QUANTIFICATION OF GREEN SPACE LANDSCAPE STRUCTURE FOR SUSTAINABLE LAND USE PLANNING IN PASIR MAS, KELANTAN

by

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A final year project report submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (Sustainable Science) with Honours

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THESIS DECLARATION

I declare that this thesis entitled "Quantification of Green Space Landscape Structure for Sustainable Land Use Planning in Pasir Mas, Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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

ABSTRACT

Globally, rapid urban expansion has caused a significant decline of green spaces in the urban areas. Urbanization can lead to the variation of the spatial structure and causes serious changes in term of the landscape ecological function. This study intends to fill the gap in knowledge to reveal the land use components as networks of social area also the spatial structure and pattern of green space. The research objectives are to quantify the landscape changes of urban expansion and green space area of year 1994, 2004, and 2014 in Pasir Mas, Kelantan and to determine the landscape structure pattern of urban expansion and green space of year 1994, 2004, and 2014 in Pasir Mas, Kelantan. The method that has been used is the landscape change, landscape structure and statistical analysis by using the software such as ERDAS Imagine, ArcGIS, FRAGSTAT and SPSS. Three raw satellite images were extracted for year 1994, 2004 and 2014. The classification of land use land cover (LULC) was based on five types of the area which are forest, agriculture area, cleared land, water bodies and built-up area. This study resulting in the changes between the percentages of area for every class. For Pasir Mas district the highest percentage of area is agriculture while water bodies are the lowest among five classes. Six metrics for landscape structure analysis were selected such as Euclidean nearest neighbour distance (MNN), mean patch area (MPA), patch density (PD), landscape shape index (LSI), percentage of area (PAREA), and largest patch index (LPI) in order to represent the changes of characteristics such as patch isolation, shape and size in green space landscape. In a nutshell, this study will aid the understanding to provide the first and latest statistical representation of data tracking of urban expansion in Pasir Mas, Kelantan by using GIS and remote sensing application in order to produce the land use map as the final output.

Kuantifikasi Struktur Kawasan Landskap Hijau untuk Perancangan Penggunaan Lestari di Pasir Mas, Kelantan.

ABSTRAK

Di peringkat global, perkembangan bandar yang pesat telah menyebabkan kemerosotan ruang hijau yang ketara di kawasan bandar. Perbandaran boleh membawa kepada perubahan struktur ruang dan menyebabkan perubahan serius dalam fungsi ekologi landskap. Kajian ini bertujuan untuk mengisi jurang dalam pengetahuan untuk mendedahkan komponen penggunaan tanah sebagai rangkaian kawasan sosial juga struktur spasial dan corak ruang hijau. Objektif penyelidikan adalah mengukur perubahan landskap pengembangan bandar dan ruang hijau tahun 1994, 2004 dan 2014 di Pasir Mas, Kelantan dan untuk menentukan corak struktur lanskap pengembangan bandar dan ruang hijau tahun 1994, 2004, dan 2014 di Pasir Mas, Kelantan. Kaedah yang digunakan ialah perubahan landskap, struktur landskap dan analisis statistik dengan menggunakan perisian seperti Imagine ERDAS, ArcGIS, FRAGSTAT dan SPSS. Tiga imej satelit telah diekstrak untuk tahun 1994, 2004 dan 2014. Pengkelasan adalah berdasarkan lima jenis kawasan iaitu hutan, kawasan pertanian, tanah yang dibersihkan, kawasan air dan kawasan pembangunan. Kajian ini menghasilkan perubahan antara peratusan kawasan untuk setiap kelas. Bagi daerah Pasir Mas, kawasan peratusan tertinggi adalah pertanian manakala kawasan air adalah yang paling rendah di antara lima kelas. Enam metrik untuk menganalisa struktur landskap telah dipilih seperti MNN, MPA, PD, LSI), PAREA dan LPI untuk mewakili perubahan ciri-ciri seperti pengasingan tampalan, bentuk dan saiz dalam landskap ruang hijau. Secara ringkas, kajian ini akan membantu pemahaman untuk menyediakan perangkaan statistik terkini bagi pengesanan data pengembangan bandar di Pasir Mas, Kelantan dengan menggunakan aplikasi GIS dan penginderaan jauh untuk menghasilkan peta penggunaan tanah sebagai hasil akhir.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
GIS	Geographic Information System
ERDAS	Earth Resources Data Analysis System
UHI	Urban Heat Island
ENN	Euclidean Nearest Neighbour
PD	Patch Density
LSI	Landscape Shape Index
LPI	Largest Patch Index
MPA	Mean Patch Area
PAREA	Patch Area
LULC	Land Use Land Cover
USGS	United States Geological Survey
GADM	Global Administrative Areas

LIST OF SYMBOLS

%	Percentage
m	Metre
ha	hectares

CHAPTER 1

INTRODUCTION

Nowadays, the world has experienced urbanization at an accelerating pace in the last century. As more than 50% of the world's inhabitants live in urban areas, the process of urbanization has become rise rapidly over time (Wu, 2014). A report titled 'Landscape Urban Changing Urban East Asia: Measuring the Spatial Growth Decade' shows that Malaysia is one of Asia's more populous countries. There are many impacts of urbanization towards green space area.

Urbanization can lead to the variation of the spatial structure and at the same time will causes serious changes in term of the landscape ecological function (Faculty, 2003). Landscape fragmentation is one of the impacts that take serious attention. Landscape fragmentation is the human activity that consists the process of fracturing up a regular ecosystem, land use type, biota or habitat (Dobbs, Escobedo, & Zipperer, 2011a). The process of urbanization is also one of the major cause that can affect the green space area in environment and its ecosystem inside it (Adegun, 2017). In order to mitigate the impact of urbanization towards environment, landscape ecology is the significant way to explain all the inter linkage of economic, sociological, cultural and also ecological factors.

Landscape ecology is one of the approaches that targets on the process of urbanization and analyse the changes that occur in the landscape structure (Aguilera, Valenzuela, & Botequilha-leitão, 2011). 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 (Aguilera et al., 2011).

Landscape metrics have been extensively used for quantifying landscape patterns and their change. For example, Luck & Wu (2002) evaluate the urban expansion according to diversity, shape complexity, fragmentation and landscape area. From this context, the urbanization issue will lead to the limitation of green space area. There are lot of importance in maintaining green space area.

Green space area can supply the ecosystem services that can benefits the human population by upgrading their health in the safe environment (Wolch, Byrne, & Newell, 2014). 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.

1.1 Background of study

According to 'Malaysia among Most Urbanized Countries in East Asia' report (2015), Malaysia has the fourth-largest amount of built-up land in East Asia as of 2010. Its urban land grew from about 3,900 square kilometers to 4,600 between 2000 and 2010, an average annual growth rate of 1.5%, which was lower than the 2.4% average for the region. Urban areas were, on average, among the least dense in

East Asia, with an overall urban population density of 3,300 people per square kilometer in 2010, up from 2,600 in 2000, and lower than the regional average of almost 5,800 people per square kilometer. 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 decrease.

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 (Tian, Jim, Tao, & Shi, 2011). Besides from being able to raise the landscape fragmentation process, urbanization also can erase the green space area (Kong, Yin, Nakagoshi, & Zong, 2010). Furthermore, the fragmentation process can contribute to the rise of the habitat isolation and reduce the connectivity in certain urban area (Nor, Corstanje, Harris, Grafius, & Siriwardena, 2017).

The finding of this study could be useful for the planning of future urban green space area management to form the sustainability concept in the crowded city (Heacock & Hollander, 2011). Moreover, it also can provide the better understanding in term of landscape ecological perspective in order to form green networks and increase the connectivity (Tian et al., 2011).

1.2 Problem Statement

Rapid urban development usually happens at the expense of prime agricultural land, with the destruction of natural landscape and public open spaces, which has an increasing impact on the global environmental change (Niemelä, 2014). This indicates possible urban sprawl and an alarming rate of urbanization on the green space.

This study intends to fill the gap in knowledge to reveal the land use components as networks of social area also the spatial structure and pattern of green space. This research will directly meets the need of economy, social and physical of resident well-being (Bhatta, 2010). 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.

1.3 Research Objectives

The research objectives of this study are as follows:

- To quantify the landscape changes of urban expansion and green space area of year 1994, 2004, and 2014 in Pasir Mas, Kelantan.
- To determine the landscape structure pattern of urban expansion and green space of year 1994, 2004, and 2014 in Pasir Mas, Kelantan.

