CLASSIFICATION AND SPATIAL PATTERN CHANGES OF LAND USE LAND COVER IN BACHOK, KELANTAN

By

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DECLARATION

I hereby declare that this thesis entitled ‘‘Classification and Spatial Pattern Changes of Land Use Land Cover in Bachok, Kelantan’’ is the result of my own research excluding 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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Date : ______________________________

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Classification and Spatial Pattern Changes of Land Use Land Cover in Bachok, Kelantan

ABSTRACT

Nowadays, developing regions has made land use land cover (LULC) change as a main and current issue arise from the world environmental change. Heterogeneity purpose on land make land use are not developed sustainably and global pattern of land use understanding by people is weak due to lack of empirical data. Therefore, this study to identify: i) LULC at Bachok and ii) LULC change and spatial pattern changes of LULC in Bachok. In this study, three satellite images of study area in 1994, 2004 and 2016 were processed and analysed with three methods that interlinked each other: (Remote Sensing, Geographical Information System and Landscape Ecology). Landscape pattern of the maps was analysed using landscape metrics calculated by FRAGSTATS software. Results stated that, five class of LULC in Bachok: (water body, forest, agriculture, urban/built up land, and clear land) and revealed that through the years, forest class was decreased due to human activities of agriculture and build up area in Bachok. Generally, landscape metric of ENN proved a significant change of LULC in Bachok that indicate fragmentation process had occurred. Therefore, a study on LULC is essential to provide empirical data for the sustainable management and planning future trends of LULC change and sustaining the landscape ecology.

Klasifikasi dan Perubahan Separa Corak Penggunaan Tanah Penutup Tanah di Bachok, Kelantan

ABSTRAK

Pada masa kini, kawasan membangun telah menjadikan perubahan penggunaan tanah penutup tanah (LULC) sebagai isu utama dan semasa timbul daripada perubahan alam sekitar dunia. Tujuan heterogenasi di atas tanah membuat penggunaan tanah tidak dibangunkan secara lestari dan corak pemahaman penggunaan tanah oleh orang adalah lemah disebabkan kekurangan data empiris. Oleh itu, kajian ini untuk mengenalpasti: i) LULC di Bachok dan ii) perubahan LULC dan perubahan pola ruang LULC di Bachok. Dalam kajian ini, tiga imej satelit kawasan kajian pada tahun 1994, 2004 dan 2016 telah diproses dan dianalisis dengan tiga kaedah yang saling berkaitan antara satu sama lain: (Penderiaan Jarak Jauh, Sistem Maklumat Geografi dan Ekologi Landskap). Corak landskap peta dianalisis menggunakan metrik landskap yang dikira oleh perisian FRAGSTATS. Keputusan menyatakan bahawa, lima kelas LULC di Bachok: (badan air, hutan, pertanian, tanah perkotaan / tanah yang dibina, dan tanah yang jelas) dan mendedahkan bahawa selama bertahun-tahun, kelas hutan telah berkurang disebabkan oleh kegiatan manusia dalam pertanian dan kawasan pembangunan di Bachok. Pada amnya, metrik landskap ENN membuktikan perubahan LULC yang ketara di Bachok yang menunjukkan proses pemecahan telah berlaku. Oleh itu, satu kajian mengenai LULC adalah penting untuk menyediakan data empirikal untuk pengurusan lestari dan perancangan masa depan perubahan LULC dan mengekalkan ekologi landskap.

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LIST OF ABBREVIATION

N	North
LULC	Land Use Land Cover
GIS	Geographical Information System
NIR	Near Infrared Reflectance
NDVI	Normal Difference Vegetation Index
PAREA	Percentage Area
PD	Patch Density
MPA	Mean Patch Area
LPI	Largest Patch Index
LSI	Largest Shape Index
ENN	Euclidean Nearest Neighbour
CA	Class Area
.shp	shapefile
ROI	Region of Interest
Zn	Zinc
Cu	Cuprum
MLC	Maximum Likelihood Classification
ANOVA	Analysis of Variance
SPSS	Statistical Package Social Science
GPS	Global Positioning System
GDP	Gross Domestic Product
ERDAS	Earth Resource Data Analysis System

USGS	United State Geological Survey
ARSM	Agency Remote Sensing Malaysia
RGB	Red, Green, Blue
TM	Thematic Mapper
ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System

LIST OF SYMBOL

Ha	Hectare
Mils.	Millions
km^2	Kilometres square
m^2	Meter square
m	Meter
mg/L	Milligram per litre
mg/g	Milligram per gram
%	Percentage
$<$	Less than

CHAPTER 1

INTRODUCTION

1.1 General Introduction

Recent years, significant shift in land use from forest to agriculture area and from forest to urbanization in several region through land development are stimulated by high economic growth of a country. Land Use Land Cover (LULC) change is the major one of socioeconomic pressure driving changes in degradation of environmental quality and ecosystems. The Earth's landscape is altered or modified by human activities including deforestation, agriculture and urban development (Wu Junjie, 2008). According to Department of Statistics Malaysia (2018), there are estimated of 32.5 million populations in third quarter 2018.

Nowadays, land based resource in production keeps increasing. The existing production systems need to be focus more on sustainably. However, understanding of people towards global pattern of land use is weak due to the land use intensity is complex and lack of appropriate datasets across broad geographic area (Kuemmerle et al., 2013). This will contribute to the difficulties and inconsistent in planning and management of land use. The condition force human to modify land in various ways and intensities in order to meet their basic need and future demand that resulting in exploitation of resources (Silva, 2011).

As stated by Turner (2005) in order to have better understanding relationships between changes in environmental condition mainly caused by human activity on land use and landscape pattern, landscape ecology have been introduced as integrated concept of approach. Landscape is altered by modification by human, number and types of patches also been disturbed at the landscape pattern of a particular area. As stated by Kim (2016) land use patterns were analysed to determine the landscape structure, which in turn was analysed using the landscape indices obtain through the analysis of land use patterns. Spatial structure pattern of landscape change is essential to been understand in order to stabilize the landscape structure in planning sustainable management of landscape (Mohammad Reza et al., 2018).

