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SPATIOTEMPORAL LANDSCAPE PATTERN CHANGE IN RAPID URBANIZATION OF ISKANDAR MALAYSIA

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ABSTRACT

The urbanization process is continuously modifying the pattern of land use and land cover to support human development. Analyzing spatiotemporal land use change is essential for understanding its characteristic and ecological consequences. The study explored the spatiotemporal landscape changes in Iskandar Malaysia region before and after the booming of development. Remote sensing and GIS were used to analyse the spatial changes from 1994 to 2011 and the landscape pattern was analysed using selected matrices in FRAGSTATS software. The findings show that agriculture areas were the major land converted into urban land use. It also changed the water body to urban land and modified the structure of the remaining ecological areas. The landscape pattern of the region will continuously change in accordance to its comprehensive develop plan. The result is important in contributing to a better understanding of the past landscape changes and improve decision-making of land use planning in the region.

1. INTRODUCTION

Land use and land cover changes have removed a lot of natural areas rich in ecological value. However development is needed and it will continuously be spreading out and taking over the natural areas. In fact, it becomes difficult when development continuously penetrated natural areas. On the global basis, almost 1.2-million kilometer square of forest and woodland and 5.6-million kilometer square of grassland and pasture have been converted to other uses (Prato, 2005). Then many wilderness areas have been harvested, river channels have been altered, and changes brought on the important agriculture and forest areas. Artificial development such industrial, residential, commercial and transportation have significantly replaced the natural and agricultural land.

There is significant change in the past decade has that seen the urban growth accelerating with massive immigration of the population to cities. As a result, the urban population is estimated approximately 3.8 billion in 2015 and predicted to reach 5.0 billion in 2030 (United Nation, 2009). The landscape will tremendously change in response to the situation that directly causes a series of environmental problems such as loss of agriculture land, appearance of heat island effect, edge effect, altering of hydrological characteristic and reduction of biodiversity (Collinge, 1996; Levin et al., 2007; McDonald et al., 2009; Vergara et al., 2009 and Han, 2009). The rapid land use change impairs the serenity of natural areas and causes various impacts on ecosystem structure, function and dynamics (Ting et al., 2008 and Yang et al., 2011). In regard to this, the purpose of this study is to analyze the spatiotemporal landscape changes in the area of Iskandar Malaysia region, Johor.

2. EXPERIMENT

2.1 Experimental Apparatus

The study area is at the southern part of Iskandar Malaysia Region. It covers 221 634.1 hectares (2 216.3 km square) of land area within the most southern part of Johor (Figure 1). The area is planned as the most comprehensive development area by the federal government of Malaysia. Iskandar Malaysia region itself is located of the Straits of Johor (Selat Tebrau), which separates Malaysia and Singapore. It has large coastal land with ecologically rich swamplands and important river systems such as Sungai Pulai, Sungai Tebrau and Sungai Johor. The area is selected because now it is facing a comprehensive development and significant impact on the landscape changes in the last two decades. A lot of existing natural and agricultural land cover have been converted into anthropogenic land cover.

Figure 1: Iskandar Malaysia region and the analysis zone.

2.2 Methodology and Technique

There are several stages in the framework of the research (Figure 2). The first stage of the study is to identify the conceptual model for analyzing the data. This model is applied to the study area and referred to analysis of the study and probability of the data availability. Section 2.2.1 and 2.2.2 discuss details about the method of analysis involved and process in the study.

2.2.1 Landscape changes analysis

The establishment of data in the study used satellite images (SPOT images). The processing and classification of land cover were done using ERDAS Imagine. Then the landscape changes analysis in the Iskandar Malaysia is analyzed by using spatial analyst function in ArcGIS. ArcGIS 10 software is used to evaluate the changes of land cover from 1994 to 2002 and 2002 to 2011. The raster overlay is used to trace the land conversion from the past to the latest year. The location and the period of the changes are detected from the analysis. In fact the type of land cover transformation is also traced in this analysis. The different value of the temporal land cover data is calculated using Raster Calculator.

