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Spatial analysis to assess the trend of urban land conversion in the process of urbanization

Tran Thi Van*, Pham Ngo Khoa, Ha Duong Xuan Bao, Nguyen Van Tinh

[a]*Ho Chi Minh City University of Technology, Vietnam National University Ho Chi Minh City, 268 Ly Thuong Kiet Street, District 10, Ho Chi Minh City, Vietnam;*

Abstract

The trend of transition from agricultural to urban land is inevitable in the process of urbanization in the region. This paper presents the assessment of land use changes for District 2 of Ho Chi Minh City, based on GIS applications combined Markov forecasting model. The results of the changes calculated by area in 2005-2010 showed that agricultural land was reduced significantly and turned to other forms of land use such as urban residential land and land for special-use purposes. In particular, land for special-use purposes were increased the highest, due to the expansion of industrial parks, ports, land for offices, land for administration agencies and land for schools. In the second rank it was urban residential land. Forecasted data by Markov chains and data of land use master plan to 2020 of District 2 have similarities pretty good. Urbanization has a positive impact on socio-economic development of District 2; nevertheless it still has a certain influence, such as pressure on infrastructure, changing the land use, and adverse impact on the environment. The study results are good reference for the management of urban land in the district.

Keywords: GIS, land use change, Markov chain, simulation, urbanization

1. Introduction

Today, due to the population growth, the development of urban areas, the socio-economic growth and some other issues have to accelerate the process of urbanization. Urbanization has a huge impact on the land, which is specifically here to change the purpose of land use, land transfer from agricultural to urban land. Before these pressures, the volatility of land is inevitable, leading to demand for land for different purposes and is constantly changing. Therefore, the problem of urban land use is receiving a special attention.

The study of land use changes is becoming more quickly and accurately with the help of calculation models in the analysis of land use change associated with GIS in data processing. At present and in the future, with the strong development of information technology, it allows us to use GIS to solve the complex problems of land-use change and urbanization, thereby solving issues of economic and social, and it is also indispensable requirement should be put out.

District 2 of Ho Chi Minh City, is surrounded mostly by the Saigon River and Dong Nai river, away from the city center about 300 meters towards the Saigon River, with attractive location due to diversified network of rivers , it is becoming a new city center with class projects, which have been deployed, along with new residential development, meanwhile, the existing residential area is embellishment, district administrative center

* Corresponding author. Tel.: 84-091-918-8485
E-mail address: vanbaokt@yahoo.com.

was formed ... has set the stage for District 2 became a new urban center of civilization and modernity in a near future (Fig. 1).

This paper presents the research and application of GIS evaluation of land use changes in District 2, and the integration of Markov chain model to simulate the movements of land until 2020, in order to understand the impact of urban processes turned to the change, and to have a basis for suggestions on layout and space planning appropriate oriented sustainable urban development.

Fig. 1. The study area
(Source: District 2 Committee)

2. Methodology

2.1. Data Standardization of input map

Research base is made by starting from the maps of land use with 5-year period (2005 and 2010), collected from natural resources and environmental department of the district. Then, they have been grouped according to the class into the main land use types, including agricultural land, urban land, and land for special purposes and rivers. The type of land use was to standardize the codes described in the following attributes:

- Styled text with symbols: NNP - Agricultural land; ODT - Urban residential land; CDG - Land for special purposes; SMN – rivers
- Numerical symbol: 2005 (NNP = 10, ODT = 20, CDG = 30, SMN = 40), 2010 (NNP = 1, ODT = 2, CDG = 3, SMN = 4)

2.2. Change detection mapping

From 2 layer maps of land use, we conduct overlay, to determine the class change, and establish a matrix of land use changes in 2005-2010. The findings were included in the Markov chain models to predict the cycle based on the input data in 5 years, which means that the results forecast made for 2015 and 2020

2.3. Markov chain model predicted land changes

Markov chains have been used to determine the ability to change the land use change based on the type of land use inputs and factors affecting the change (Nguyen Kim Loi, 2005). Generalization of the model is illustrated in Figure 2.

