

Research on the effect of urban expansion on agricultural land in Ho Chi Minh City by using remote sensing method

Tran Thi Van*

Institute for Environment and Resources, VNU-HCMC

Received 11 April 2008; received in revised form 13 July 2008

Abstract. Ho Chi Minh City is a one of the biggest cities of Vietnam. Before 1945, there were about 400,000 inhabitants living in the city. During the last two decades, it became the biggest industrial and commercial center of the country. According to the statistics in 2005, its population was about 6.2 million people. In the suburban areas of the city, particularly in the northern part, agricultural activities produce the main income of these local residents. Within the last 15 years, due to urbanization and emigration from other provinces, the population explosion became a serious problem. The conversion of agricultural land into residential areas has increased more and more, causing the change of land-use structure. This paper describes the capability of remote sensing for detecting and analyzing spatial changes as well as quantifying results to show the urban growth process, and its impact on the land-use distribution in the northern part of Ho Chi Minh City.

Keywords: Agricultural land; GIS; Remote sensing; Suburban; Urban expansion.

1. Introduction

Over the world, the cities cover only about one percent of the earth's surface, but most of the issues happening in the cities greatly impact on the environment and global change [7]. Urbanization leads to urban spatial expansion due to the demand for development and housing growth, as well as facilities areas to serve human life.

In Vietnam, land use and land cover patterns have undergone a fundamental change due to rapid economic development under its reformative economic policies. Urban growth has been speeding up; as a

result, an extreme stress to the environment has occurred. This is particularly true in Ho Chi Minh City where agricultural land has been gradually disappearing each year, converted into urban or related uses. Furthermore, because of the lack of appropriate land use planning and the measures for sustainable development, rampant urban growth is creating severe environmental consequences.

Although Ho Chi Minh City has a history of establishment and development over 300 years, urbanization has just started from few last decades. Industry began to play an important role merely in 1960 – 1970 years [6], and then some urbanized regions were obviously on the rise. However, the war had caused the constrained situation of

* Tel.: 84-8-8651132.

E-mail: tranthivan@hcmier.edu.vn

urbanization with the great concentration of huge population, while the industry slowly developed and living standard was still low. From the end of the 1980s, Ho Chi Minh City has really entered into the period of urbanization and was speeded up by industrialization with fairly strong progress [6].

Agriculture and rural areas belong to general socio-economic structure of Ho Chi Minh City with their advantages of geographical location exist as a suburban of the big scientific, technological, industrial and commercial city. The city has taken full advantages of location, exploited strength of industry, service, science and technology to serve the development of agriculture and rural areas. In recent years, due to the requirements of city expansion, a part of suburban agricultural land was urbanized. According to developing strategy for a civilized, modern and environmental sustainable city, suburban agriculture has intended to transform into ecological and high-tech agriculture.

If the urban and urbanization issues had been studied for a long time in the world and then still have been continued to study, in Vietnam this problem merely is on research focus from the middle of 90s [2]. The monitoring of temporal and spatial changing issues in urban is usefull for managers and planners to draw up a strategy for urban suitable development. Traditional methods requiring extensive labour do not bring the effectiveness in the regional scale because of high cost of field measurements. Remote sensing and geographic information systems (GIS) has been widely applied and has been recognized as a powerful and effective tool in detecting urban land use and land cover change [4]. GIS technology provides a flexible environment for entering, analyzing and displaying digital data from various sources. It is necessary to identify urban features for

change detection and database development. Remote sensing technology can acquire on the ground objects without touching them. Satellite remote sensing collects multi-spectral, multi-resolution and multi-temporal data and turns them into valuable information for understanding and monitoring urban land processes and for building urban land cover datasets [8]. Especially, it is useful to consider the historical development of a region. This study uses the Landsat TM and ETM⁺ to extract the built-up land in the city and evaluate the change of agricultural land under urbanization in Ho Chi Minh City.

2. The study area

Ho Chi Minh City has a very favorable geographical location in the centre of the rich Southern region with many resources. The city has the common administrative boundary with Long An, Tay Ninh, Binh Duong, Dong Nai, and Ba Ria – Vung Tau provinces. Its natural surface area is about 209,502ha, among them 45% is the agricultural land. The land of the city is formed by old and recent alluvions, having poor fertility of soil, not suitable for development of annual crop production [5].