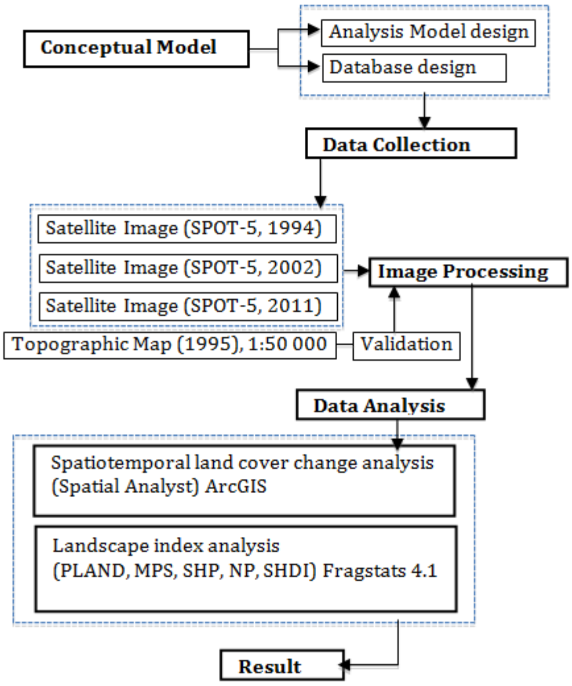

Figure 2: The methodology framework of the study

2.2.2 Landscape pattern analysis

Another analysis of the study is to measure the changes of the landscape structure in the study area. The temporal changes of the natural areas were analyzed by using landscape matrices. The analysis shows the percentage of landscape (PLAND), number of patches (NP), mean patch size (MPS), shape index (SHI) and shannon's diversity index (SHDI) of ecological areas throughout the years. Fragstat 4.1 software is used to run the analysis and the transition change is shown in table.

3. ANALYSIS AND RESULT

3.1 Landscape changes

The spatiotemporal analysis of land cover change in the study area shows a significant transformation from natural areas and agricultural area into built up areas. In 1994 to 2002, agricultural is the major landscape converted into built up area with total of 953.46 hectares, which is 90.97% of the whole conversion area (Figure 3a and Table 1). Meanwhile the amount of natural areas converted into built up areas is 953.46 hectares, which is 3.29% from the total of conversion for the study period. Then, the critical conversion of land cover happened in 1994 to 2002 where the conversion is from water body to built up areas. The changes happened due to the development of a port that replaced the natural areas and water body.

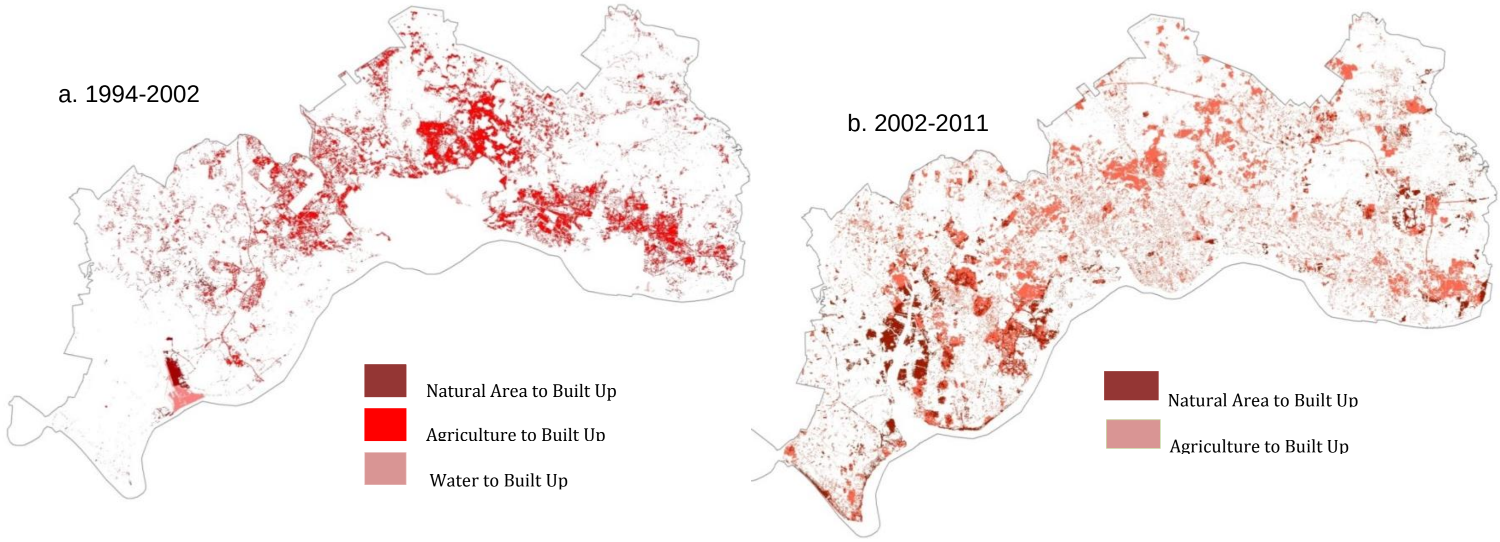

Figure 3: Spatiotemporal of the landscape changes characteristics (a. 2010-2002, b. 2002-2011)

The percentage of the conversion from water body to built up areas is only 3.29% from the total of land conversion but it covered 546.48 hectares. This landscape change put the ecological area in different level of stability.