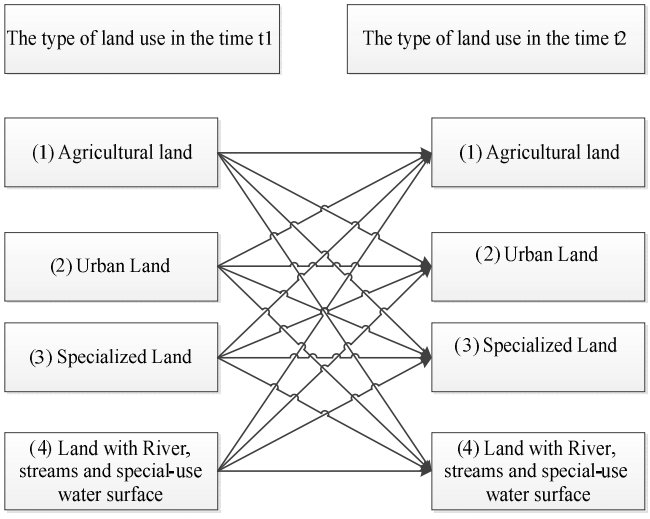

Fig. 2. Generalization of the Markov chain in research

With α_{ij} - the probability of a change from the overlay of the land use map at two different times. To predict the distribution of different types of land use in the next moment can be applied Markov chain model, as follows

[The area of land use at the 2nd time] * [Change percentage of land use] = [The area of land use at the 1st time]

The forecast of the land use change from time to time according to the following mathematical equation:

$$Vt2 = M * Vt1 \quad (1)$$

Where, M - Change percentage of land use during the period of data collection; Vt1 - The area of land use at the first time; Vt2 - The area of land use at the 2nd time.

To perform the forecast, we first need to identify the time period predicted by the following formula (Tran Anh Tuan, 2011):

$$TDB = TCT + (TCT - TCD) \quad (2)$$

Where, TDB - forecast moment; TCT - upper timeline of the assessment process; TCD - the lower timeline of the assessment process.

3. Results and Discussion

3.1. Current land use in 2005 and 2010

According to maps of land use in 2005, the four types of land use, agricultural land accounts for the highest percentage, due to District 2 has a plain topography, soil types mainly gray, stable climate. Besides District 2 is also surrounded by the Saigon River and by the many canals in service for production and irrigation. With a population density of 2005 was 2,513 people/km^2 (HCMC Statistics Office), the area of urban residential land accounts in the second-highest proportion, distributed mainly in the central area of the district, adjacent to the road traffic main. The area of the land for special purposes accounts for the lowest percentage, because this time District 2 has yet to thrive in the trade and services sector, the area of land used for special use is still not high, focusing mainly in industrial areas. The area of the river is mainly belonging to the Saigon River and Dong Nai River. With the structure of the current use of the land in 2005 (Figure 3), District 2 in the future needs to be planned to develop the type of land use, such as land for special purposes and urban residential land for development under way towards industrialization and modernization (NRE Division district 2, 2006).

Meanwhile, in 2010 the proportion of types of land use change markedly, with specialized land accounted for the highest percentage. The reason for the increase is due to the state policy of planning new center of urban areas in three wards near the Thu Thiem tunnel, going through the Saigon River, which are Thu Thiem, An Khanh and An Loi Ward Dong. Urban residential land accounted in the second-highest proportion, distributed in areas similar to 2005 but extended area. Agricultural land occupies the lowest rate, the majority of agricultural land to be transferred to specialized land and urban residential land to serve the changing needs of economic development structure of the county, serving the needs of the residential land people in the region (Fig. 4) (NRE Department district 2, 2011).