1.4 Scope of Study

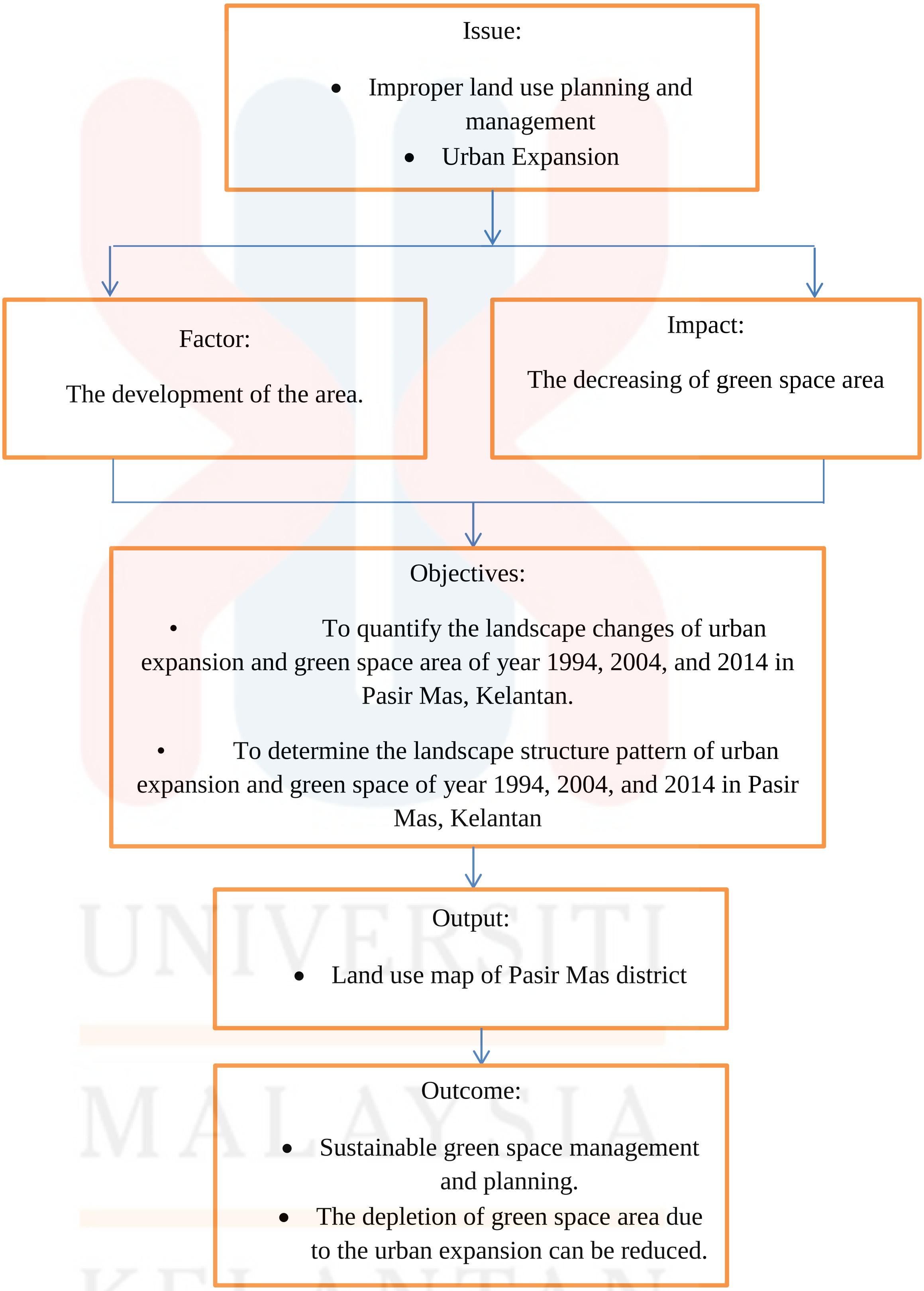


Figure 1.1: Research framework of the study.

This study will focused on quantification of the landscape changes and to determine the landscape pattern of urban expansion and green space in Pasir Mas, Kelantan. The study analyses the landscape change in a series of the year starting from 1994, 2004 to 2014 by using remote sensing and GIS application.

1.5 Significance of Study

In this research, an attempt has been made as one of the contributions to investigate the usefulness of the spatial techniques, remote sensing, and GIS for urban sprawl detection and handling of the spatial and temporal variability (Wolch et al., 2014) . Classified images have been used to understand the dynamics of urban sprawl and to extract the area of impervious surfaces. Remote sensing and GIS techniques have been used to extract the information related to urban expansion (Plexida, Sfougaris, Ispikoudis, & Papanastasis, 2014). Spatial and temporal variation of urban sprawl is studied to establish a relationship between urban expansion and some its causative factors, like population, population density, and density of built-up (Kumar, Garg, & Khare, 2008).

This study will aid the understanding to provide the first and latest statistical representation of data tracking of urban expansion in Pasir Mas, Kelantan by using GIS and remote sensing application in order to produce the land use map as the final output. Besides, an urban land expansion index computed in this study will be a significant contribution in aiding the decision maker regarding the issue. This will also open rooms for improvement and re-evaluation of the current physical plan for the region as well as an implementation of the planning and policies.

CHAPTER 2

LITERATURE REVIEW

This study discuss six main topics which are terminologies pertaining to this study, the impacts of urbanization on green space, remote sensing application and GIS, green space and landscape ecological approach, and spatial landscape metric. Most of the literature review related to the use of these applications in tracking the land use change in urban areas from the various views of local researchers and academician and also from the international studies.

2.1 Terminologies

There are a few important key terms discussed in this subtopic:

2.1.1 Land

According to the Law of Property Act (1925), land is an area with a surface layer on the ground including the building and each part of the building itself is considered as land. Another definition of land is citied by Food and Agriculture Organization of the United Nations (n.d), land is an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man.

2.1.2 Urban

The definition of 'urban' varies from country to country, and, with periodic reclassification, can also vary within one country over time, making direct comparisons difficult (State & The, 2012). An urban area can be defined by one or more of the following: administrative criteria or political boundaries such as area within the jurisdiction of a municipality or town committee, a threshold population size (where the minimum for an urban settlement is typically in the region of 2,000 people, although this varies globally between 200 and 50,000), population density, economic function such as where a significant majority of the population is not primarily engaged in agriculture, or where there is surplus employment or the presence of urban characteristics such as paved streets, electric lighting, sewerage. In 2010, 3.5 billion people lived in areas classified as urban (Reyes, Páez, & Morency, 2014).

2.1.3 Urban sprawl

Urban sprawl has become a major threat in the developing area. The developments of socioeconomic activity give a great impact towards the society especially the population that live in that particular area (Heacock & Hollander, 2011). The urban sprawl term generally has a negative connotation due to the health, environment, and culture issues associated with the fate (Ismail, 1996).

2.1.4 Urban Growth

Urban growth can be described as the absolute or relatively increments in the total numbers of inhabitant who live in the certain areas especially in cities and towns. The population growth rates can be classified either through natural growth or due to the number of populations from the outside. For example, there are some people who migrate to a new place in order to work, study, and sort of it. (Dobbs et al., 2011a).

2.2 Impact of Urbanization

It can be a serious environmental problem that arises from the process of urbanization and the anthropogenic activity. For instance, the pollution might be occurring such as air pollution, water pollution, noise pollution and especially land or soil pollution. Apart from that, the management of solid waste also will become uncontrolled and produce the emission of greenhouse gases (Coseo & Larsen, 2014). There is also an extensive literature on the effects of urbanization on vegetation phenology, biogeochemical cycling, hydrology, soil properties and climatic conditions (Wu, 2014). Health problems of humans and the environment might be occurring from the urbanization process in the open space area. This process can lead to major releasing of air pollutants and greenhouse gases (Coseo & Larsen, 2014).

The process of urban expansion can automatically lead to anthropogenic climate modifications which is urban heat island (UHI). This phenomenon can affect the regional and local climate by modifying the energy balance and surface radiation regime and at the same time will consequently reduce the land cover patterns (Coseo

& Larsen, 2014). This urban heat island (UHI) tend to have greater and surface temperatures and air than its rural surroundings (Wu, 2014). There are studies that justify this effect of urban heat island (UHI) on the social well-being, energy consumption for cooling and heating, plant growth and phenology and local climate (Wu, 2014).

The urbanization process also can affects the stream flows and hydrological cycling in the urban landscape by altering the evapotranspiration rates, modified the patterns of runoff, impervious surfaces, water contamination and increased the use of water (Wu, 2014) The soil in urban areas are always variably affected by management practices, chemically contaminated, or physically disturbed (Pereira, Segurado, & Neves, 2011).

2.3 Green Space

Urban green space can make a beneficial contribution through economic, environmental and social advantage (Camacho Olmedo, Pontius, Paegelow, & Mas, 2015). Many of these benefits are well established from previous research and are generally supported by the available evidence. The significantly contribution of social inclusion advantage on green space because the access is available to all an most importantly it is free (Kong et al., 2010). Hence, it also give huge improvement to cultural heritage and landscape of the physical urban environment by contributing to the carbon dioxide sink and cost-effective sustainable urban drainage systems, moderating the extremes of the urban climate and reducing the pollution (Reads & Profile, 2015). Moreover, the health benefits of urban green space are also particularly essential. The conservation and enhancement of the distinctive range of urban habitats is one of the dominant environmental benefits of urban green space as it also can maintaining biodiversity inside its area (Reads & Profile, 2015).

2.4 Remote sensing and GIS and their urban application

Remote Sensing is one of efficient way in order to collect the information from untouchable physical phenomenon in the ground surface, hydrosphere and atmosphere (Noorollahi, 2005). There are many researchers have used remote sensing to analyse the model growth and changes of urban areas. Land use change data from remote sensing application can supply the significant information (Noorollahi, 2005). This fact can be used for evaluating the structural variation of land use and land cover patterns (Ismail, 1996). This is also crucial in enhancing the placement of urban services. Researcher also used remote sensing to measure the urban sprawls and for the change detection of urban area (Noorollahi, 2005). This technique of remote sensing also give benefits in describing the spatiotemporal trends of urban sprawl as well as can give the base for decision maker to construct the future urbanization planning and conservation of natural resource ecosystem (Niemelä, 2014).

The use of remote sensing and GIS application can facilitate the producing a proper action and best decision in order to address impact assessment (Plexida et al., 2014). The generation of environmentally sensitive areas and high risk zones map using GIS base modelling would have very much help to decision maker (Noorollahi, 2005). For better understanding of urban development dynamics, the integration of urban simulation modelling, geographic information systems (GIS) and remote sensing has been successfully used to predict the activities of urban planning (Xu, n.d.) Satellite images and land surveying are the approach for measuring and estimation of resistant areas. Resistant area of coverage considered as a simple index for urban sprawl measurement (Camacho Olmedo et al., 2015).