For historical conditions, Ho Chi Minh City was formerly a kind of monocentric city. Before 1975, activities of economy, finance, culture, education, commerce were mainly concentrated in District 1, 3 and a part of District 5. Ho Chi Minh City has the fairly rapid speed of urbanization. According to statistics, the population density has increased from 552 people/km² in 1985 to 2,601 people/km² in 2002 (in urban areas about 10,076 people/km², in rural areas about 602 people/km²). Non-agricultural population rate has significantly increased from 83.3% in

1985 to 95.2% in 2002. The population growth causing population overload in the city has been shown not only by the natural increase on the spot, but also by the mechanical movement from other provinces.

As a result, there is an indispensable need to improve, expand and develop the old urban areas in this situation. In addition, the city sometimes has not controlled unplanned constructions and urban encroaching expansion on suburban agricultural land in the northern part. Therefore, the study area is focused on this part. This is a region with a lot of advantageous conditions for developing infrastructure for residential, commercial and industrial areas. Here is the place where the urbanization process is happening fairly strong in the recent years (Fig. 1).

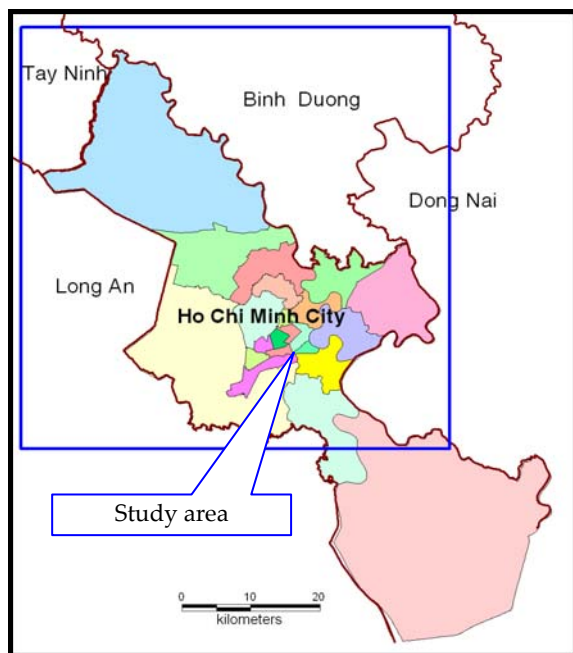


Fig. 1. The study area.

3. Methodology

This study was based on remotely sensed

data (satellite images), along with fields check and existing maps. Land cover patterns for 1989 and 2002 were mapped by using Landsat TM and ETM data (Dates: 16 January 1989 and 13 February 2002). Five types of land cover are identified and used in this study, including: urban, agricultural land, bare land, shrub/grass land and water.

As the first step, the data pre-processing was initiated for two images. The images were geometrically rectified and registered to the same map projection to lay them over each other for change detection. The image registration was carefully carried out with the RMS errors less than 0.3 pixel to guarantee the two coincident images. Due to lack of atmospheric measures during image acquisition, the atmospheric correction was ignored. However, these images were acquired in dry season (in January and February) in the study area, so they appeared very clear and cloud free. In this context, the atmospheric effects on these images were not significant.

In order to obtain a high accuracy for the interpretation results, we selected the training samples for each group of specific object. For each group (e.g. water) some types of sample were selected by the spectral signatures in the images (e.g. water 1, water 2, etc.). The Maximum Likelihood Classification was carried out for each image. After testing several times to carrying out the classification as well as adding samples for achieving higher accuracy, the final results were accepted. Further activity is the post-classification to group the fragmentary results in five main types of land cover as initial determination. The confusion matrix was calculated for the study area after masking the unnecessary outside. The overall accuracy was about 88% for the year of 1989, and 86% for 2002. Then, for analyzing the nature, rate

and location of urban expansion in compared with loss of agricultural land; an image of urban-residential area was extracted from each original land cover image.

The urban expansion image was further overlaid with some geographic reference images to analyze the patterns of urban expansion, including image of district boundary, major roads.

4. Results and discussions

4.1. Urban expansion during the period of 1989-2002

The research results showed that population explosion was the main cause of urban expansion. Ho Chi Minh City is the biggest industrial and commercial center of Vietnam. The high economic growth and

abundant employment opportunities caused influx of labor immigration. According to general demographic investigation to 1st April 2004, Ho Chi Minh City had 1.8 millions immigrants in the population total of 6.11 millions. Local increase of population plus immigrants made the city become too stuffy. According to statistics, the urban population has increased 2 times from 1990 to 2005. The population density in urban districts in 2005 was reported around 10,608 people per square kilometers [1]. Due to housing demand and city development, agriculture land was transformed into land for houses, roads, industrial and commercial areas.