1.2 Background of the study

Land use land cover (LULC) change has known as a local environmental issue in Malaysia and become the main attraction issue in across the world. Previous decade of studies, shown rapidly modification of landscape throughout the world contributes change in atmospheric composition that act as one of example environmental impacts of land use land cover change (Foley et al., 2005). As indicated by Lo et al., (2014) coastal region is the most widely used areas of humanity for development activities and they have been endured fierce pressure throughout history and likely to continue in the future.

Peninsular Malaysia consists of 13.2 mils. Ha, of the total land area that includes water surface, agricultural land, arable land, forest area and else. Kelantan is placed in northeast of peninsular Malaysia and consist about 15,099 km^2 of total area. Department of Statistic Malaysia stated that, the population in Kelantan State is about 1.718 millions. Bachok has been chosen as the case study. According to

Department of Statistic Malaysia, Bachok consists of eight areas which are Beklam, Gunong, Mahligai, Melawi, Perupok, Tanjung Pauh, Tawang, and Telong.

Based on the geographical area in Bachok are mostly consist of sandy grease ground that enables for agricultural activities such as paddy plants and rubber tree. Agricultural activities were the main economy in Bachok. As studied by Jamal et al., (2014) profit or share to the nation's Gross Domestic Product(GDP) has decrease by agriculture sector however this sector still provide significant development in Malaysia. The increasing agricultural productivity and intensification, changes in population density, urbanization in country, and tourism development, are the several factors that had contributes to land use land cover change and spatial pattern changes in landscape.

1.3 Problem statement

The land use for heterogeneity purpose in Malaysia was getting rapid and most of the lands are not developed sustainably. Apart from this, the uses of land especially in agricultural area had become the crucial factors that contribute to LULC change and also the landscape structure pattern. The previous study mentioned that there was lack of empirical evidence of qualitative and quantitative analysis of data towards categorizing the land use heterogeneity and lack of empirical evidence of spatial structure to allow planners and decision makers for environmental planning strategy (Kok et al., 2010). Classification of LULC is important for detecting and analysing the changes of land use. This study intends to fill the gap to reveal the classification of LULC towards their changes detection by using remote sensing and geographical information system. Last but not least, finding from this research was helped to implement and improve a future successful sustainability on land planning and management in Bachok, Kelantan.

1.4 Objectives

The main objectives are as follow:

I. To classify land use land cover in 1994, 2004, and 2016 in Bachok, Kelantan.

II. To quantify change detection and spatial pattern changes of land use land cover in Bachok, Kelantan in 1994, 2004, and 2016

1.5 Scope of study

Scope of this study was focus on classification and spatial pattern changes of land use land cover in Bachok. Below was the framework for this research study:

