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Quantification of Green Space Landscape Structure for Sustainable Land Use Planning in Pasir Mas, Kelantan

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Abstract. Globally, the amount of green space in urban areas has significantly decreased because of fast urban expansion. Urbanization may modify the spatial structure of a landscape and have an impact on its ecological function. The research aims to quantify the landscape structure changes of green space in the years 1994, 2004, and 2014 in Pasir Mas using remote sensing, GIS and landscape ecology approach. Three satellite images were classified into five land use land cover (LULC) which are forest, agriculture area, cleared land, water bodies and built-up area. The results show that the highest percentage of area in year 1994 is forest followed by agriculture, built up area and water bodies. However, in year 2014 the percentage of land use are vice versa. In the period from 1994 to 2004, 1.92% of forest was converted into built up areas in Pasir Mas district. However, in the period of year 2004 to 2014, the percentage of forest area that has been converted into built up area is increase about 4.32%. Forest shows significance increase in the transition into agriculture area by 49.63% in the year of 1994 and 2004. For the period of year 2004 and 2014, the conversion of forest area into agriculture area also in high percentage which is 17.66%. Landscape structure changes analysis show that there are significant changes of Euclidean nearest neighbour distance (MNN) indicating that there is fragmentation and isolation between patches. Similarly, the size and shape of forest patches also decreased indicating by percentage of area (PAREA) and landscape shape index (LSI). Therefore, using remote sensing, GIS, and landscape ecology, this project will help understand the spatial structure of green space and the impact of urban expansion in Pasir Mas, Kelantan, in order to give the knowledge necessary for sustainable land use planning.

1. Introduction

Nowadays, the world has experienced urbanization at an accelerating pace in the last century. Given that urban regions are home to more than 50% of the world's population, the process of urbanization has accelerated throughout time [1]. Urbanization can create significant changes in the spatial structure and biological landscape function, such as fragmentation [2]. Landscape fragmentation is Landscape fragmentation is the human activity that consists of the process of fracturing up a regular ecosystem, land use type, biota or habitat [3]. The process of fragmentation is also one of the major causes that can affect the green space area in environment and its ecosystem inside it [4]. In order to mitigate the impact

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of urbanization towards environment, landscape ecology is the significant way to explain all the inter linkage of economic, sociological, cultural and also ecological factors.

One approach that focuses on the urbanization process and examines changes to the landscape's structure is landscape ecology [5]. Set of metrics can quantified a lot of spatial landscape properties. From this perspective, the characterization of urban process and the consequences towards green space area can be facilitate accurately by using the spatial landscape metrics [5]. Landscape metrics are widely used to quantify landscape patterns and their changes. For example, [6] evaluate the urban expansion according to diversity, shape complexity, fragmentation and landscape area. Green space area can supply the ecosystem services that can benefits the human population by upgrading their health in the safe environment [7]. For instance, the trees that have been planted in development area can diminish the emission of pollutant such as carbon dioxide by absorbing those airborne pollutants from the atmosphere. However, according to [8], as of 2010, Malaysia has 1.5% of annual average growth rate. From this context, the increase of population and urbanization issue will lead to the limitation of green space area.

The increase in landscape fragmentation will reduced the green space area. From the fragmentation process, the number of the patches that available in that area will also decreased. The reclamation and evolution of ecosystems will be affected directly by the process of fragmentation. This will result in the enhancement, displacement and elimination of species populations [9]. Besides from being able to raise the landscape fragmentation process, urbanization also can erase the green space area [10]. Furthermore, the fragmentation process can contribute to the rise of the habitat isolation and reduce the connectivity in certain urban area [11]. The results of this study may help plan future urban green space management to shape the concept of sustainability in congested cities [12]. Moreover, it also can provide the better understanding in term of landscape ecological perspective in order to form green networks and increase the connectivity [9][13].

This study aims to fill a knowledge gap and show land use components as networks of spatial structures and patterns of green spaces. This research will directly meet the need of economy, social and physical of resident well-being [14]. There is lack of empirical evidence of qualitative and quantitative analysis of data in the previous research. The result of finding from this research would produce significant evidence on the green space quality that affected by the urban expansion and at the same time can assist to a better design and planning of green space area in the cities of Malaysia especially in Pasir Mas, Kelantan. Therefore, the objectives of this study are i) to quantify the landscape changes of urban expansion and green space area of year 1994, 2004, and 2014 in Pasir Mas, Kelantan and ii) to determine the landscape structure pattern of urban expansion and green space of year 1994, 2004, and 2014 in Pasir Mas, Kelantan.