From the source of the Department of Natural Resources and Environment, the main land use structure in Ho Chi Minh City is shown in Table 1 and Fig. 2.

Table 1. Main land use structure in Ho Chi Minh City over years

Land use / Year	1995 (ha)	2000 (ha)	2005 (ha)	1995 (%)	2000 (%)	2005 (%)
Total	209,376.00	209,502.00	209,554.00	100	100	100
Built-up land	31,196.34	38,571.07	50,523.72	14.90	18.41	24.11
Agricultural land	100,366.37	97,247.78	89,659.21	47.94	46.42	42.79
Forest	34,657.58	33,472.15	33,857.86	16.55	15.98	16.16
Water	34,153.02	34,011.29	33,250.02	16.31	16.23	15.87
Unused land	9,002.96	6,199.54	2,263.67	4.30	2.96	1.08

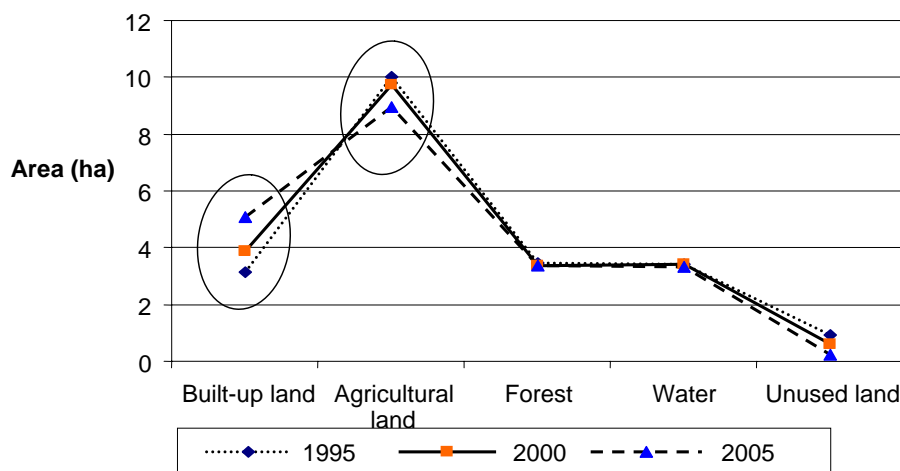


Fig. 2. The changes between built-up land and agricultural land from 1995 to 2005 by statistics.

Over the whole city, the land transformation was realized mainly in the northern part of the city as shown by the results from remote sensing data. Fig. 3 shows that the dense settlement presented a rapid expansion and concentrated in urban districts and along the main roads in the suburban areas, where the agricultural land yielded to property development. Although built-up areas have increased in all directions, it was mainly concentrated in the

North, West and East of the city and along the mainroads.

Result of Landsat image interpretation shows that during 13 years, from 1989 to 2002, agricultural land was decreased by 39,329 ha, among which 6,045 ha were changed to urban residential land, and 23,065 ha appeared as bare land since the local farmers sold their lands. They will be used for future built-up purposes (see Table 2).