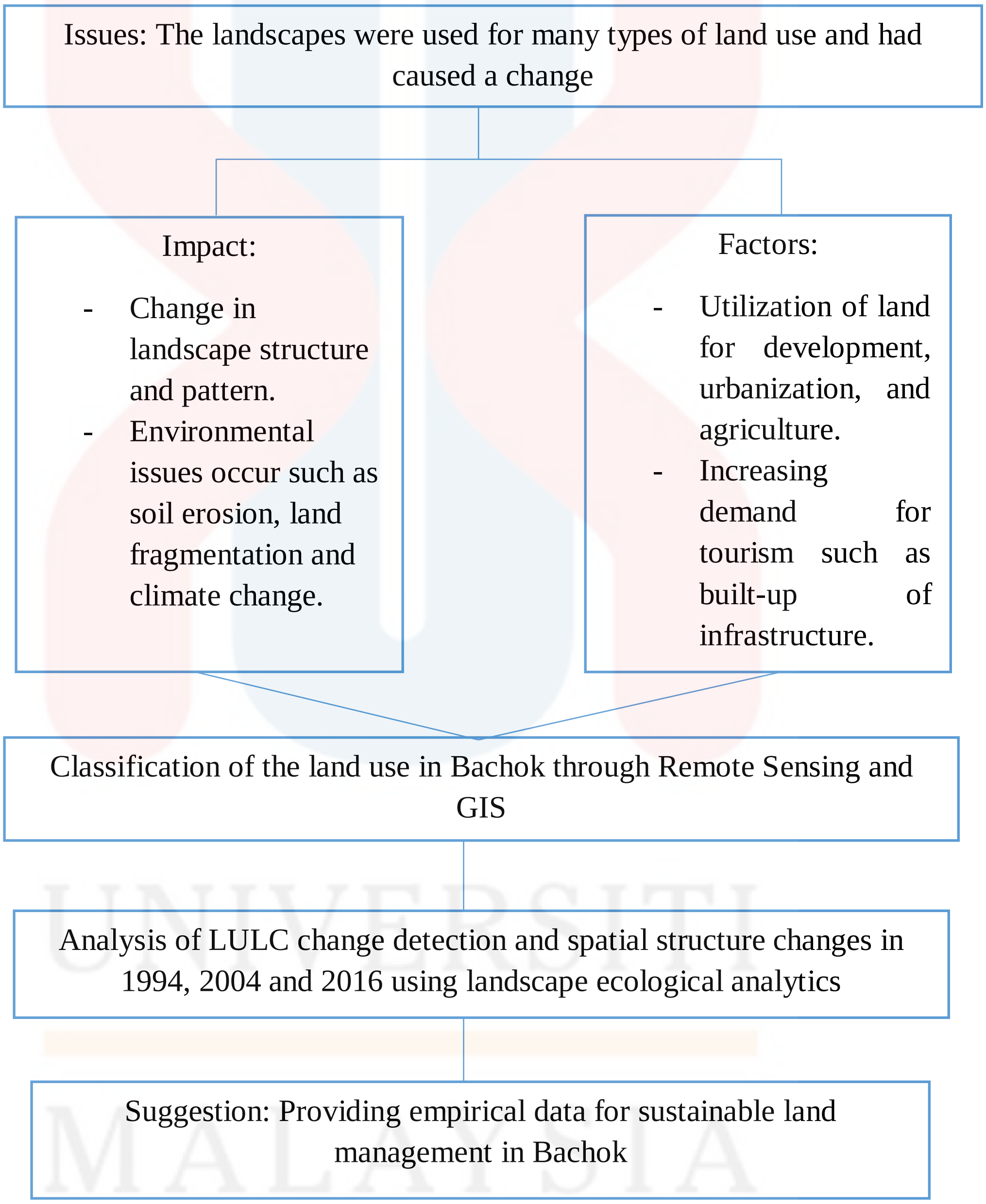

Figure 1.1: Research Framework

1.6 Significant of study

Land use land cover change study has scientific and developmental importance for the future. This study produced an empirical data of LULC change and spatial pattern changes in Bachok, Kelantan. Data gain from this study, were valuable for the sustainable management and planning for local government, policy maker, development planners and local land managers and concerned bodies benefit for land use planning in Bachok, Kelantan. Besides, this study also provided baseline information on issues of LULC change so that the issues arise from the environment can be solved in a proper manner. Basically, such information was vital for comparing the past and present condition and predicts the future trends of the LULC change and develop such methods for sustaining landscape ecology.

CHAPTER 2

LITERATURE REVIEW

2.1 Classification of land use land cover

Land is a complex that consist dynamic factors that including hydrology, geology, topography and soil that are continually interacting with the pressure from climate and anthropogenic activities. If people understand a different form usage of land, the change in land must be identified, characterized and the information communicated via the most broad and cost-effective means. Rozenstein and Karnieli, (2011) stated that the information and education about land use has become increasingly significant. Meaning of land use land cover change is interchangeable, although they are different by many books.

Land use refers to the adjustment and human activities that occur on land cover to produce or sustain it (FAO, 1998). Sometimes land use is not always precisely observable. Field visit and interviews is essential platforms to strengthen information on determined the human activities on land use. As mentioned by Herold et al., (2006) land covers is a natural -physical cover on the landscape that produces the major of human interference on the land. According to Duhamel (1998) revealed that land cover is directly observable from various sources of observation at a different distance between the earth's surface and source. Examples sources of observation are manual observation by using eye and the latest and easier observation through satellite sensors. Land use land cover changes consist of very broad and advance process that give significant impact to natural ecosystem by driving forces including human activity and natural phenomena (Ruiz-Luna and Berlanga-Robles, 2003).

According to Jacob and Elin (2004) land use classification refers to action or process of categorizing types of land use. Classification and categorization carry similar meaning which refers to the process of classifying the world into groups of entities whose members are in some way similar to each other. Rozenstein and Karnieli, (2011) has stated that a good example of land use classification for the classification of satellite images have become the milestone for the current mapping technique of land use land cover as well. In the table below, it shows the land use land cover classification sheme.

Table 2.1: Land Use Land Cover Classification Sheme (modified from Rozenstein & Karnieli, 2011)

Class of land use	Characterization of LULC in class
1)Forest	Evergreen, mixed forests and deciduous
2) Urban/built up land	Residential, industrial, agricultural commercial, transportation and road, built up land and urban area.
3) Agricultural	Cropland, nurseries, orchards and vineyard
4) Water body	Coastal water and reservoir
5) Clear land	Bare exposed rock, quarries and disturbed ground at building sites

2.2 Important of land use land cover study

Decision making process can be decided with help from land use plan and spatial analysis technique that provides an integrated framework from GIS database As mentioned by Synes et al., (2016) modelling future land use is based on landscape ecological approach that focuses on activity happen on land surface that have interlinked between structure or pattern and ecological processes happen. This model is beneficial for the land use planner, policy maker, government or public sector for increasing their function and responsibility on generating alternative landscape spatial planning and management of different land use policies and environmental constraint.

A case study of land use change in Pakistan watershed discovered that studies conducted between 1992 and 2012 have shown the period of area protected by agriculture class in watershed rising by 163.7% and the area allocated nearby coastal water and stream in the reservoir had been converted to agriculture cover from other class area such as clear land. Deforestation and water depletion are the major impact to this conversion on the land use (Butt et al., 2015).

Another case study is on land use and coastal zone in England concluded that effects of climate change on land use in England arise on eventual change later. Hadley (2009) mentioned that, increasing sea level become the greater outcome of climate change on the coastal zone. Change on land use in coastal zone also contributes to risk of flooding to occur and distribution of habitat in coastal zone will be affected. A study on the effect of the different land use on Johor coastal water proved that aquaculture activities which are the farming of green mussel is one of the factors that lead to land use change in Johor coastal water. Coastal water recorded Zn concentration and Cu concentration (in mg/L) was increased while green mussels recorded (in mg/g) increased also in Zn and Cu. This indicated that increase of economic activities influence by urbanization process also enhance the increase of human population. Development of socio economy mostly catalysed through industry and urban process occur on development area. However as mentioned by Azman et al., (2012) effect of socio economy enable heavy metal and waste water enter through various ways to running into reservoir and hence affected of land use.

Last but not least on case study regarding study Green area changes in Kuala Lumpur. Land use detection analysis was conducted on during 20 years starting from the year 1990, 2001 and 2010. The result of the study shows that in Kuala Lumpur loss of green area is about 70.2% on year 1990 until 2010. Total increase of built up area is 114.82% for the twenty years period of study at Kuala Lumpur. Factors that indicated these change probably due to urban development process that resulting increase in built up area and urban sprawl pattern (Noor et al., 2013).

2.3 Remote Sensing and Geographical Information System (GIS)

Remote sensing and Geographic Information Systems (GIS) are used as a modern tool that allows for determination of the land use spatial distribution and the change of detection by multi temporal analysis (Community and One, 2001). Remote sensing is also refer as a technique of collecting information from a distance without contact with the object that been observed. Remote sensing focus on land use management due to their advantages such as have higher spatial and temporal resolution imagery, an easier access to this information, an improved absolute image location and to lower cost (Polidori, 2011).

As mentioned by United State Geographical Survey, Geographical Information System (GIS) is a computer system analysing that enable to view all types of information and data from variety of sources. Examples of source are from land use maps and global positioning system (GPS). Geographic Information System (GIS) also can bring spatial land cover data and spatial analysis methods and act as a data source in study of land use land cover detection. Geographic Information System also functioning to procure all data, methods, driving factors and impact analysis towards land use land cover change (Eduardo et al., 2004).