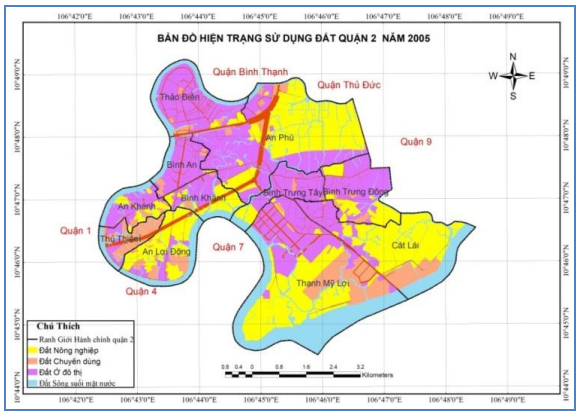

Fig. 3. Land use map of Dist. 2 in 2005

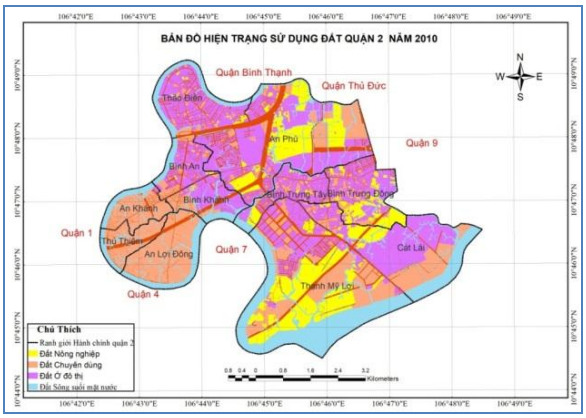

Fig. 4. Land use map of Dist. 2 in 2010

3.2. Land use change in 2005-2010

Agricultural land was significantly reduced and was transferred to another type of land use that is specialized land and urban residential land. This also reflects the orientation of economic development of the district, which is focused on industrial development rather than agricultural services, along with attention to people's lives.

The area of land for special purposes was increased due to the expansion of Cat Lai industrial parks and port, located in the southeast of the county to serve the purpose of economic development; the revoked agricultural land, urban residential land in An Loi Dong Ward, Thu Thiem, An Khanh and to plan for Thu Thiem New Center of Urban Area. In addition to the planning area to build the Thu Thiem new urban area, the land for spcial purposes was also increasing due to development of land for construction of offices, land for construction of non-business facilities and a variety of schools, serving the learning needs of children nearby residents.

Urban residential land area is slightly increased due to an increase in the number of population as well as development of infrastructure, traffic and transport, helping people from other districts to move to District 2 living and working. This promotes the expansion of the urban residential area. Rivers and water land were reduced a little by District 2 posing many canals, so to build the roads throughout, forced to backfill the canal passage unnecessary to roads or bridges. (Table 1, Figure 5)

Table 1. The current status and changes the type of land use at the time of 2005-2010

N	Land use types	2005		2010		Area in 2010 compared with 2005 (+) Increased (-) Decreased
		Area (ha)	Percent (%)	Area (ha)	Percent (%)	
1	NNP	1617.67	32.22	807.17	16.09	-810.5
2	ODT	1401.93	27.96	1543.59	30.75	+141.66
3	CDG	931.84	18.57	1641.26	32.70	+709.42
4	SMN	1066.63	21.25	1026.05	20.45	-40.58
5	Total	5018.07	100	5018.07	100	0.00

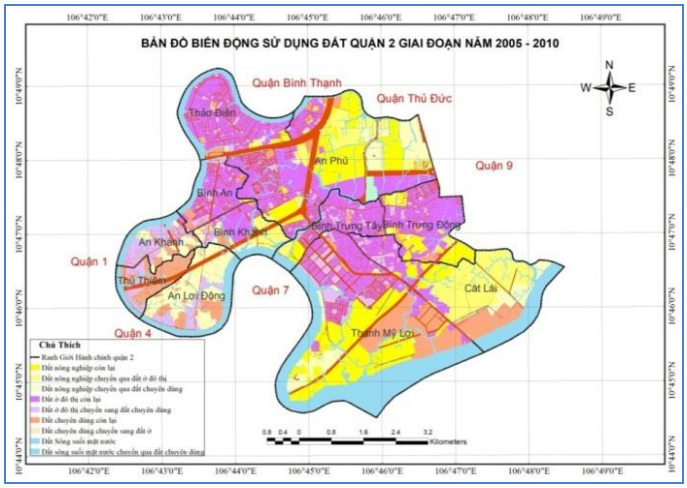

Fig. 5. Map of land use change of Dist. 2 in 2005-2010

3.3. The forecast of land use changes to 2020

Markov chain support assessment for change forecasting in future time. To conduct the change forecast, we need a probability matrix of land use change (Markov matrix). Based on the input data changes every 5 years (2005-2010), the land use for the next 5 years is forecasted (2015, 2020). To forecast land use changes in the future, we conduct multiply probability matrix for land use change in period 2005 - 2010 with the table of the area of land use types in 2010 by the formula (1).