2. Materials and Methods

2.1 Study Area

Kelantan is one of the states in the northeastern part of Peninsular Malaysia and its capital is Kota Bharu. The state consists of 10 districts: Kota Baru, Pasir Mas, Tumpat, Bachok, Pasir Puteh, Tanah Merah, Kuala Krai, Guamsan, Machan and Jeri. Kelantan occupied 15,099 km2 of land. In 2011, the state's total population was 1.6 million, with an average annual population growth rate of 1.6%. The state's population consisted of several ethnic groups. Malay (95%), Indian (3%), Chinese (1.9%), others (0.1%). Unlike the west coast of Malaysia, Kelantan has not experienced rapid industrialization and consequent economic growth. Based on official portal of [15], Pasir Mas is in the north of Kelantan. It is bordered by Tumpat to the north, Tanah Merah to the south, Sungai Kelantan and Kota Bharu to the east, and Sungai Gorok of Thailand to the west. The area is comprised of flatlands mostly. Pasir Mas town is connected to the main road linking the state capital to Bandar Sungai Golok, Thailand. The road is also the main road link to Kota Bharu for states on the East Coast. Located on Malaysia's east coast, the city serves as a major gateway to Thailand and crosses important transport routes from the west coast. Pasir Mas District originally belonged to Kota Bharu District. In 1918, the town of Pasir Mas and its surroundings was separated from Kota Bharu and given its own local government. The main factor in the selection of the Pasir Mas as a study area is that it was one of the developing districts in Kelantan and experiencing rapid urban expansion. Based on 2010 data, Pasir Mas District Council has a total population of about 185,741 residents, which is the second largest district in Kelantan after Kota Bharu. The density is 300/km^2 (30000 Ha) and the coordinate of Pasir Mas district is 6.0424° N, 102.1428° E.

2.2 Data Collection/Acquisition
Satellite images of Landsat 8 OLI/ TIRS C1 Level 2 and Global Land Survey resolution image of year 1994, 2004 and 2014 were downloaded from the United States Geological Survey (http://www.usgs.gov/) [11].

Three geocoded satellite images were processed using ERDAS Imagine 2014 and ArcGIS 10.5 to map the Pasir Mas district in 1994, 2004 and 2014. A land cover map (LULC) was generated and extracted based on area of interest from image boundaries of Global Administrative Area (http://www.gadm.org/). Furthermore, the selection of a satellite image needs to be emphasized. The satellite images that have been chosen must have a good quality and less cloud coverage around it for all three selected years which are 1994, 2004 and 2014. This is because higher resolution imagery provides more accurate results when performing landscape analysis of urban green spaces [11]. The maps were classified into five land use and land cover types (forest, agricultural land, cleared land, water bodies, and built-up areas) using the ERDAS Imagine 2014 supervised classification. Google Earth was used as a reference for classification. We performed ground truth validation using fieldwork to assess the accuracy of the generated land-use maps [16][17]. Then, stratified random sampling method was used to validate the samples for each class. Accuracy assessment produced statistical outputs to check the quality of the classification results [18][19]. In this method, 40 points were assigned to each land use to avoid maldistribution [11]. Raster data was converted to vector format using ArcGIS. Finally, we analyzed the LULC map to study the evolution of the spatial pattern of green spaces.

2.3 Landscape Change Analysis
Percentage area for each class were determined using change detection analysis in ArcGIS software. For spatial change, the amount of areas in hectares for each class was calculated in order to find the percentage of area in year 1994, 2004 and 2014. Next is the transition of metrics. For this analysis, maps from two different years were overlaid and converted by land use to create an attribute table. This process will compare each class that available for the year 1994 to 2004 and year 2004 to 2014.