2.5 Landscape ecological approach

Landscape ecology is the finding of connection between the elements of landscape (Nor et al., 2017). The spatial configuration of mosaics can be the impacts in a large ecological phenomenon (Cushman, Evans, & Mcgarigal, 2009). The ecological process is affected by the spatial pattern generated in landscape ecology. It provides an analytical basis for urban planning and landscape patches that have been proposed, matrix and corridors as the three basic component types of any landscape. (Cook, Crewe, & Wu, 2011).

2.6 Spatial landscape metric

There is previous research on the fragmentation of landscape by using spatial metrics. This spatial metrics is basically preferable to identify landscape change in order to avoid yielding redundant results (Tian et al., 2011). At the landscape level, the theory and concept of landscape ecology can produce high quantitative data regarding the pattern and structure of green spaces area. It shows a great linkage among the different land uses and it can essentially measure the landscape over the entire study area with metrics (Kong & Nakagoshi, 2006).

Landscape structure is quantified using landscape metrics where three basic attributes exist to characterise landscape structure, these being size, shape, and distance. They are important attributes that contribute to the characterisation of landscape structure and ecological processes (McGarigal, K., Marks, 1994). In order to analyse the relationship between all of the metrics, a partial correlation analysis was regulated by using FRAGSTAT 3.3 (Eichler, Dahlhaus, & Sandkühler, 2003). The output results determine the preferable metrics for representing the characteristics of landscape in patch isolation, shape and size respectively.

Moreover, previous studies indicate that the usage of a set of metrics comprised of Euclidean nearest neighbour (MNN), patch density (PD) landscape shape index (LSI), mean patch area (MPA) and largest patch index (LPI). This is usually the most ideal way for representing the landscape characteristics in order to analyse the fragmentation of landscape and consecutively, avoid yielding repetitious results (Jaeger, 2000). Fragmentation has three ecological components which are loss of green space (attrition), reduction in size of green space (shrinkage), increasing isolation of green space patches due to the landscape resistance exerted on remnant green space by the surrounding matrix of built-up area (Andrén & Andren, 1994).

CHAPTER 3

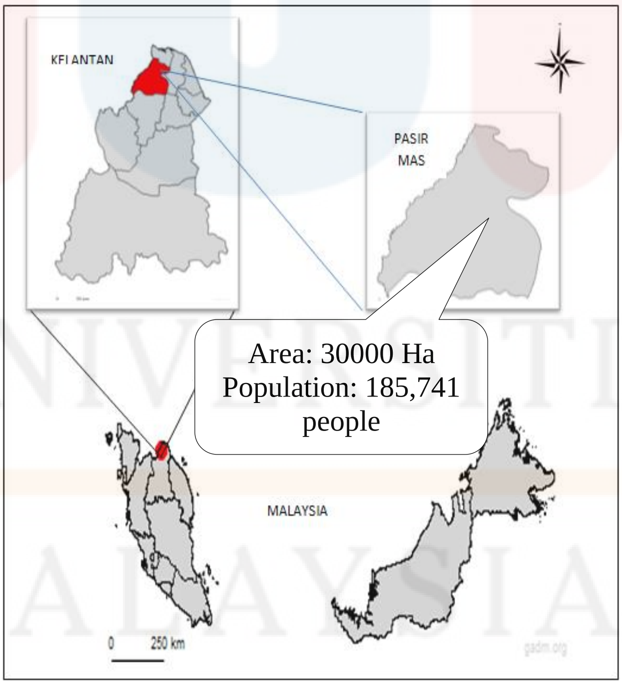
METHODOLOGY

3.1 Study Area

Kelantan is one of the states in Malaysia positioned in the north-east of Peninsula with Kota Bharu as its main city. This state comprised of ten districts namely Kota Bharu, Pasir Mas, Tumpat, Bachok, Pasir Puteh, Tanah Merah, Kuala Krai, Gua Musang, Machang, and Jeli. The Kelantan state occupied an area of 15,099 km2 of land. The total population of the state in 2011 was 1.6 million with average annual2 population growth rate of 1.6%. The population of the state comprised several ethnic groups. Malay (95%), Indian (3%), Chinese (1.9%) and others (0.1%). Unlike the West coast of Malaysia, Kelantan has not experienced rapid industrialization and consequently economic growth.

Based on official portal of Pasir Mas District Council (2018), Pasir Mas is located in the north of Kelantan. It borders Tumpat to the north, Tanah Merah to the south, Sungai Kelantan and the Kota Bharu to the east and Sungai Golok, 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. Due to its geographical location, it acts as the main gateway of the East Coast of Malaysia to Thailand and is also traversed by major road transport routes from the West Coast to the state capital of Kota Bharu. The district of Pasir Mas was originally part of the district of Kota Bharu. In 1918, the town of Pasir Mas and its surrounding areas were separated from Kota Bharu and granted 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, the total population of Pasir Mas District Council residents was about 185,741 which is the second largest district in Kelantan after Kota Bharu. The density is 300/km2 (30000 Ha) and the coordinate of Pasir Mas district is 6.0424° N, 102.1428° E.



(source: gadm.org)

Figure 3.1: The map of Pasir Mas district.

Case study method was being used to conduct this research with three basic steps which were collecting data, processing data, and analyzing data. Land use maps were generated via the interpretation of imagery satellite which then will be recorded in the forms of soft copy and hard copy at the end.

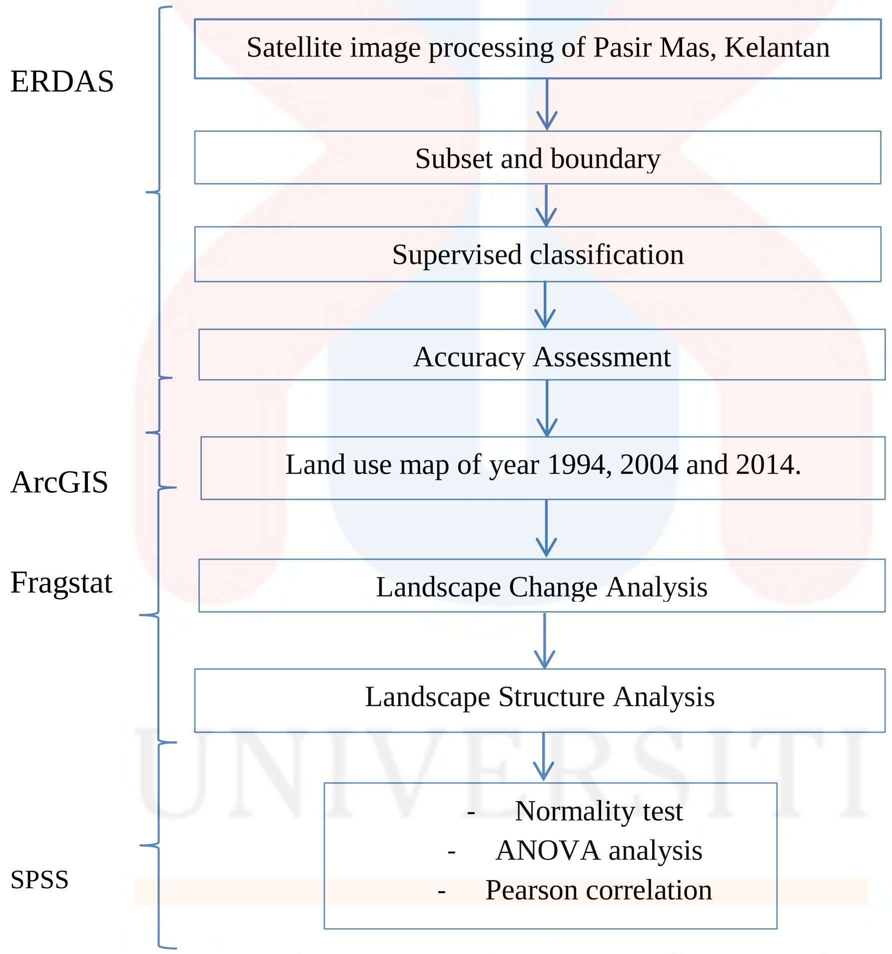


Figure 3.2: Flowchart of methodological framework.

3.2 Data Collection/ Acquisition

Data acquisition played a very important part in the statistical analysis. Satellite image have been used in order to acquire land use land cover (LULC) data for the selected study areas. 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/). Landsat satellite imagery for monitoring urban landscape has been successfully used across the world (Nor, Corstanje, Harris, & Brewer, 2017).

Three geocoded satellite images were processed by using ERDAS Imagine 2014 and ArcGIS 10.5 to produce Land Use Land Cover (LULC) maps for Pasir Mas district for year 1994, 2004 and 2014. Then, the satellite images were subset by using the boundaries obtained from the Global Administrative Areas (http://www.gadm.org/) to extract the area of interest from the image. 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 high resolution imagery may produce more accurate results when conducting landscape analysis on urban green spaces (Nor et al., 2017).

The classification of land use land cover (LULC) was based on five types of the area which are forest, agriculture area, cleared land, water bodies and built-up area. This process was classified by using supervised classification for each year (Nor et al., 2017).

Table 3.1: Land Use Land Cover (LULC) classification.