2.4 Accuracy assessment

Congalton (1991), state that accuracy assessment has become more essential technique to accurate distortion error present in image satellites (Peacock, 2014). There are few of standard summaries for accuracy assessment including Kappa coefficient, overall and user accuracy. Relationship between classified image and reference data refer to error matrices quantitatively. The accuracy is essential to quantify of how many ground truth pixels were grouping accurately and differentiating between pixels or polygons from a classification map obtained from satellite image and reference data. High accuracy in error matrix approach is one of approach why error matrix has been chosen in method used in accuracy assessment (Lu and Weng, 2007).

2.5 Land use land cover change analysis

Land use land cover change detection refer as a process of identifying temporal change in the phenomenon condition or object by observing it at temporal times (Al-Doski et al., 2013**)**. Mostly, change detection have been applied and widely used to assess urban growth, deforestation, and land use land cover changes. Afify (2011) stated that the post-classification comparison approach is the most accurate method for detecting analysis change through Maximum Likelihood Supervised Classification. Maximum Likelihood Supervised Classification focus on rectify of many classified image.

2.6 Spatial patterns changes using landscape ecological approach

Landscape ecology is a concept that highlighted interlinked between ecosystem and pattern of interaction on the landscape in a specific area. Clark (2010) stated that unique effects of spatial heterogeneity in ecological process also been studied on the way the interaction contribute to ecological processes. The relationship between ecological process and spatial pattern are the major focus in landscape ecology (Yue, 2012). The arrangement, structure, and placement of the object in a landscape represent to spatial patterns. Landscape ecologists talk about landscapes as “mosaics”. Landscape mosaic contains the most common and extensive pattern which is the “matrix”. The matrix is focus on area surrounding landscape that contains patches in the landscape mosaic. According Comeau (2000) stated that patch is defined by patch an area within the landscape that is distinct from the matrix and isolated from other similar areas. Heterogeneity of patches makes various patches have different values for different species.

2.6.1 Landscape Metric

Landscape metrics defined by exclusively to indices developed for categorical maps (K.McGarigal, 2009). As indicated by Gustafson, (1998) landscape metrics used for distinguish variety landscape configuration for example in assessing the same landscape at the different specific duration period. Su et al., (2012) in her studied revealed that landscape level metric is effective for quantifying the entire landscape while class level metrics analyse landscape patterns of each LULC individually. Specific information regarding landscape spatial pattern, can be gained from the class level metrics. Perotto-Baldivieso et al., (2011) mentioned that understanding the mechanism of landscape change in patch level metrics are critical and important in determining significant changes between patches within a land use land cover class. The most popular of software using categorical raster maps is FRAGSTATS due first and its result is easy to understand and can be easily imported analysed on statistical software (McGarigal and Marks, 1995).

Table 2.2: Landscape metrics used for landscape structure analysis (McGarigal et al., 2009)

Metrics	Abbre-Viation	Details 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	Percentage of each patch 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 divided by the number of patches of that type. A function of the number of patches in the total area.	A function of the number of patches in the class and total class area.	A function of the difference in patch sizes among patches.
Largest patch index	LPI (%)	Area (m^2) of 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 landscape. A measure of the overall geometric complexity of the landscape.	A measure of the overall geometric complexity of a focal class. It can also be interpreted as a measure of landscape disaggregation. The greater the value of LSI, the more dispersed the patch types.	LSI is one patch and any patch edges (or class edges) measured by the perimeter.
Euclidean Nearest-Neighbor Distance	ENN (m)	Distance (m) from a patch to nearest neighbouring patch in a landscape.	The distance between a patch and its nearest neighbour of the same class, based on the distance between cell centres of the two closest cells from the respective patches.	ENN 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 neighbouring habitat patches; variation in nearest-neighbor distance among patches.

CHAPTER 3

MATERIAL AND METHOD

3.1 Study of area

Bachok refer to study area that comprises of the eight districts in Bachok which are Beklam, Gunong, Mahligai, Melawi, Perupok, Tanjung Pauh, Telong and Tawang. Bachok located in northern Malaysia and faces the open South China Sea. Universal Transverse Mercator (UTM) stated that a geographic coordinate system of Bachok is located in 48 N. Latitude and longitude of Bachok coordinates are 6.069586, 102.397186 respectively. Predominant ethnic group in Bachok is Malay and like the rest are Chinese and Siamese as the minority groups in Bachok. Recent studies stated that there was lack of quantitative and qualitative data analysis regarding land use land cover in Bachok, Kelantan. Apart from this, Bachok has been choosen as study of area. This can be as example for other cities in applying the integrated approach of remote sensing, GIS and ecological approach.