2.4 Landscape Structure Analysis
Six landscape structure analysis metrics were selected, such as Euclidean nearest neighbor distance (MNN), mean patch area (MPA), patch density (PD), landscape shape index (LSI), percent area (PAREA) and largest patch index (LPI). All the spatial metrics were calculated using FRAGSTATS [20]. The fragmentation of green space area due to urbanization was quantified using MPA, PD, and PAREA. A landscape with low MPA values and high PD values indicates a landscape with many small, fragmented patches. These landscape metrics can be used to show changes in characteristics such as patch isolation, shape, and size in green space landscapes [11].

2.5 Statistical Analysis
For statistical analysis, the patch level metrics data was computed into SPSS software. Then, information was tested by normality test to determine the next analysis. According to the landscape metrics, this research will relate the significant changes at the level of landscape for each year of 1994, 2004, 2014 in Pasir Mas Kelantan by using one way ANOVA analysis. In this method, area and ENN is used as the dependent variable while the class name is independent variable.

3. Results and Discussion

3.1 Landscape Change Analysis

In the year 1994, built-up area shows 8.63% followed by the decreasing of area to 6.05% in year 2004. However, the area increases to 8.30% in year 2014. For the cleared land, the area of percentage increase rapidly between year 1994 and 2004 which are 5.17% and 30.16% respectively. Then, in the year 2014, it shows a little decrease which is 21.24%. Agriculture area shows a uniform pattern of increasing percentage of area for year 1994, 2004, and 2014 which are 22.42%, 40.56% and 64.98% respectively. Water bodies present the least percentage of area between all five classes. In year 1994 the area is 3.61%. For year 2004, it increases for 5.98% but decrease to 4.88% in year 2014. There are also significant changes in the percentage of area for forest as it is 17.60% in 1994 and slightly decreases to 17.25% in year 2004. However, it gradually decreases to 43.15% in the year 2014 (Figure 1).

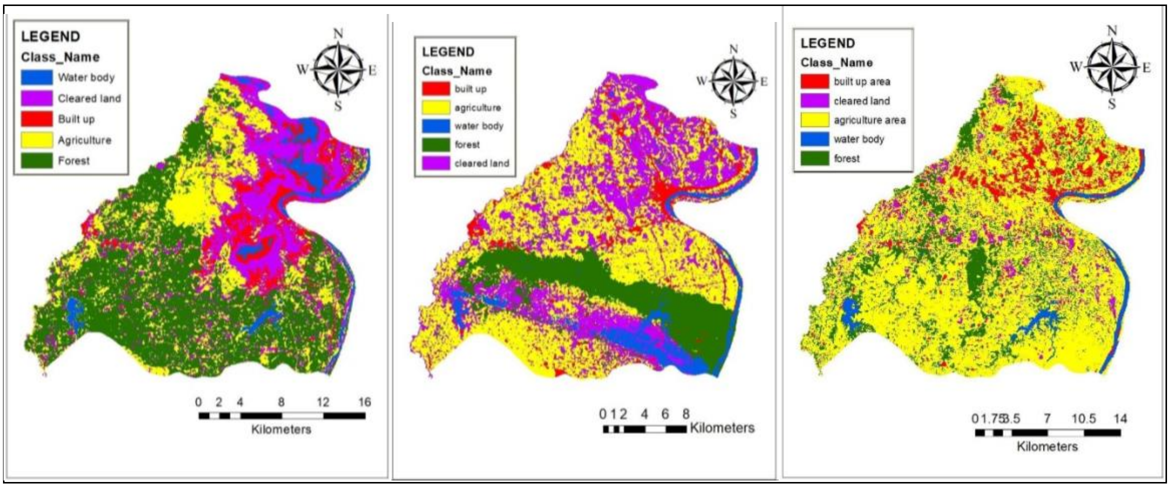

Figure 1. Land use map of Pasir Mas, Kelantan in year 1994, 2004, 2014.

In the period from 1994 to 2004, there are about 1.92 of forest was converted into built up areas in Pasir Mas district (Table 1). However, in the period of year 2004 to 2014,the percentage of forest area that has been converted into built up area is increase for about 4.32% (Table 2). Forest shows significance increase in the transition into agriculture area by 49.63% in the year of 1994 and 2004. For the period of year 2004 and 2014, the conversion of forest area into agriculture area also in high percentage which is 17.66%. In period of year 1994 to 2004 and 2004 to 2014, the percentage of area that was converted from green space area which is forest into cleared land is quite high which are 21.03% and 13.67% respectively. Furthermore, the percentage of cleared land that changed into built up area is 11.37% and 7.61& for year 1994 to 2004 and 2004 to 2014 respectively.