LULC Categories	Example
Built up area	industrial area
Green space area	shrub, grassland, forest
Water body	river, lake
Agriculture area	paddy field, rubber estate
Cleared land	land emptied for development area

(Source: Anderson, Hardy, Roach, & Witmer, 1976)

Moreover, 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 high resolution imagery may produce more accurate results when conducting landscape analysis on urban green spaces (Pintar, Udovč, Istenič, Glavan, & Slaviče, 2010) .

In the classification process, Google Earth was used for reference. Ground truth verification was performed using a field work in order to evaluate the precision of the generated land use maps. This is an effective way to ensure the assessment of a very large area and the cost limited (Li, 2014). Accuracy assessment produced statistical outputs to check the quality of the classification results (Tewolde & Cabral, 2011). The main purpose of conducting error analysis and accuracy assessment in this study was to analyse the quantitative comparisons of different interpretation (Dobbs, Escobedo, & Zipperer, 2011b).

Stratified random sampling method was used to validate the samples for each class. For this method, 40 random points were assigned to each land use to avoid uneven distribution (Nor et al., 2017). Raster data was converted to vector format using ArcGIS. Finally, the LULC maps were analysed in order to study the spatial pattern evolution of green space.

3.3 Landscape Change Analysis

The areas of percentage for each class were determined by 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. In this analysis, maps from two different years were overlaid, and the attribute table containing the conversion of each land use was produced. This process will compare each class that available for the year 1994 to 2004 and year 2004 to 2014.

3.4 Landscape Structure Analysis

Landscape structure of Pasir Mas district for the selected three years were analysed to compute the differences in the spatial structure of green space (McGarigal, K., Marks, 1994). This process required to evaluate the difference at landscape level, class level and patch level. The quantification of the whole landscape can be performed by landscape level metric. However, in order to evaluate the landscape pattern of each land use separately, class level metrics was the effective way (Wolch et al., 2014).

Class level metrics can provide more accurate data about distribution of LULC, variations at the local level and the landscape spatial patterns (Abdullah & Nakagoshi, 2008). Patch level metrics is substantial in order to analyse the significant changes between patches in all the class.

3.5 FRAGSTAT

For this study, six landscape metrics for landscape structure analysis were selected such as Euclidean nearest neighbour distance (MNN), mean patch area (MPA), patch density (PD), landscape shape index (LSI), percentage of area (PAREA), and largest patch index (LPI). All of this spatial metrics were computed by using FRAGSTATS (McGarigal, K., Marks, 1994). Fragmentation in green space area resulting from urbanization process was quantified using MPA, PD and PAREA. Low values of MPA and high values of PD will indicate a landscape that composed of many fragmented small patches (Nor et al., 2017). These landscape metrics can be used to represent the changes of characteristics such as patch isolation, shape and size in green space landscape (Nor et al., 2017).

3.6 Statistical Analysis (SPSS)

For statistical analysis, the patch level metrics data was computed into the Mirosoft Excel. Then, the 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, and 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. Moreover, associations between changes in built-up area and green space, urban expansion and population density were illustrated using a correlation analysis.

Table 3.2: Landscape metrics used for landscape structure analysis (modified from McGarigal, K., Marks, 1994).

Metrics	Abbreviation	Description of Metric Level (Units)		
		Landscape Level Metrics (The landscape as a whole)	**Class Level Metrics (Each patch type (class) in the landscape)**	**Patch Level Metrics (Individual patch in the given class, where applicable)**
Percentage of area	PAREA (%)	N/A	The percentage of each patches type in the landscape. Proportional abundance of class types in the landscape	n/a
Patch density	PD	Number of patches per 100 ha.	Number of patches per 100 ha in that class.	n/a
Mean patch area	MPA (Ha)	The area occupied by a particular patch type	A function of the number of patches in	A function of the difference in patch

		divided by the number of patches of that type. A function of the number of patches in the total area.	the class and total class area.	sizes among patches.
Largest patch index	LPI (%)	Area (m^2) the largest patch of that type divided by total landscape area (m^2), multiplied by 100.	An indication of the dominance of the different land cover classes	n/a
Landscape shape index	LSI (m/ha)	SHAPE equals patch perimeter (m) divided by the minimum perimeter of the corresponding patch area in a	A measure of the overall geometric complexity of a focal class. It can also be interpreted as a measure of landscape	LSI is one patch and any patch edges (or class edges) measured by the perimeter

		landscape. A measure of the overall geometric complexity of the landscape.	disaggregation. The greater the value of LSI, the more dispersed the patch types.	
Euclidean Nearest-Neighbor Distance	MNN (m)	Distance (m) from a patch to nearest neighboring patch in a landscape.	The distance between a patch and its nearest neighbor of the same class, based on the distance between cell centers of the two closest cells from the respective patches.	MNN deals explicitly with the degree to which patches are spatially isolated from each other. The context of a patch is defined by the proximity and area of neighboring habitat patches; variation in nearest-neighbor distance among patches

CHAPTER 4

RESULT AND DISCUSSION

4.1 Image pre-processing

First and foremost, the metadata images were stacked into layers according to the pixels sizes, projection, resolutions and scales. For this study, multispectral image were stacked within the RGB colours which consist of layer 5, layer 4 and layer 3. This will facilitate the classification as the colours of the resulting colour composite image resemble closely what would be observed by the human eyes (Unger Holtz, 2007) . Next, the image that obtained from USGS was clipped with the boundary of the specific district obtained from Global Administrative Areas .This is because the whole previous image consist a large area of interest. Then, the area of interest was selected before supervised classification was carried out.

For supervised classification, maximum likelihood classification was used in this study because this process safely determines which classes are the results of the classification and classified each of the pixels into correct class type based on the data value (Hütt, Koppe, Miao, & Bareth, 2016).

The next step is the image enhancement that is essential to enhance the image quality of certain satellite image. The median statistical filtering was used because it is a nonlinear digital filtering technique, often used to remove noise from an image or signal. Such noise reduction is a typical pre-processing step to improve the results of later processing (Camacho Olmedo et al., 2015).

Table 4.1: Overall accuracy assessment and Kappa Statistic for year 1994, 2004 and 2014.

Satellite Image	Global Land Survey (1994)	Global Land Survey (2004)	Landsat 8 OLI/TIRS C1 (2014)
Overall accuracy (%)	87.00	83.00	80.00
Kappa Statistic	0.8297	0.7646	0.6022

Accuracy assessment is the important process to determine the quality of the final output that produced from supervised classification. This accuracy assessment can also determine the overall error of the producer and user accuracy for each year selected. The table 4.1 shows the overall accuracy for year 1994, 2004 and 2014 were 87.00%, 83.00% and 80.00% respectively. The lowest accuracy showed by the Landsat 8 OLI/TIRS C1 in year 2014 probably due to the error in classification while selecting the points according to each LULC types.

4.2 Landscape Change Analysis

Landscape change analysis was conducted to determine the LULC changes. The areas of percentage for each class name which are built-up area, cleared land, agriculture area, water bodies and forest were calculated by using ArcGIS software as the results were tabulated in the table 4.2 below.

Table 4.2: Result of spatial area change for year 1994, 2004 and 2014.

Year	**1994**		**2004**		**2014**	
Class Name	**Area (Ha)**	**%**	**Area (Ha)**	**%**	**Area (Ha)**	**%**
Built up Area	4938.62	8.30	3597.27	6.05	5134.28	8.63
Cleared Land	12631.72	21.24	17937.75	30.16	3074.19	5.17
Agriculture	13332.84	22.42	24119.37	40.56	38644.26	64.98
Water Bodies	2903.96	4.88	3554.47	5.98	2148.61	3.61
Forest	25661.15	43.15	10259.43	17.25	10466.94	17.60

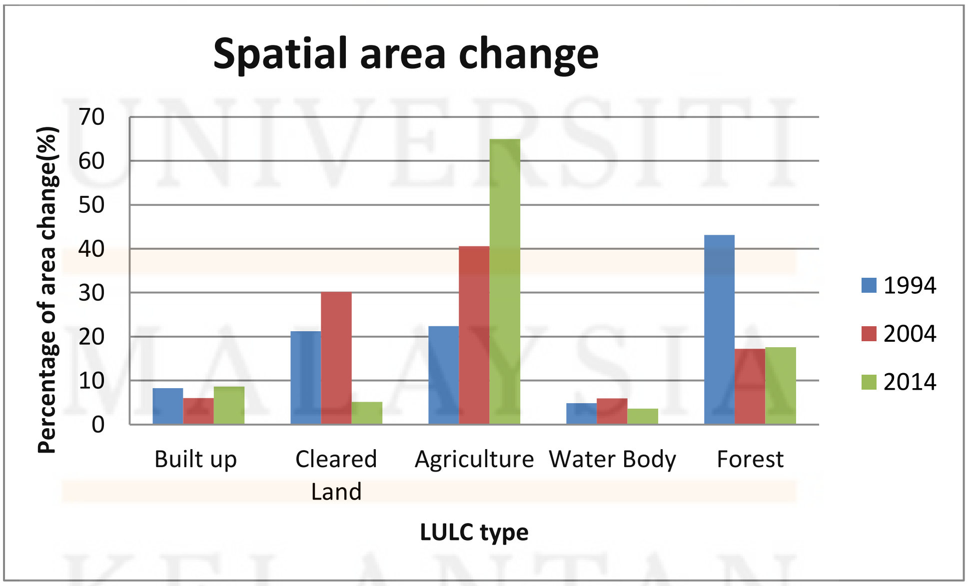


Figure 4.1: The graph of spatial area change for year 1994, 2004 and 2014.

