5.2	0.8	15.1	18.3	44.3	98.4
	Water	2.7	0.1	4.0	0.4	0.4	2.2	9.8
	Industry	0.7	0.1	0.1	0.1	0.2	1.0	2.2
	Built-up	2.6	1.8	0.0	3.2	6.2	7.3	21.1
	Shrub	14.0	2.8	1.6	6.2	10.2	26.5	61.3
	Total	84.4	21.0	9.6	39.3	53.0	133.4	340.7

4. Conclusions

The rapid increase in the industrial and built-up land without checking will be a major threat to land cover, resulting in the reduction of land and habitat quality. Therefore, in order to meet the demand for economic development while ensuring the quality of land for agricultural areas, it is necessary to have a suitable economic growth policy. To focus on arranging industrial parks in agricultural production areas for poor efficiency, reduce the use of land with stable cover. In addition, it is necessary to prioritize the construction of industrial parks using materials from specific agricultural areas of the study area such as rubber, pepper, coffee, fruits, rice and vegetables. And the area of the water body should be protected and used effectively, because it is the main source of water used for irrigation for agricultural and aquaculture purposes. Industrial zones need to be managed in a way that avoids the loss of this type of land use due to pollution. Some previous domestic studies have shown that the rate of population growth and urbanization has markedly changed the LULC [15], [16]. Thus, through the results of this study, it shows that the LULC of agricultural is decreasing significantly while the population and the industrialization speed are increasing.

This area should be rather researched in order to have a more tightly managed solution which can solve both economic development and improve the quality of land and habitats on the basis of stable and sustainable development, increasing LULC.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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