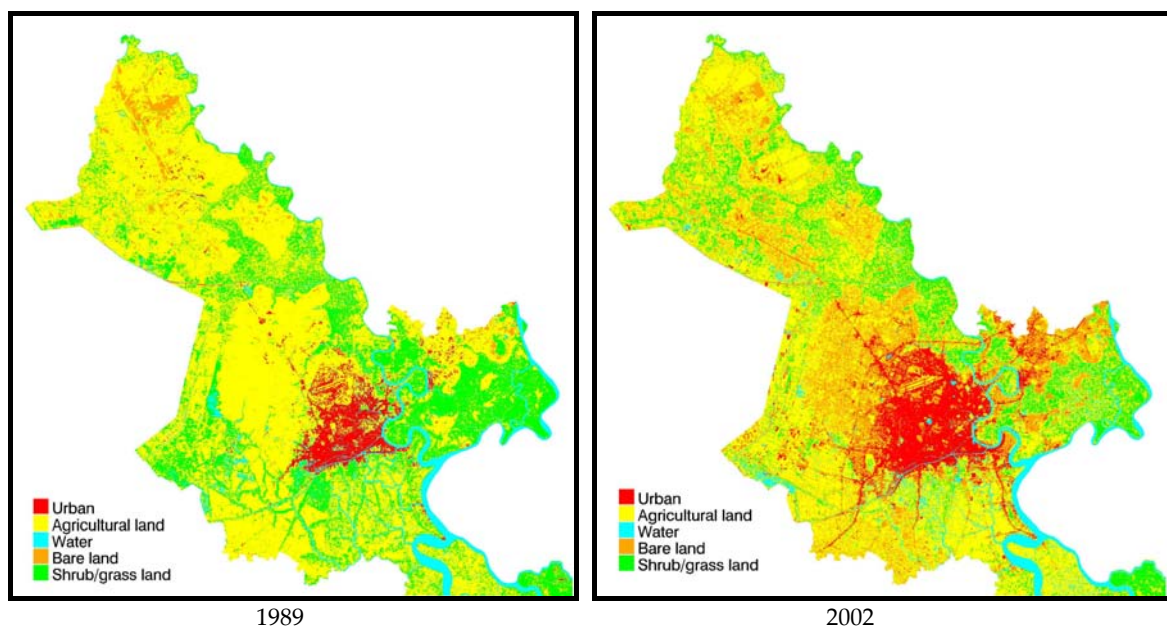


Fig. 3. Results of urban expansion in the northern part of Ho Chi Minh City in 1989 and 2002 from remotely sensed data.

Table 2. Land use transformation from 1989 to 2002 in the northern part of Ho Chi Minh City (ha)

	Urban	Agricultural Land	Water	Bare land	Shrub / grass land	Row total (2002)	Class total
Urban	5,150.88	6,045.48	687.96	84.15	892.26	12,860.73	12,860.73
Agricultural land	393.93	52,577.37	2,200.86	1,550.52	17,276.22	73,998.90	74,060.10
Water	98.82	1,556.01	5,297.04	18.99	982.62	7,953.48	7,963.02
Bare land	851.76	23,065.65	351.45	1,120.59	3,378.15	28,767.60	28,767.78
Shrub / grass land	81.63	8,661.87	310.23	69.30	9,584.10	18,707.13	18,731.16
Class total (1989)	6,577.02	91,906.38	8,847.54	2,843.55	32,113.35		
Class changes	1,426.14	39,329.01	3,550.50	1,722.96	22,529.25		
Image difference	6,283.71	(17,846.28)	(884.52)	25,924.23	(13,382.19)		

By history, due to intensive urbanization in the suburban districts, such as Tan Binh, Go Vap, Binh Thanh and District 8, residential land becomes more and more cramped. Under the force of circumstances, some suburban areas were changed into five new urban districts from 1997. Districts 2, 9 and Thu Duc have been divided from Thu Duc suburban district; District 7 from a part of Nha Be and District 12 from a part of Hoc Mon. Beside that, the development of the new urban areas such as Nam Sai Gon helped to extend Ho Chi Minh City in all directions.

As it is shown by the analysis of remote sensing data in 1989 and 2002, the built-up land increased most in districts Tan Binh, Go Vap, Binh Thanh and District 8, where the population is densely located (see Table 3).

Table 3. Built-up land increase with population

District	Increased area built-up land (km ²)	Increased in population total	Increased population per km ²
Tan Binh	20.34	324,904	14,517.61
Go Vap	13.49	205,656	10,418.24
Binh Thanh	11.07	83,864	4,039.69
District 8	8.25	88,423	4,610.17

The change of agricultural land has happened in the areas with available infrastructure, near main roads, in the gateway areas of the city, especially in the areas planned for residential, industrial, commercial zones.

4.2. Effect of loss of agricultural land due to urban expansion

Agricultural activities in suburban areas belong to general socio-economic structure of Ho Chi Minh City. From the Day of Liberation in 1975, agricultural fields as the city's green belt have been changed on

general demand of city development through different stages with mission of supplying fresh foods and a part of raw materials for industrial processing. Nowadays, rural areas have been charged with production of high-economic-value agricultural goods, accommodated market and export. In recent years, due to the needs of expansion of the city, a part of suburban agricultural land has been urbanized. Suburban agriculture has a tendency to transform into ecological and high-tech agriculture, according to developing strategy of a civilized, modern and environmental sustainable city.