In the year 1994, built-up area shows 8.30% followed by the decreasing of area to 6.05% in year 2004. However, the area rise back to 8.63% in year 2014. For the cleared land, the area of percentage increase between year 1994 and 2004 which are 21.24% and 30.16% respectively. Then, in the year 2014, it shows a rapid decrease which is 5.17%. 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 4.88%. For year 2004, it increases for 5.98% but decrease to 3.61% in year 2014. There are also significant changes in the percentage of area for forest as it is 43.15% in 1994 and gradually decreases to 17.25% in year 2004. However, it slightly rises to 17.60% in the year 2014.

From the landscape change result in table 4.2, it clearly shows the agriculture is the dominant land use in Pasir Mas district. Agriculture area gradually increase year by year started with 22.42% in 1994, 40.56% in 2004 and 64.98% in 2014. Among all the resources, agricultural land resource has played a vital role since time immemorial engaging the largest percentage of inhabitants of the world. Agricultural land resource also is the backbone of the economy of a nation and important basic natural resource for human survival (Survey, n.d.).

Forest is the second highest land use class in Pasir Mas district. Besides providing habitats for animals and livelihoods for humans, forests also offer watershed protection, prevent soil erosion and mitigate climate change (McAlpine et al., 2006). The percentages of forest area decrease from 43.15% in 1994 to 17.25% in 2004. Kelantan experienced high rate of deforestation that will be the major cause to the loss of forest.

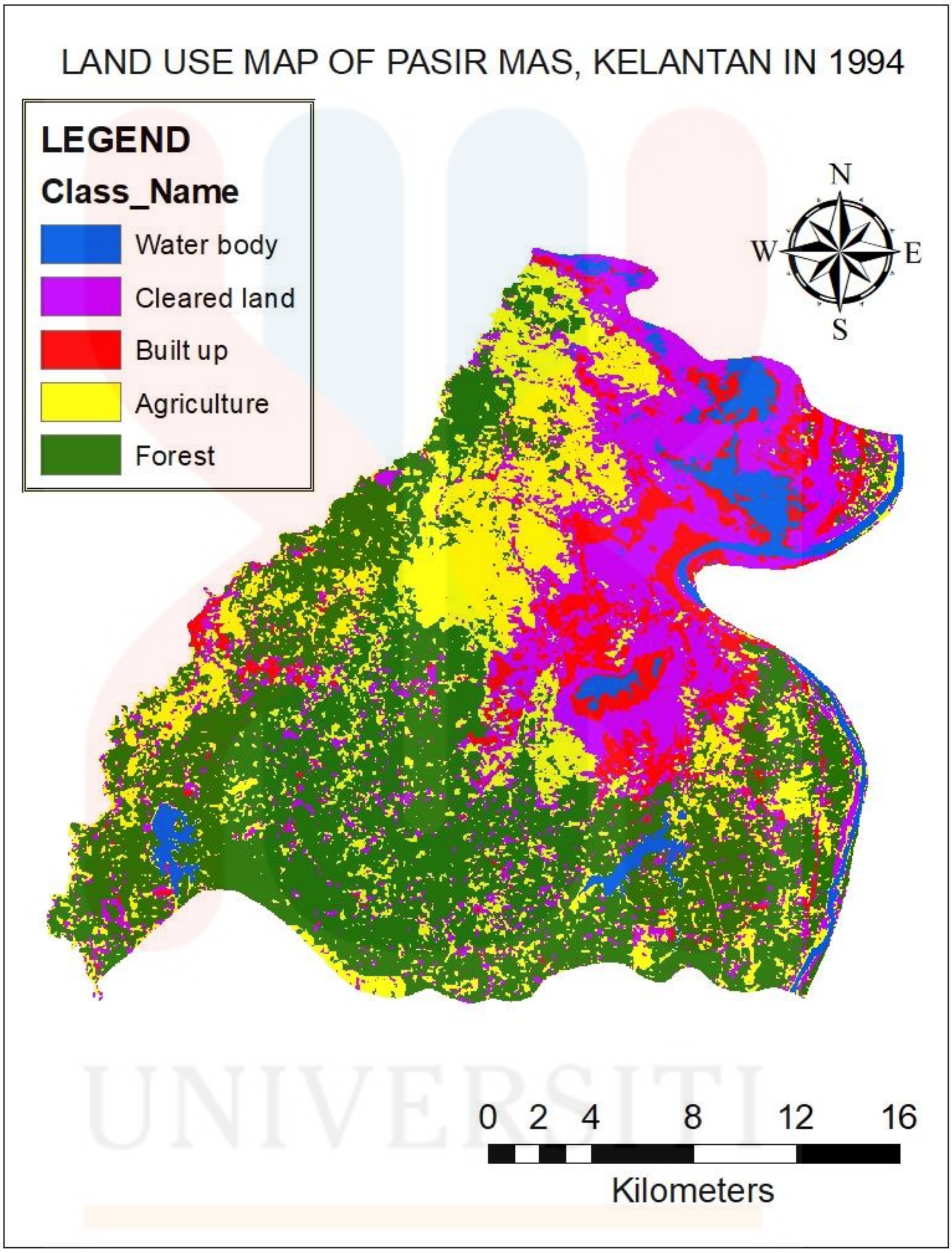


Figure 4.2: Land use map of Pasir Mas, Kelantan in year 1994.

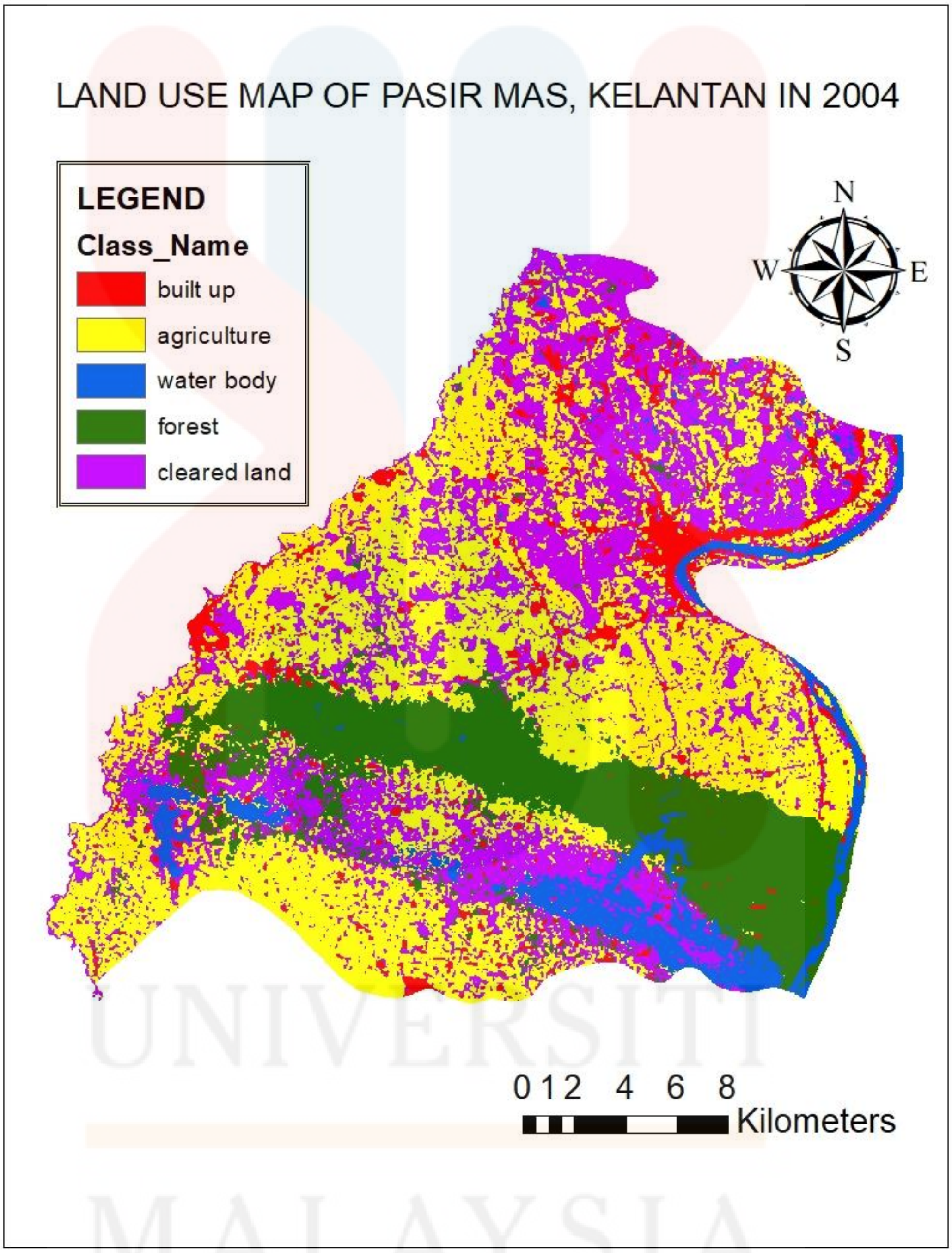


Figure 4.3: Land use map of Pasir Mas, Kelantan in year 2004.