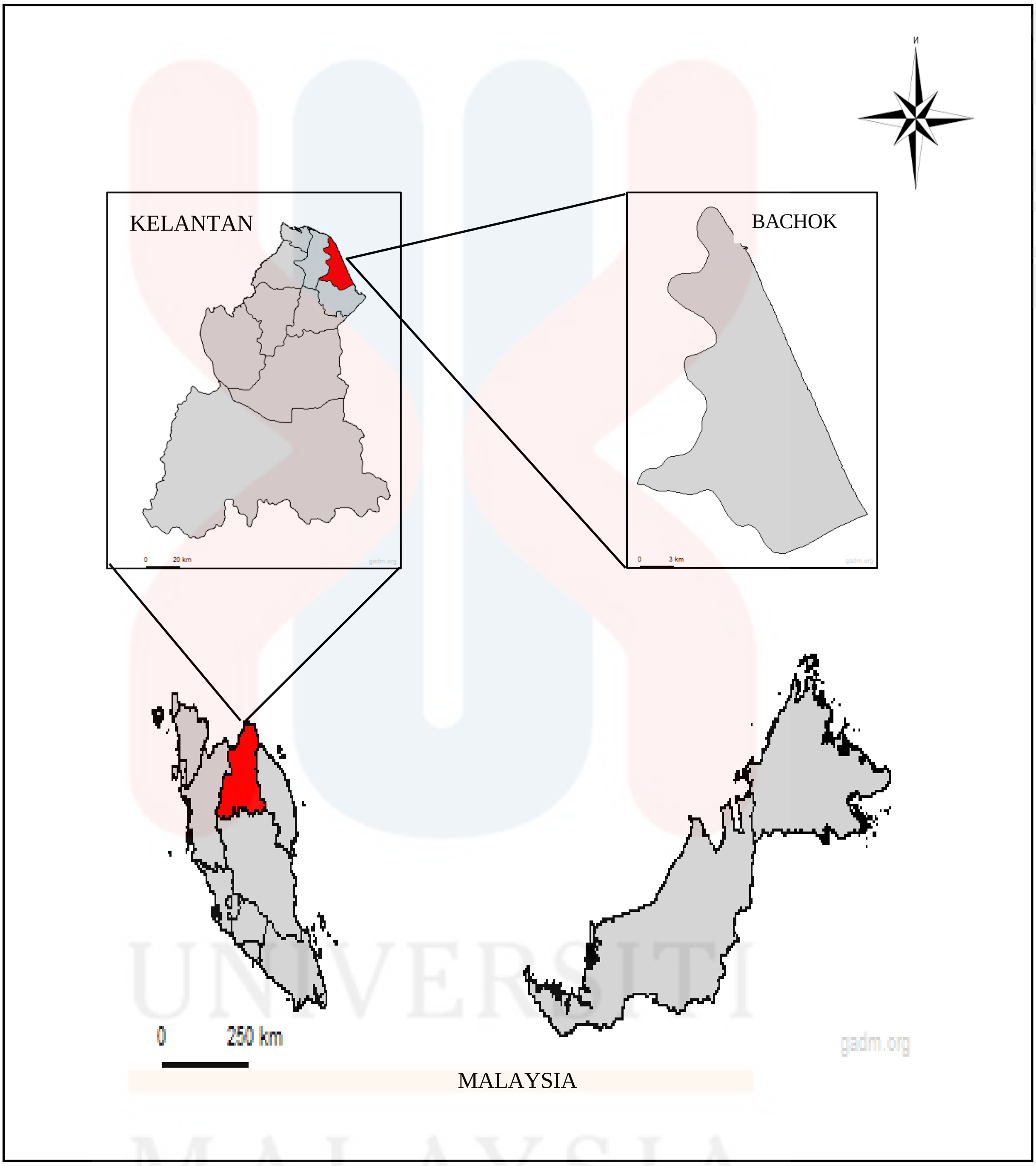

Figure 3.1: Location map of Bachok, Kelantan (source: gadm.org)

3.2 Data Collection

Primary data source was collected. Satellite imagery for three years 1994, 2004 and 2016 were applied from United States Geological Survey (USGS). While ancillary information was collected from secondary sources includes Ground truth method and was used in order to support the satellite images that included the use of Global Positioning System (GPS).

Table 3.1: Types of data

Types of data	Year	Source
Landsat TM 1994	1994	
Global Land Survey	2004	United States Geographical Survey
Landsat 8	2016	(USGS)

3.3 Data Ancillary

Raw satellite images are full of errors and will not be directly used for features identification and need some rectification. The Landsat satellite imagery of the year 1994, 2004 and 2016 were uploaded in ERDAS IMAGINE 2014 software to undergo pre-processing. As indicated by Somwya et al., (2017) pre-processing required prior to the main data analysis to improve the ability to clarify the image components qualitatively and quantitatively. Geometric correction was used for pre-processing in pre-process remotely sensed data and to decreased geometric distortion (Baboo and Thirunavukkarasu, 2014).

3.4 Data Processing

After undergoes, pre-processing, clipping and subset was applied to the satellite images by using boundary of Bachok map import from gadm.org sources and need to been exported in ERDAS IMAGINE 2014 software. In order to removes data outside area of interest, clipping was been applied and file size also can be reduced and improving the processing time for many operations. Satellite images were further processed via image classification in ERDAS IMAGINE 2014 software. As stated by Kumar (2004), classification of image involving grouping and classifying cells of image into their types of land use and land cover.

A method that was used in image classification is supervised classification. According to Richards (2013) mentioned that supervised classification is the accurate and most frequent use method for the quantitative analysis of satellite image. Information and data from the field and land cover classification was used to identify training areas that also been referred as land cover classes. Each satellites image was applied to the supervised MLC Algorithm to produce land use maps. Google earth and ground truth method were used as data reference for classification image was being classify accurately.

After classification image was being performed, land use classification in Bachok was classified according to land use classification by Rozenstein and Karnieli, (2011) which include the class of urban/built-up area, clear land, agricultural, forest, and water body. LULC was then further process by using Normalized Difference Vegetation Index (NDVI) in ERDAS IMAGINE 2014 software.

Vegetation and non-vegetation area can be measure by using NDVI that involve function of a ratio from NIR and red bands to detect change in green vegetation (Morawitz et al., 2006). Furthermore, using NDVI in pixel-by-pixel classification can improve the result from classification. NDVI also used to represent the green vegetation area present due to the major part of the study area in Bachok is dominated by agriculture class. As stated by Nedal et al., (2017) NDVI value increase indicated the increase in vegetation density.

Table 3.2: NDVI values (Nedal et al.,2017)

Value of NDVI	Density of vegetation
0.624-0.50	Very high
0.496-0.353	High
0.348-0.201	Moderate
0.0039-0.0019	Poor
0.000117-0.000126	Very poor
Less than 0	No vegetation

3.5 Accuracy Assessment

Accuracy assessment is vital to compare the obtained result with the existing data references. Ground truth was carried out by using GPS tracking to mark selected coordinates were carried out as well as pictures of selected area location along the Bachok road, were marked using the GPS device. Ground truth data also acted as reference for classification satellite image from year 1994, 2004 and 2016. Errors from classification spatial data or images may occur through various source including position errors resulting from low quality of training or test samples, data processing error and analysis error that will effects the classification accuracy (Lu and Weng, 2007).