However, due to uncontrollably rapid urban expansion in the year's 1990, loss of agricultural land in rural areas has made a change of the unplanned city. Agricultural land in Ho Chi Minh City is not only limited in the size but also is poor on quality due to the alum-salted effect plus unfavourable conditions on topography and water. This has influenced land exploitation potential on goods orientation. As consequence, the effectiveness of agricultural land use in suburban areas has a lower level in comparison to the whole country. In addition, the average norm of agricultural land distribution for each household was very low: 0.32 ha per household, just equal 2/3 of the average norm of the South-East Region and equal 1/3 of the Mekong Delta. This situation is a pressure on suburban farmers in keeping agricultural production [6].

According to the investigation of Institute of Economic Research in June 1996, the number of farmers owned the crop land was decreased by 23% compared with the total land in urbanized areas [6]. Due to the above limitations, plus the impacts of urbanization, these farmers would not hesitate to sell land in order to make capital for another type of investment. They hoped for higher profits or

improvement their life in the short term. As a result, this circumstance caused the rapid reduction of agricultural land. Most of the yielded land has been changed into the urban uses. A lot of new urban areas has rose for satisfaction of housing demand from population explosion. This made the city facing problems of ecological unbalance and loss of traditional agricultural villages. Typically, Go Vap floricultural village was disappeared, now a few points of decorative plant trade exist as the reminder of this tradition. Low land areas cultivating wet rice (such as in District 2) naturally were places for balance of the drainage, but constructing and concretization process made flow to convergent narrow sewerages; or the altitude raise of new urban areas caused concentration of water flow in lower old urban areas and instant inundation was unavoidably happening in the city centers. However, it is worth to mention that after land selling, the situation of fallowing agricultural land has becomes widespread in suburban districts. This causes the prodigality in land use of the city.

5. Conclusions

In this study, remote sensing and GIS method was developed for evaluation of rapid urban expansion and loss of agricultural land. Results revealed a notable increase in urban land cover between 1989 and 2002. Built-up areas has increased in all directions but it was more concentrated to the North, West, and East of the city.

Under impact of urbanization, land-use types have suffered a lot of changes, especially for the agricultural land. The results from remote sensing data shown that urban expansion has spatially increased in all

directions, but it was mainly concentrated in the North, West and East of the city and along the main roads. In the upcoming years, due to trend of expansion, Ho Chi Minh City will become a special urban with population more than 10 millions by 2010 year [3]. Urban expansion supplied conditions to disperse the habitants from excessive concentrated areas of inner city districts. However, the uncontrolled sale of agricultural land makes difficulty in land management under sustainable development

In the future, it is required a huge amount of investment to improve the productivity and effectiveness of agriculture in the situation of less remained agricultural areas with bad fertility plus unfavourable conditions on topography and water resources. Finally, although urban expansion cannot be stopped, with proper management and planning it can be directed in a desirable and sustainable way, protecting fertile agricultural land and ecological areas, creating green belt for the city.

Acknowledgements

This paper was completed within the framework of Fundamental Research Project 719706 funded by Vietnam Ministry of Science and Technology.

References

- [1] Bureau of Statistics in Ho Chi Minh City, *Statistical yearbook in 2005*, Statistical Publishing House, HCMC, 2006 (in Vietnamese).
- [2] Dam Trung Phuong, *Urban in Vietnam*, Construction Publishing House, Hanoi, 1995 (in Vietnamese).
- [3] *Decision of the Primer Minister No. 1570/QĐ-TTg about approval of mission to adjust the general*

- planning on construction of Ho Chi Minh City to 2025*, Hanoi, 27/11/2006 (in Vietnamese).
- [4] P.M. Harris, S.J. Ventura, The integration of geographic data with remotely sensed imagery to improve classification in an urban area *Photogrammetric Engineering and Remote Sensing* 61 (1995) 993.
 - [5] Institute of Economic Research and Department of Culture and Information of Ho Chi Minh City, *Economic of Ho Chi Minh City - 30 year construction and development (1975-2005)*, Institute of Economic Research, HCMC, 2005 (in Vietnamese).
 - [6] Nguyen Thi Tuat, *The impact of urbanization process on the socio-economic change of rural areas in Ho Chi Minh City - A proposal of criterion for supporting employment situation to District 2*, Report of the Scientific Project, Institute of Economic Research, HCMC, 1998 (in Vietnamese).
 - [7] P. Vellinga, N. Herb, *Industrial Transformation: Science Plan*, IHDP Report No. 12. Bonn: The International Human Dimensions Program on Global Environmental Change, 1999.
 - [8] Q.A. Weng, Remote sensing - GIS evaluation of urban expansion and its impact on surface temperature in the Zhujiang Delta, China, *International Journal of Remote Sensing* 22 (2001) 1999.