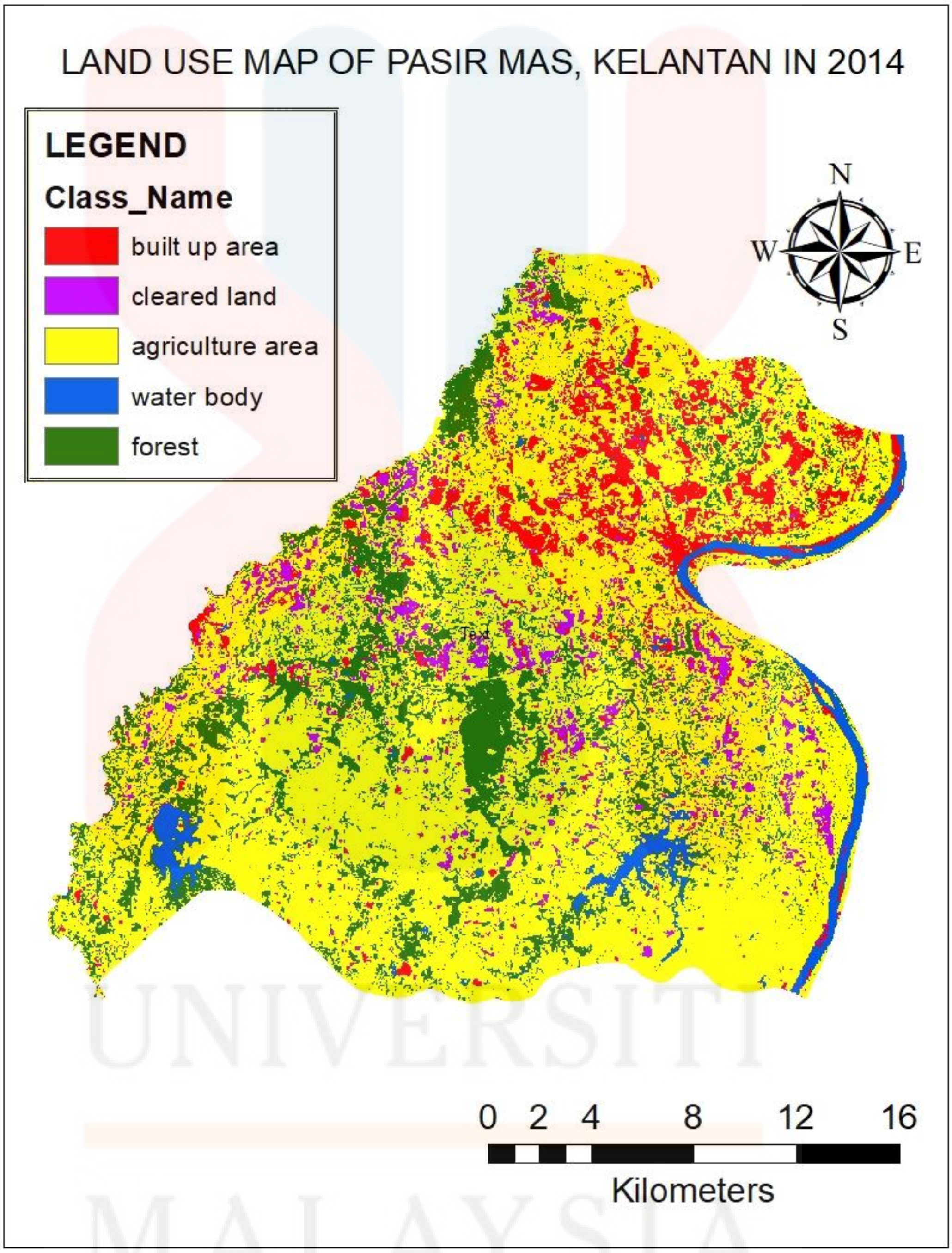


Figure 4.4: Land use map of Pasir Mas, Kelantan in year 2014.

Table 4.3: The transition for all the classes of year 1994 & 2004

TRANSITION OF YEAR 1994 AND 2004										
2004 / **1994**	**Built up Area**		**Cleared Land**		**Agriculture**		**Water Bodies**		**Forest**	
	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

Table 4.4: The transition for all the classes of year 2004 & 2014

TRANSITION OF YEAR 2004 AND 2014										
2014 / **2004**	**Built up Area**		**Cleared Land**		**Agriculture**		**Water Bodies**		**Forest**	
	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

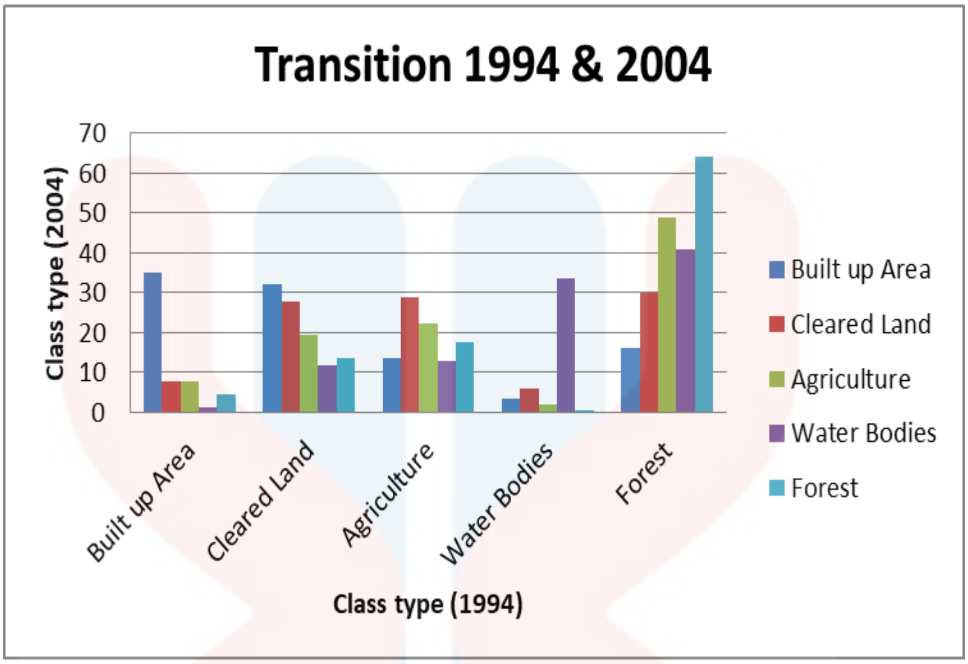


Figure 4.5: The graph of transition for all the classes of year 1994 & 2004

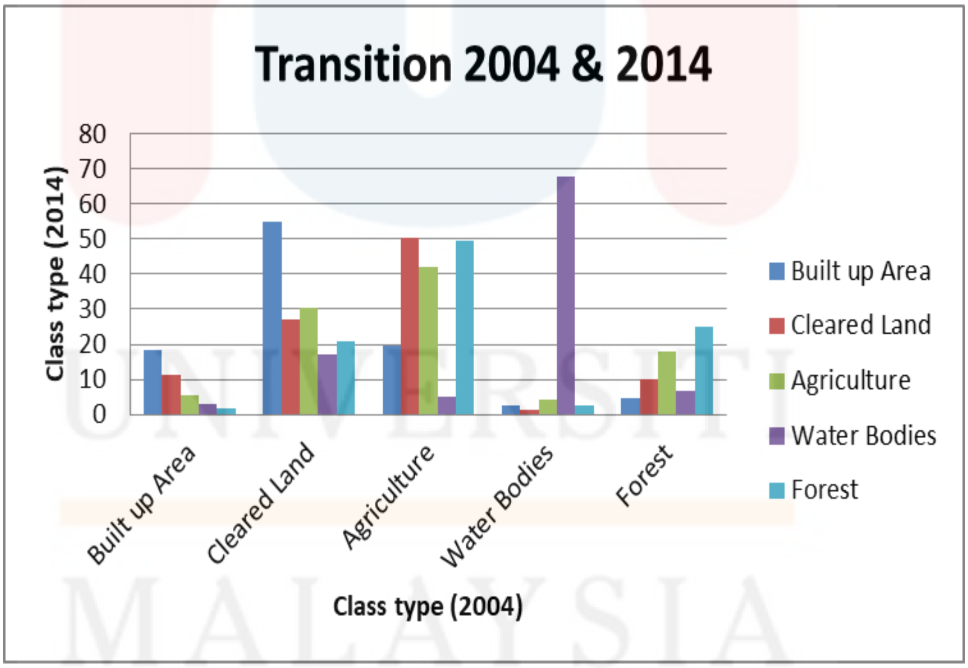


Figure 4.6: The graph of transition for all the classes of year 2004 & 2014

In the period from 1994 to 2004, there are about 4.32% 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 decrease for about 1.92%. Forest shows significance increase in the transition into agriculture area by 17.66% 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 49.63%. 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 13.67% and 21.03% respectively. Furthermore, the percentage of cleared land that changed into built up area is 7.61% and 11.37% for year 1994 to 2004 and 2004 to 2014 respectively.

For the Pasir Mas district, the urbanization process has given the less significant impact towards the green space area. This is contradict to the study of previous research that process of urban expansion can lead to the decreasing of green space area (Nor et al., 2017). 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.

This research interprets various pattern of green space change and sequences of changes in the certain area that face the urbanization process. The green space area does not necessarily transformed into built up area only but also can converted into the other source.