Accuracy of spatial reference data map determined by using an accuracy assessment was conducted by using Error Matrix. Error matrix need to been performed with other important accuracy assessment element including overall accuracy and kappa coefficient. These processed images were then converted into a shape file (.shp) format because in raster formats are difficult to analyse change detection. Finally, land use map was produced.

3.6 Data Analysis

Land use land cover change detection was analysed by using ArcGIS. This software was selected to use due most easiness and common version indicated the most recent version. Through ArcGIS, the change detection was interpreted in table or graph by overlay LULC map of year 1994 and LULC map of year 2004. Change detection in three satellites images on the year 1994, 2004 and 2016, landscape metric analysis was performed by using FRAGSTATS software (McGarigal et al., 2002).

Landscape metric is used to determined spatial pattern or structure of land cover patches and classes (Herold et al., 2013). Spatial pattern changes over the three years (1994, 2004 and 2016) was analysed at all level. According to Su et al., (2012), effective result for quantifying landscape was on landscape level while class level metric measured the landscape patterns of each LULC respectively. Patch level metrics are the most difficult in understanding the landscape change due to complexity of the landscape (Perotto-Baldivieso et al., 2011) and important in determining significant changes between patches within a land use class. Patch level was undergo statistical analysis due to the complexity to interpret patch result. Normality test was performed in SPSS software. In this study, six metrics for spatial pattern changes were selected including percentage of area, patch density, mean patch area, largest patch index, and landscape shape index and Euclidean nearest neighbour distance.

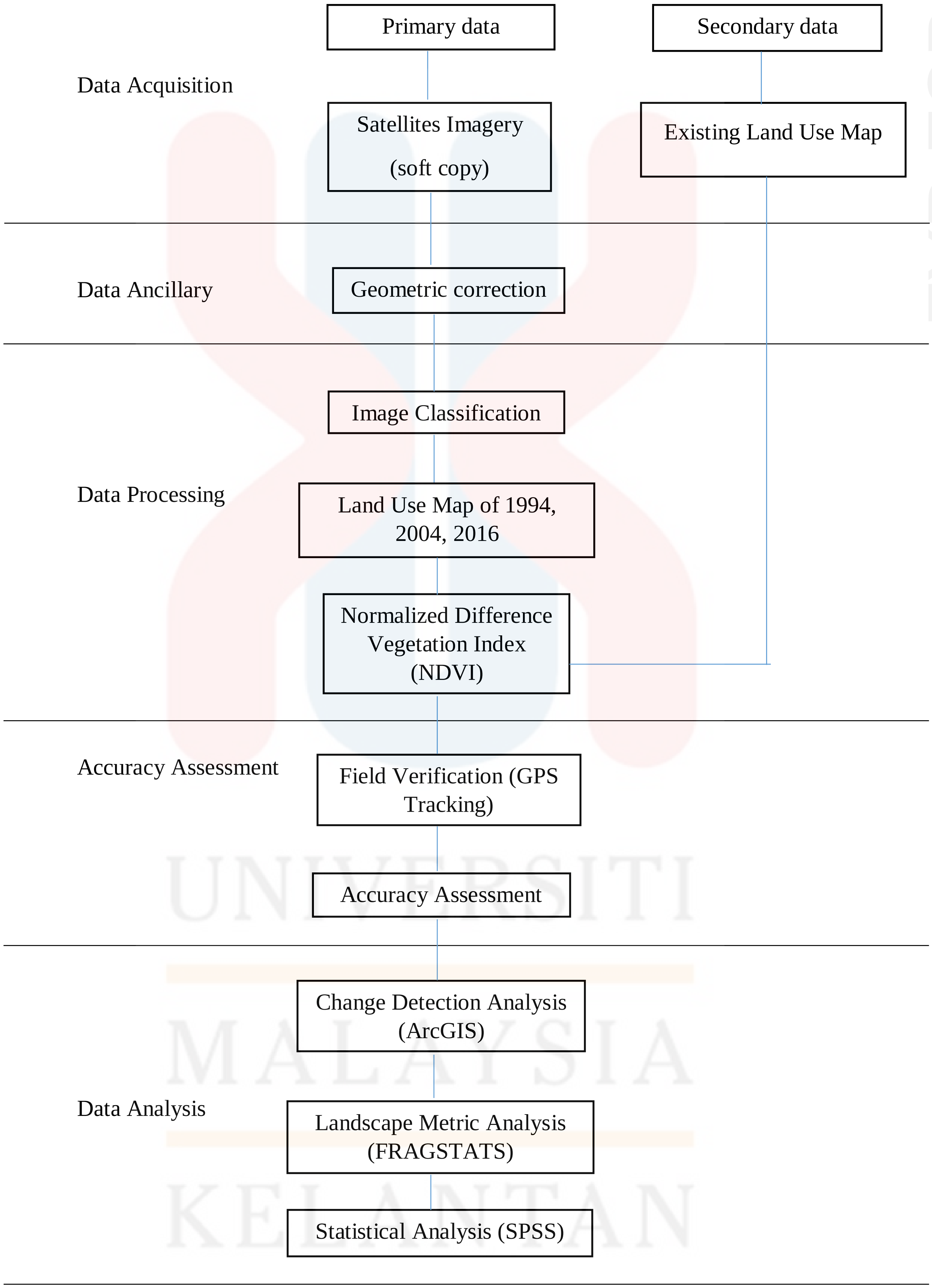

Figure 3.2: Methodology Flowchart

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Pre-processing result

Six subtopics highlighted includes research area, collected data, processed data, land use map of Bachok in three years (1994, 2004, 2016), land use changes in Bachok and spatial pattern changes of LULC in Bachok. All of these subtopics were discussed in more specified and cover the crucial part of the finding research. Three satellite images acquired from year 1994, 2004 and 2016 undergoes pre-processed through geometric correction in order to improve image quality.