Table 1: The statistics of temporal changes of land cover in the study area.

Land Cover Change	1994 -2002		2002-2011	
	%	Hectares	%	Hectares
Agriculture to Built Up	90.97	15109.12	61.01	20748.29
Natural to Built Up	5.74	953.46	38.99	13262.49
Water to Built Up	3.29	546.48		
Converted Area	100	16609.05	100	34010.79
Converted Area/Total Area	12.57	132105.51	25.75	132105.51

In the next period, rapid development in 2002-2011 continuously changed the landscape characteristics of the study area. The conversion directly reduced the agricultural and natural areas. The total of the converted area in 2002-2011 is 34010.79 hectares and the biggest land conversion is agriculture (Figure 3b and Table 1). Agriculture is the main area removed by development with a total of 20748.29 hectares, which is 61.01% of the total converted area. The total of natural areas converted to built up is 13262.49 hectares which is bigger than the conversion of natural areas in the past period. The rapid transformation of the development in the study area has tremendously reduced the natural areas.

3.2 Landscape Index Analysis

The development of Iskandar Malaysia has significantly reduced the natural areas and changed the landscape structures of the remaining natural areas. Throughout the years, the natural areas become more fragmented and the transformation also changed the sizes and shapes of the remaining natural areas. In fact, the diversity of the landscape matrix is different because of the land use change at the surrounding of the natural areas. All these factors are described in the landscape index in Table 2.

Table 2: The temporal change of natural landscape structures of Iskandar Malaysia region in 1994, 2002 and 2011.

Land. Index	1994	2002	2011
PLAND (%)	23.13	18.17	11.13
NP	62	20183	31221
MPS	218.83	1.187	0.9787
SHI	2.04	1.26	1.28
SHDI	0.95	1.44	1.3119

In 1994, the percentage of natural landscape in the study area is 23.13%, however it has a significant changed and was reduced into 18.17% in 2002. However, a bigger changed was happened within 2002 and 2011 where the remaining natural landscape areas was only 11.11% from the whole study area. It shows the conversion from 2002 to 2011 converted 7.04% of the natural areas into anthropogenic land use and is higher than the conversion in the previous period (1994-2002). Thus, it shows big natural areas were substitude in the last period for the anthropogenic development.

Meanwhile, the number of patches (NP) of the natural landscape in 1994, 2002 and 2011 is 62, 20183 and 31221 respectively. It clearly shows that natural landscape areas become more fragmented throughout the years. The landscape structure changes directly influenced the stability of landscape function especially on the ecological network which affects the metapopulation, predator-prey and the nutrient stability. Moreover the mean patch size (MPS) also reduced from 218.83 hectares in 1994, 1.26 hectares in 2002 and 0.9787 hectares in 2011. It shows the size of the natural areas become smaller and it creates another pressure on the landscape function in the natural areas. This relates to another landscape index that shows a big change of natural areas in study area. The shape index (SHI) in 1994, 2002 and 2011 is 2.04, 1.26 and 1.28 respectively. It shows the shapes of the natural landscape pattern have changed from time to time which is affected by anthropogenic development. The development has manipulated the shape of natural areas that remain the natural areas unstable for ecological function. The size and shape of the natural landscape is important because it influences the stability of the ecological activities. Moreover the persistence of the natural areas toward edge effects strongly depends on the size, shape and their land use context.

Meanwhile, at the landscape level, the index shows the diversity of the landscape from the past to the latest year. In 1994, SHDI is 0.95 which shows the low diversity of landscape of the study area. Then in 2002, the diversity value has increased to 1.44 and shows the development has changed the landscape of the study area by spreading out new built up areas. The index is quite similar in 2011 whereby the value is 1.33 and shows quite a similar pattern of landscape in 2002.

4. CONCLUSION

In conclusion, the study has revealed the consequences of the development in terms of the landscape changes. It is apparent that the development will keep changing the existing landscape. The changes directly put pressure on the ecological elements. Thus the interaction between the remaining landscape and built up area is another issue that needs to be noted. The multidisciplinary research and integrated approach is highly required in studying the ecology stability of the remaining ecological patches with regard to land use change. The gaps between decision, action and results can be managed by having this kind of integrated spatial dynamic modelling. It is very important for future generation of method be used for a better decision-making process in more complex landscape resource planning.

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