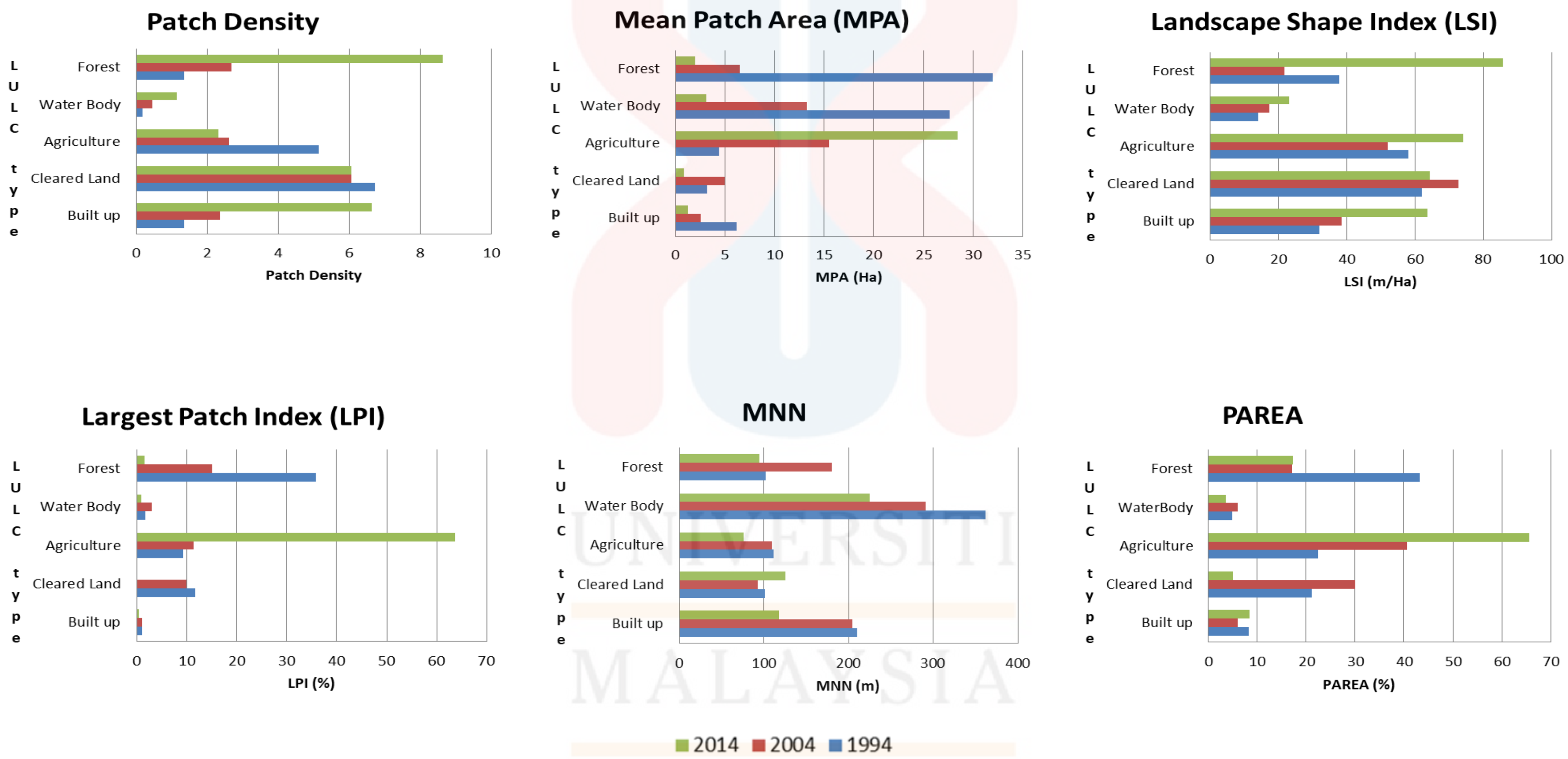


Figure 4.7: Comparison of metrics at class level for each class from 1994 to 2004, and 2004 to 2014 [Patch density (PD); Mean patch area (MPA); Landscape shape index (LSI); Largest patch index (LPI); Euclidean nearest neighbour (MNN); Patch Area (PAREA)].

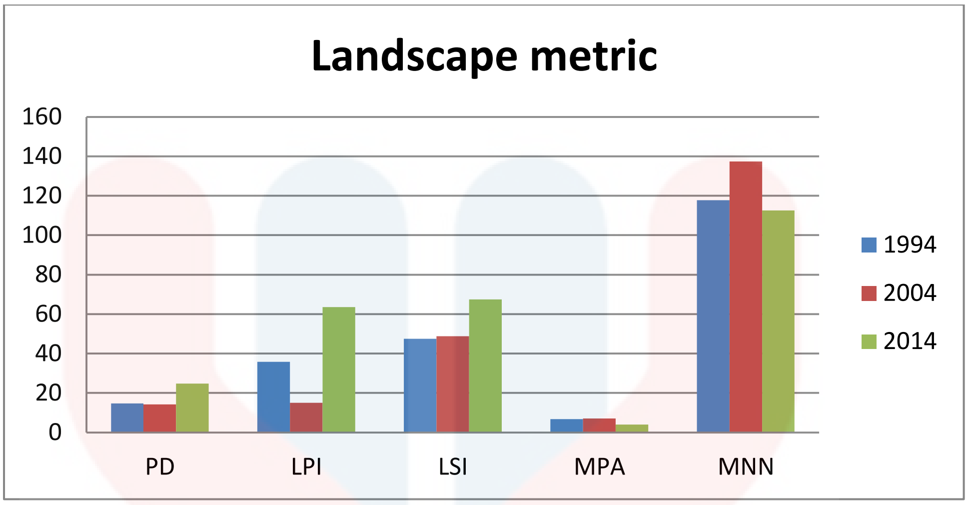


Figure 4.8: Comparison of metrics at landscape level for each class from 1994 to 2004, and 2004 to 2014 [Patch density (PD); Mean patch area (MPA); Landscape shape index (LSI); Largest patch index (LPI); Euclidean nearest neighbour (MNN); Patch Area (PAREA)].

4.2 Landscape Structure Analysis

FRAGSTATS computes several simple statistics representing area and perimeter (or edge) at the patch, class, and landscape levels. Patch density (PD) of a particular habitat type may affect a variety of ecological processes, depending on the landscape context. The number or density of patches also can alter the stability of species interactions and opportunities for coexistence in both predator-prey and competitive systems (Kareiva, Mullen, & Southwood, 1990). At the landscape level, mean patch size and patch density are both a function of number of patches and total landscape area. Landscape shape index (LSI) measures the perimeter-to-area ratio for the landscape as a whole. Euclidean nearest neighbour distance (ENN) is perhaps the simplest measure of patch context and has been used extensively to quantify patch isolation. Nearest neighbour distance is defined using simple Euclidean geometry as the shortest straight-line distance between the focal patch and its nearest neighbour of the same class (Kareiva et al., 1990).

At the class level, patch density (PD) of year 1994 shows the highest value for cleared land area which is 6.72 followed by agriculture area (5.13), forest (1.35), built up area (1.34) and the last is water body (0.17). 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 forest and water body class that have the highest and lowest PD value which are 8.64 and 1.14 respectively. Mean patch area (MPA) of year 1994 recorded forest as the biggest area of hectares (31.97 ha) while cleared land is the lowest (3.14 ha). Year 2004 also shows agriculture as the highest MPA and built up as the lowest area which are 15.51 ha and 2.57 ha respectively. For year 2014, agriculture shows the highest percentage of MPA (28.41 ha) while the lowest is cleared land (0.83 ha). Largest patch index (LPI) of forest area is the highest percentage while built up is the lowest percentage in year 1994. However in year 2004, the percentage of LPI of built up area is increased from 0.98 % in year 1994 to 1.04% and eventually reduced to 0.43% in the year 2014. Landscape shape index (LSI) for forest in year 1994 is 37.77 m/ha decreases into 21.82 m/ha in 2004 and lastly increases back to 85.85 m/ha in 2014. Last metric is Euclidean nearest neighbour (MNN) that recorded the highest value 361.45 m for water body in 1994 and decrease into 180.51 m and 225.08 m respectively in 2004 and 2014.

For the landscape level, the value of PD increases 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 rise in pattern from year 1994 to 2014. By contrast, the MPA value of year 2004 is decrease from the previous in 1994 but slightly lessen in 2014. For MNN, the highest value recorded in 2004 and the lowest is in year 2014.

All of 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 process will occur. If the condition is vice versa, the process that occurs is aggregation. When both 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.

When comparing the three years, different patterns of changes in overall landscape structure were found at different scales, cities and years in response to rapid urban expansion, policies and population density (Nor et al., 2017). The different sizes, fragmentation degree, and densities of landscape features found in Pasir Mas district are related to the establishment of master planning and policies in the cities.

4.3 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. The dependent 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.

Table 4.5: The significance result of ANOVA analysis between LULC and spatial metrics.

Spatial Metrics	Year		
	1994	**2004**	**2014**
Area/	0.052	0.187	0.054
ENN	0.000	0.000	0.000

The result of ANOVA test shows that all the value is not significant as it is greater than 0.05. So, there is no need to do the post-hoc test because the result is not significant. In the majority of analyses, an alpha of 0.05 is used as the cut off for significance. If the p-value is less than 0.05, the null hypothesis is rejected that there's no difference between the means and conclude that a significant difference does exist. If the p-value is larger than 0.05, the significant difference exists cannot be concluded.

Next is the Pearson correlation process. Correlation is a technique for investigating the relationship between two quantitative and continuous variables. For this study, the variables that have been used are class name which are green space and built up area. The bivariate Pearson correlation produces a sample correlation coefficient, r, which measures the strength and direction of linear relationships between pairs of continuous variables. By extension, the Pearson correlation evaluates whether there is statistical evidence for a linear relationship among the same pairs of variables in the population. The results show that the correlation between built up and green space area is scattered. This is because there is less relationship between these two variables that have been tested which are forest and built up area.