4.1.1 Geometric correction

Geometric correction was been conducted to transforms acquired image from satellites to image that can match correct type of projection, free from any error, and each pixel is grouping with accurate coordinates (Baboo and Thirunavukkarasu, 2014). Image need to correct depends on the available geo-referencing data. In this study, image metadata from layer staking was assigned accurately including types of projection, pixel size, scales, resolutions and Landsat layer. Multispectral data that have been used in this study involved Landsat layer 5, layer 4 and layer 3 for layer staking image processing. True colour (RGB colour) was used due to the simples and commonly method indicates for color images representation (Tsagaris and Anastassopoulos, 2004). (Refer Figure: 4.1)

4.2 Processing result

In this part, result of image subset as well as supervised classification, image enhancement and accuracy assessment are being discussed.

4.2.1 Image subset and boundary

The satellites images applied from USGS consist of a wide area beyond the research site thus image subset were carried out by clip only the region of interest. Boundary of polygon was import from gadm.org sources in order to mark the region of interest of one location or district. The sample output of image subset and boundary process is shown in Figure 4.2.

4.2.2 Supervised classification: Maximum likelihood

Several training areas have selected based on referenced through previous case study and the capability to visually interpret type of land use on the low resolution satellite images. Maximum likelihood classification (MLC) was chosen as the best method in this study because its capability to assigned a pixel to a correct group according their specific criteria of belonging and also be able for classifying pixel based on their data values to their class (Sisodia et al.2014).

The output images are shown in Figure 4.3. Separability in signature editor was functioning to measure of the spectral distance between two signatures and was being performed by transformed divergence (TD). A good separability between classes was range value between (0-2000) and thus indicates the classification of satellites images were accurate (Campbell et al., 2005).

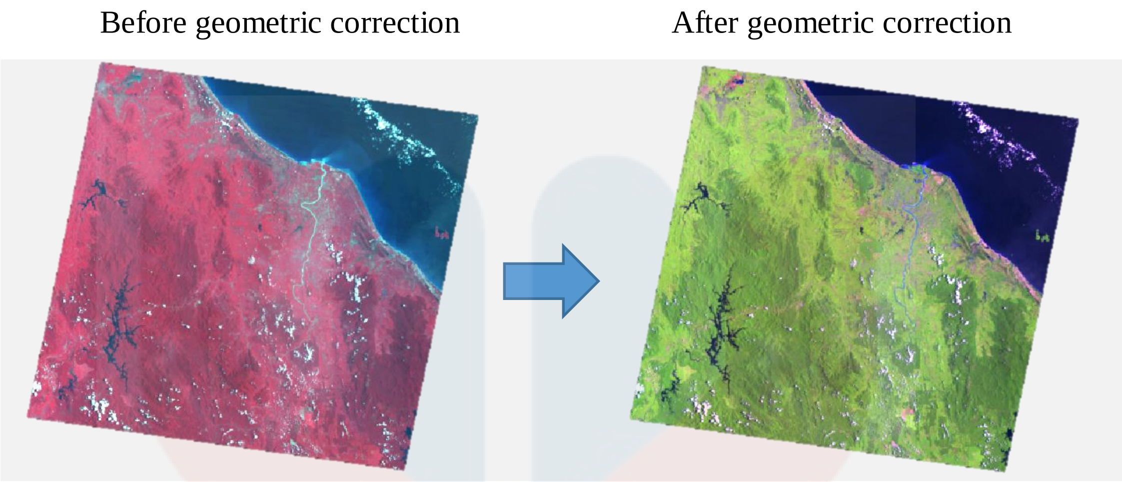

Figure 4.1: Image geometric correction of year 1994 Landsat TM before and after geometric correction

Figure 4.2: Image adding boundary and after subset of year 1994 Landsat TM

a) Landsat TM 1994 b) Global Land Survey 2004 c) Landsat 8

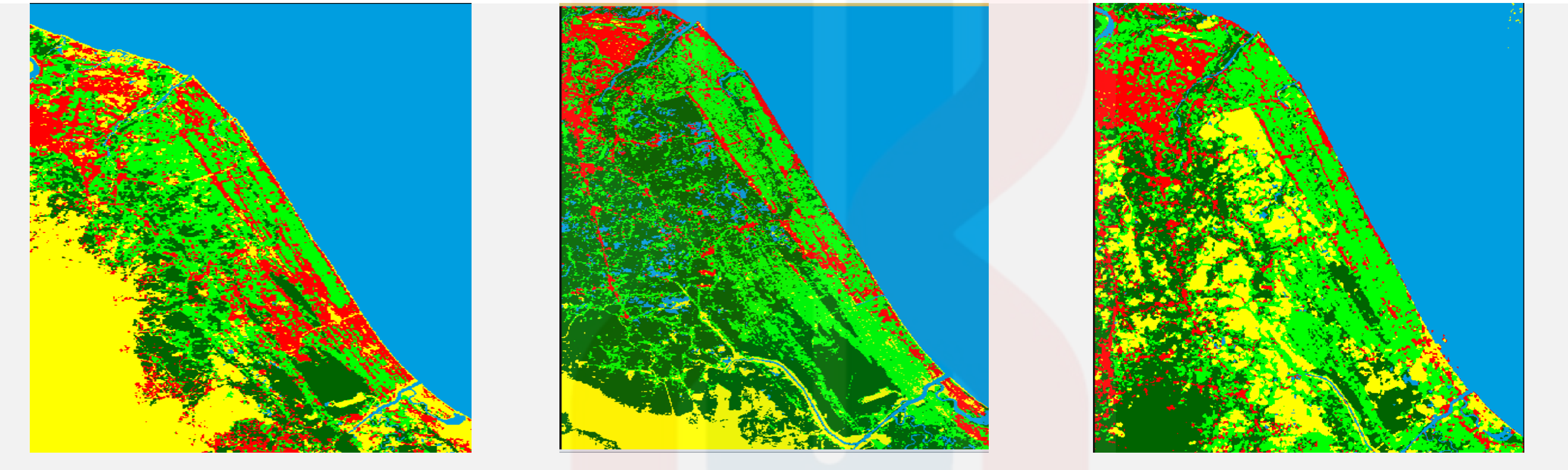

Figure 4.3: Supervised classification of (a) Landsat TM 1994, (b) Global Land Survey 2004 and Landsat 8 2016

4.2.3 Image enhancement

Image enhancement was essential to enhance the appearance of image data in visual distinction between features in a scene. Satellite image which contain noise and blurred need to undergo enhancement image to improve quality of image. According Bajpai and Soni (2017) image enhancement technique that were mostly used to enhancing the images and reducing the noise is spatial filtering. Image enhancement was being applied to the acquired satellite images by using image enhancement technique through spatial filtering by using median filter (3x3).