For the Pasir Mas district, the urbanization process does not give the significant impact towards the green space area. This is contradicted to the study of previous research that process of urban expansion can lead to the decreasing of green space area [11]. This shows that the green space area in Pasir Mas is basically not converted into development of built-up area but more to the agricultural activity and cleared land. However, the cleared land that is formed from the reducing of forest can be one of the urbanization processes in that particular area. Land that has been cleared might be transformed into development activity in the future. This process will indirectly contribute to the formation of urban areas.

Table 1. The transition for all the classes of year 1994 & 2004.

Transition of Year 1994 And 2004										
2004	Built up Area		Cleared Land		Forest		Water Bodies		Agriculture	
1994	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%
Built up Area	933.54	18.18	2821.92	54.96	1015.55	19.78	130.47	2.54	232.81	4.53
Cleared Land	349.84	11.37	829.97	26.99	1544.01	50.22	42.10	1.37	308.27	10.03
Agriculture	2051.68	5.31	11713.15	30.31	16244.53	42.04	1674.54	4.33	6960.35	18.01
Water Bodies	61.39	2.85	371.49	17.29	120.39	5.60	1453.16	67.63	142.17	6.62
Forest	200.82	1.92	2201.21	21.03	5194.89	49.63	254.19	2.43	2615.82	24.99

Table 2. The transition for all the classes of year 1994 & 2004

Transition Of Year 2004 And 2014										
2014	Built up Area		Cleared Land		Forest		Water Bodies		Agriculture	
2015	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%
Built up Area	1257.92	34.97	1151.43	32.01	489.29	13.60	119.49	3.32	579.12	16.10
Cleared Land	1365.19	7.61	4979.66	27.76	5175.76	28.85	1078.90	6.01	5338.22	29.76
Agriculture	1831.95	7.60	4680.12	19.40	5402.63	22.40	470.51	1.95	11734.15	48.65
Water Bodies	39.95	1.12	418.03	11.76	453.02	12.75	1192.57	33.55	1450.87	40.82
Forest	443.59	4.32	1402.46	13.67	1812.13	17.66	42.47	0.41	6558.76	63.93

This study looks at how different variables, such as green space change and sequence, have an impact on the process of urbanization. The green space area does not necessarily transform into built up area only but also can convert into the other source.

3.2 Landscape Structure Analysis

In order to represent area and perimeter (or edge) at the patch, class, and landscape levels, FRAGSTATS computes a number of straightforward statistics. Depending on the landscape context, the patch density (PD) of a specific habitat type may influence a number of biological processes. The quantity or density of patches can also affect prospects for coexistence in predator-prey and competitive systems, as well as the stability of species interactions [22]. Mean patch size and patch density are functions of total landscape area and the number of patches at the landscape level. The perimeter-to-area ratio for the entire landscape is measured by the Landscape Shape Index (LSI). The Euclidean nearest neighbour distance (ENN) has been widely utilised to evaluate patch isolation since it is arguably the most basic way to gauge patch context. The nearest neighbor distance is measured using Euclidean geometry, which determines the shortest straight-line distance between the focal patch and its nearest neighbor of the same class [22].

For the landscape level, the value of PD decreases from year 1994 to 2014. As for the LPI metrics, the percentage is decrease from year 1994 to 2004 but increases back in year 2014. Furthermore, LSI value shows the constant decline fromyear 1994 to 2014. By contrast, the MPA value of year 2004 is increase from the previous in 1994 but slightly lessen in 2014. For MNN, the highest value recorded in 2004 and the lowest is in year 1994 (Figure 2).