Based on the results of the forecasts to 2020 (Table 2, Figure 6) with particular emphasis on two columns of agricultural land and land for special purposes, we found that agricultural land will be greatly reduced in comparison with 2005, felt to 1415.462 ha (28.21%), instead, land for special purposes will increase at about 1339,884 ha (26.7%), urban residential land will also increase slightly around 194.22 ha (3.87%). The decrease in the area of agricultural land and increase the land for special purposes with urban residential land is due to the process of urbanization. Urbanization has significantly altered land use, conversion of agricultural land into residential land in urban areas, as well as land used for other special activities. Group of land for special purposes use will be strongly increased in the categories of land for production and business. This is also reflected in the economic structure changed in the last 5 years from 2010-2014, showing that District 2 is gradually being industrialization and modernization, shifted from agriculture to business, trade and services. Urban residential land will be increased, reflecting the attractiveness of the population, went on Districts 2 more and more, causing increased urban residential land to meet housing needs for residents.

Table 2. The area of the land use types in four times in 2005, 2010, 2015, and 2020

Land use types	NNP	ODT	CDG	SMN	Total
2005	1617.67	1401.93	931.84	1066.63	5018.07
2010	807.17	1543.59	1641.26	1026.05	5018.07
2015	402.753	1618.722	2009.585	987.01	5018.07
2020	200.961	1599.441	2268.212	949.456	5018.07

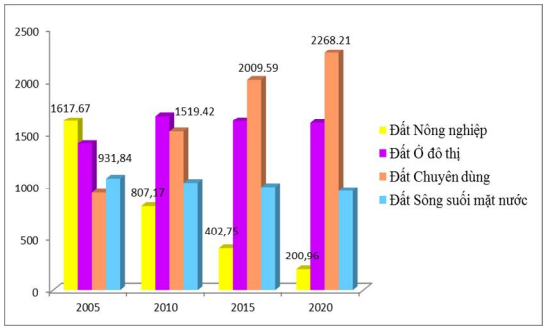

Fig . 6. Chart of the area of land use types in four times in 2005, 2010, 2015, 2020 (Focus on two columns of farmland and specific use)

3.4. Compared to the figures of land use planning by 2020

According to Table 3, we see that the figures forecasted by Markov chains and data of land use planning of Districts 2 to 2020 show the difference not too large. Only the portion of agricultural land, according to planning is no longer, to switch off to residential land and land for special use. However, in the forecast agricultural land still remains but negligible, accounting for only about 4% of the total natural land area. It was explained that planning work is to be considered on the whole the impact factor, from the natural to the economy and society. Meanwhile, the problem of forecasting based on Markov chain based exclusively on the earlier movements to deduce for future change. However, the conditions can not be gathered up all of the inputs and to quickly evaluate the case only outline planning originally envisaged, then this method can result in acceptable.

Table 3. Comparison of forecast results with data of land use planning of Districts 2 to 2020

STT	Land use types	Forecasted data to 2020		Planning data to 2020		Difference between the forecast data with planned results	
		Area (ha)	Percent (%)	Area (ha)	Percent (%)	Bias (ha)	Percent (%)
1	NNP	200.961	4.01%	0	0%	+ 200.961	100%
2	ODT	1599.441	31.87%	1634.59	32.57%	-35.149	2.19%
3	CDG	2268.212	45.2%	2357.93	46.99%	-89.718	3.95%
4	SMN	949.456	18.92%	1025.55	20.44%	-76.094	8.01%
Total		5018.07	100%	5018.07	100%	0.00	

(Sources: Authors and HCMC People's Committee, 2014)

3.5. Solutions for sustainable urban development

This will focus only on 4 solutions as following:

- Economic development
- Improving quality of life
- Improving the environment, urban landscape
- Sustainable urban development

4. Conclusion

The application of GIS to evaluate land-use change is an effective approach, because we are not simply to total up the changes of the area, but also to point out that they fluctuate in the type of land use. Besides the use of Markov chain to forecast more change in long time in the future to help us with more objective view of the solutions proposed land use planning unreasonable, and development sustainable urban. Thereby, we better understand the planning and land use, right or wrong, how influential social economy of a city, a region, a country...

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