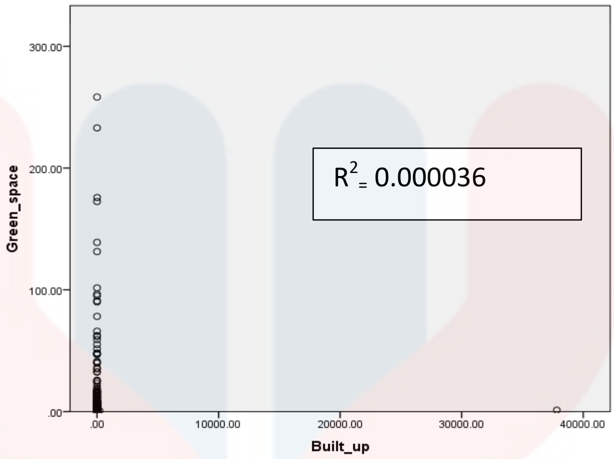


Figure 4.9: The scattered plot graph of correlation for year 1994.

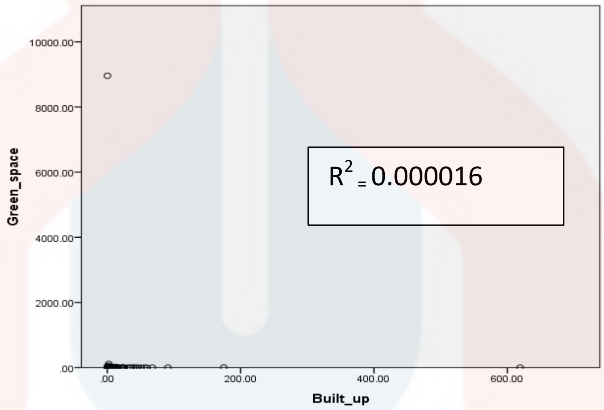


Figure 4.10: The scattered plot graph of correlation for year 2004.

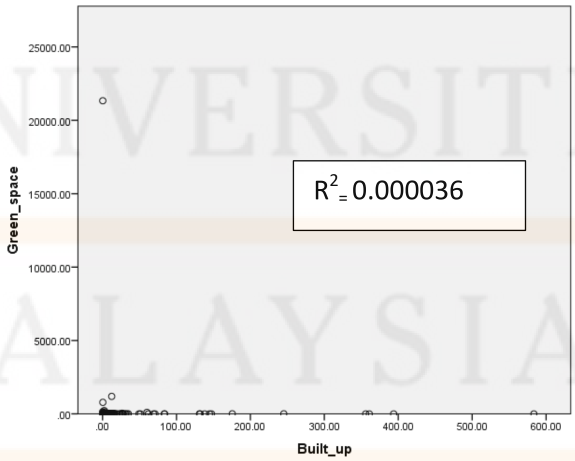


Figure 4.11: The scattered plot graph of correlation for year 2014.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As a conclusion, the objectives of this research 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. For objective 1, the finding of this study is illustrated by the final output of land use map that show the percentage of forest decrease in year 1994, 2004 and 2014 which are 43.15%, 17.25% and 17.60% respectively. The percentage of built up area shows the contradict pattern which increases in year 1994 to 2004 and decrease in year 2004 to 2014 which are 8.30%, 6.05% and 8.63% respectively. For objective 2, the results of this study is illustrated by the comparison in patch level that shows the correlation of built up area and forest is not linear for year 1994, 2004 and 2014. Thus, it concluded that urban expansion has less relationship in the reducing in green space area which is forest. However, from the transition result, agriculture contributes to the decreasing of forest which is 17.66% and 49.63% in year 1994 to 2004 and 2004 to 2014 respectively. Moreover, this study can contribute the future sustainability practices by the development and maintenance of green space structure and its network in urban areas.

5.2 Recommendations

There are some suggestions for improvements to future research study such as run the supervised classification and the accuracy assessment with detail. Next recommendations is to analyse evolution of green space under rapid urban expansion using different spatiotemporal analyses and not limited to fixed analyse only. Furthermore, the study can also identify and prioritize green area for the better sustainable planning for decision maker. Moreover, the researcher needs to apply the data from the related source such as ARSM and Department of Agriculture to support the results of the study. Lastly, the recommendation is to identify the other driving forces of rapid urban expansion and assess factors such as socioeconomic, cultural, physical, land use activities, population density and urban planning.

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APPENDICES (APPENDIX A)

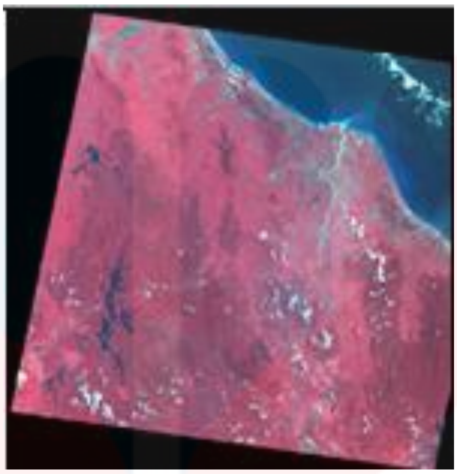

Figure A1: Raw satellite image.

Figure A2: The image after adding the boundary.

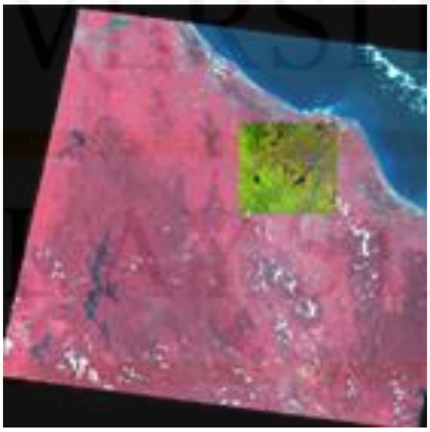

Figure A3: The image of subset AOI.

APPENDIX B

Table B1: Detail of satellite imagery information.

Year	Satellite	Date	Resolution	Source
1994	Global Land Survey	02/04/1994	30m	United States Geological Survey (USGS)
2004	Global Land Survey	03/08/2004	30m	
2014	Landsat 8 OLI/TIRS C1	10/10/2014	30m	

Table B2: The comparison of class level metrics for year 1994.

	PAREA/%	PD	MPA/Ha	LPI/%	LSI/m/Ha	MNN/m
Built up	8.29	1.34	6.15	0.98	32.00	209.91
Cleared Land	21.16	6.72	3.14	11.63	62.14	100.95
Agriculture	22.43	5.13	4.36	9.31	58.10	111.22
Water Body	4.88	0.17	27.66	1.67	14.08	361.45
Forest	43.22	1.35	31.97	35.87	37.77	101.69

Table B3: The comparison of class level metrics for year 2004.

	PAREA/%	PD	MPA/Ha	LPI/%	LSI/m/Ha	MNN/m
Built up	6.05	2.34	2.57	1.04	38.46	204.85
Cleared Land	30.07	6.05	4.96	9.97	72.75	92.83
Agriculture	40.67	2.62	15.51	11.30	52.08	109.16
Water Body	5.96	0.45	13.28	2.98	17.26	291.19
Forest	17.23	2.67	6.45	15.06	21.82	180.51

Table B4: The comparison of class level metrics for year 2014.

	PAREA/%	PD	MPA/Ha	LPI/%	LSI/m/Ha	MNN/m
Built up	8.48	6.62	1.28	0.43	63.67	117.84
Cleared Land	5.06	6.06	0.83	0.12	64.28	125.39
Agriculture	65.56	2.30	28.41	63.60	74.10	75.88
Water Body	3.59	1.14	3.12	0.88	23.11	225.08
Forest	17.31	8.64	2.00	1.52	85.85	94.40

Table B5: Accuracy assessment table for year 1994

Types of LULC	Reference data							
Classification	**Built up**	**Forest**	**Agriculture**	**Cleared land**	**Water body**	**Classified total**	**Producers Accuracy (%)**	**User accuracy (%)**
Built up	39	17	11	23	10	100	25.00	50.00
Forest	20	27	12	17	24	100	94.44	85.00
Agriculture	13	22	29	17	19	100	93.55	82.86
Cleared land	21	13	13	21	32	100	42.86	75.00
Water body	23	27	19	21	10	100	76.92	83.33
Reference total	116	106	84	99	95	500		
Overall accuracy (%)	= 87.00							
Kappa statistics	= 0.8297							

Table B6: Accuracy assessment table for year 2004

Types of LULC	**Reference data**							
Classification	**Built up**	**Forest**	**Agriculture**	**Cleared land**	**Water body**	**Classified total**	**Producers Accuracy (%)**	**User accuracy (%)**
Built up	21	32	12	19	16	100	63.64	87.50
Forest	17	34	18	22	9	100	82.35	93.33
Agriculture	26	16	28	18	12	100	92.11	77.78
Cleared land	19	24	16	31	10	100	88.46	88.46
Water body	36	27	18	14	9	100	50.00	66.67
Reference total	119	133	92	104	56	500		
Overall accuracy (%)	= 83.00							
Kappa statistics	= 0.7646							

Table B7: Accuracy assessment table for year 2014

Types of LULC	**Reference data**							
Classification	**Built up**	**Forest**	**Agriculture**	**Cleared land**	**Water body**	**Classified total**	**Producers Accuracy (%)**	**User accuracy (%)**
Built up	35	15	19	20	11	100	68.75	84.62
Forest	22	24	18	24	12	100	63.64	77.78
Agriculture	25	14	37	14	10	100	96.77	80.00
Cleared land	27	19	19	21	14	100	14.29	100.00
Water body	39	21	18	14	8	100	25.00	50.00
Reference total	148	93	111	93	55	500		
Overall accuracy (%) **Kappa statistics**	= 80.00 = 0.6022							