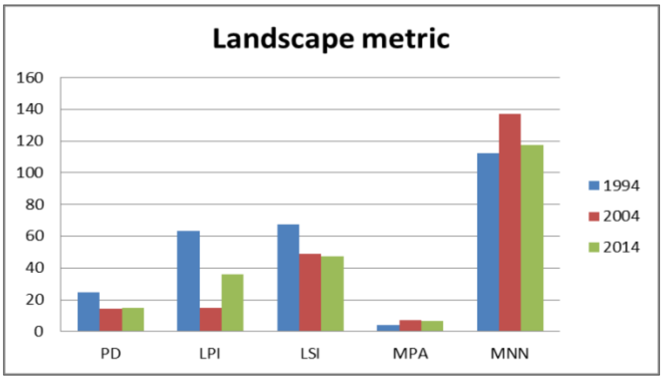

Figure 2. Landscape level metrics (Patch density (PD), Mean patch area (MPA), Landscape shape index (LSI), Largest patch index (LPI), Euclidean closest neighbour (MNN), and Patch Area (PAREA)) comparisons for each class from 1994 to 2004 and 2004 to 2014.

At the class level, patch density (PD) of year 1994 shows the highest value for forest area which is 8.64 followed by built up area (6.62), cleared land (6.06), agriculture area (2.30) and the last is water body (1.14). For the year 2004, cleared land show the greatest value of PD which is 6.05 and water body as the least value which is 0.45. Year 2014 also shows the cleared land and water body class that have the highest and lowest PD value which are 6.72 and 0.17 respectively. Mean patch area (MPA) of year 1994 recorded agriculture as the biggest area of hectares (28.41 ha) while cleared land is the lowest (0.83 ha). Year 2004 also shows agriculture asthe highest MPA and built up as the lowest area which are 15.51 ha and 2.57 ha respectively. Largest patch index (LPI) of agriculture area is the highest percentage while cleared land is the lowest percentage in year 1994. However, in year 2004, the percentage of LPI of cleared land is increased from 0.12 % in year 1994 to 9.97% and eventually 11.63% in the year 2014. Landscape shape index (LSI) for forest in year 1994 is 85.85 m/ha decreases into 21.82 m/ha in 2004 and lastly increases back to 37.77 m/ha in 2014. Last metric is Euclidean nearest neighbour (MNN) that recorded the highest value 2225.08 m for water body in 1994 and decrease into 180.51 m and 101.69 m respectively in 2004 and 2014.

All the metrics that available in this study provide difference output of result. Patch density (PD and mean patch area (MPA) are related to each other. For example, when the PD value is high and the (MPA) is low, fragmentation processwill occur. If the condition is vice versa, the process that occurs is aggregation. Whenboth PD and MPA decrease, the land of the area experienced loss of patches. The greater of largest patch index (LPI) will show the high activities that occur in that particular area.

Different patterns of changes in general landscape structure were discovered when comparing the three years at various scales, cities, and years in response to rapid urban expansion, policies, and population density [11]. The formation of master planning and policies in the cities is tied to the various sizes, levels of fragmentation, and concentrations of landscape elements present in the Pasir Mas district.

3.3 Statistical Analysis

For the comparison of patch metrics, the statistical analysis has been used in order to get the significant result of ANOVA test. First and foremost, the normality test needs to be conducted to determine whether the distribution is normal or not. Thedependent variable that used is area and ENN while class name is the independent variable. After the normal distribution is justified, the one-way ANOVA test can be done to analyse the significant result. The P value of Area show no significant changes (>0.005) in 1994, 2004 and 2014 however ENN show significant changes of P value (<0.005). Therefore, landscape structure changes analysis shows that there are significant changes of Euclidean nearest neighbour distance (MNN) indicating that there is fragmentation and isolation between patches. Similarly, the size and shape of forest patches also decreased indicating by percentage of area (PAREA) and landscape shape index (LSI).

4. Conclusion and Recommendation

As a conclusion, the objectives of this study to quantify the landscape changes and determine the landscape structure pattern of urban expansion and green space of year 1994, 2004, and 2014 in Pasir Mas, Kelantan were achieved. The decrease of forest and its transition into agriculture show the impact of human activity on green space. These lead to the landscape structure changes indicating by the process fragmentation and isolation between patches and gradually effect the ecological functioning of the landscape. Therefore, this study will aid the understanding of the spatial structure of green space and the impact of urban expansion in Pasir Mas, Kelantan by using remote sensing, GIS and landscape ecology in order to provide the information for sustainable land use planning. This study can contribute the future sustainability practices by the creation and upkeep of a network of green spaces in urban settings. This could help sustain or enhance the ecological networks and functions that are now in place for the provision of ecosystem services in fast increasing urban areas.

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