4.2.4 Accuracy assessment

Accuracy assessment play important roles in assessment of the quality of the final images produced from classification process of supervised classification. Accuracy assessment that was conducted in this study is by using Error Matrix. This assessment identified overall error and also misclassification for each category in the classification process by producer and also the user accuracy. Table 4.1 represent that 85.94% of pixels have been classified correctly in Landsat TM 1994 and 88.67% in Global Land Survey 2004. Landsat 8 2016 shows a slightly highest accuracy which was 89.45% due to the latest satellites was used. While the lowest accuracy shown by Landsat TM probably due to present of clouds and classification error while selecting the training sites.

Table 4.1: Overall accuracy and Kappa statistic

Satellite Image/Year	Landsat TM 1994	Global Land Survey 2004	Landsat 8 2016
Overall Accuracy (%)	85.94	88.67	89.45
Kappa Statistic	0.8085	0.8415	0.8584

4.3 Normalized Difference Vegetation Index (NDVI)

Method of vegetation indices that mostly used was NDVI. NDVI enabled to monitor between vegetation and non-vegetation. NDVI performed by using density in range -1 until +1. Based on the density, NDVI through three years (1994, 2004 and 2016) were classified into five groups. First group was very poor range density from 0.0001117 until 0.000126 while second group was poor consists range from 0.0039 until 0.0019. Third group from range 0.348 until 0.201is called as moderate of vegetation density. Range density 0.496 until 0.353 is call high vegetation density. The last group was very high consisting of 0.624 until 0.50 (Nedal et al., 2007). The higher vegetation density was near +1 of NDVI, the healthier the vegetation. The output images of year 1994, 2004 and 2016 are shown in figure below.

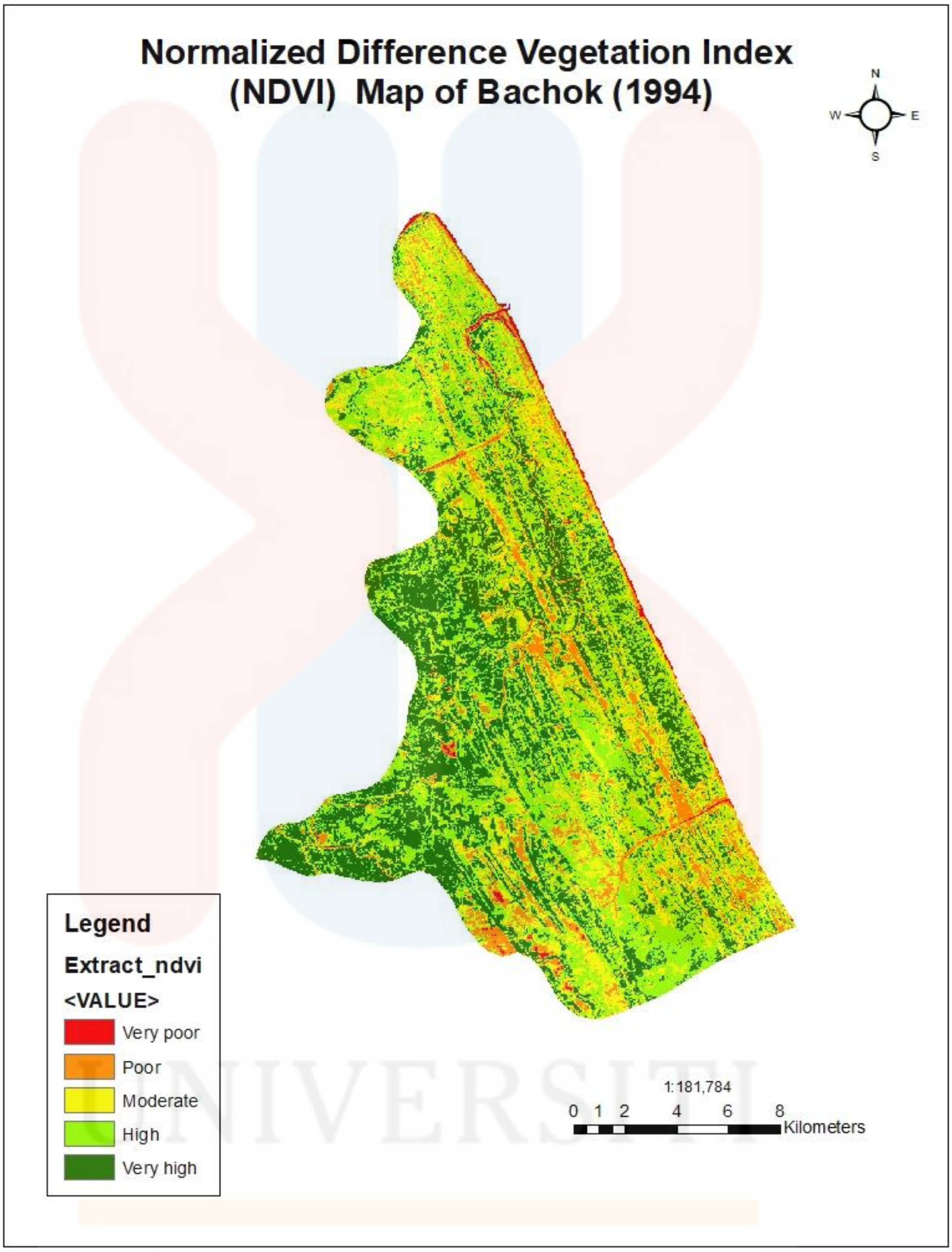

Figure 4.4: NDVI Map of Bachok (1994)

Figure 4.5: NDVI Map of Bachok (2004)

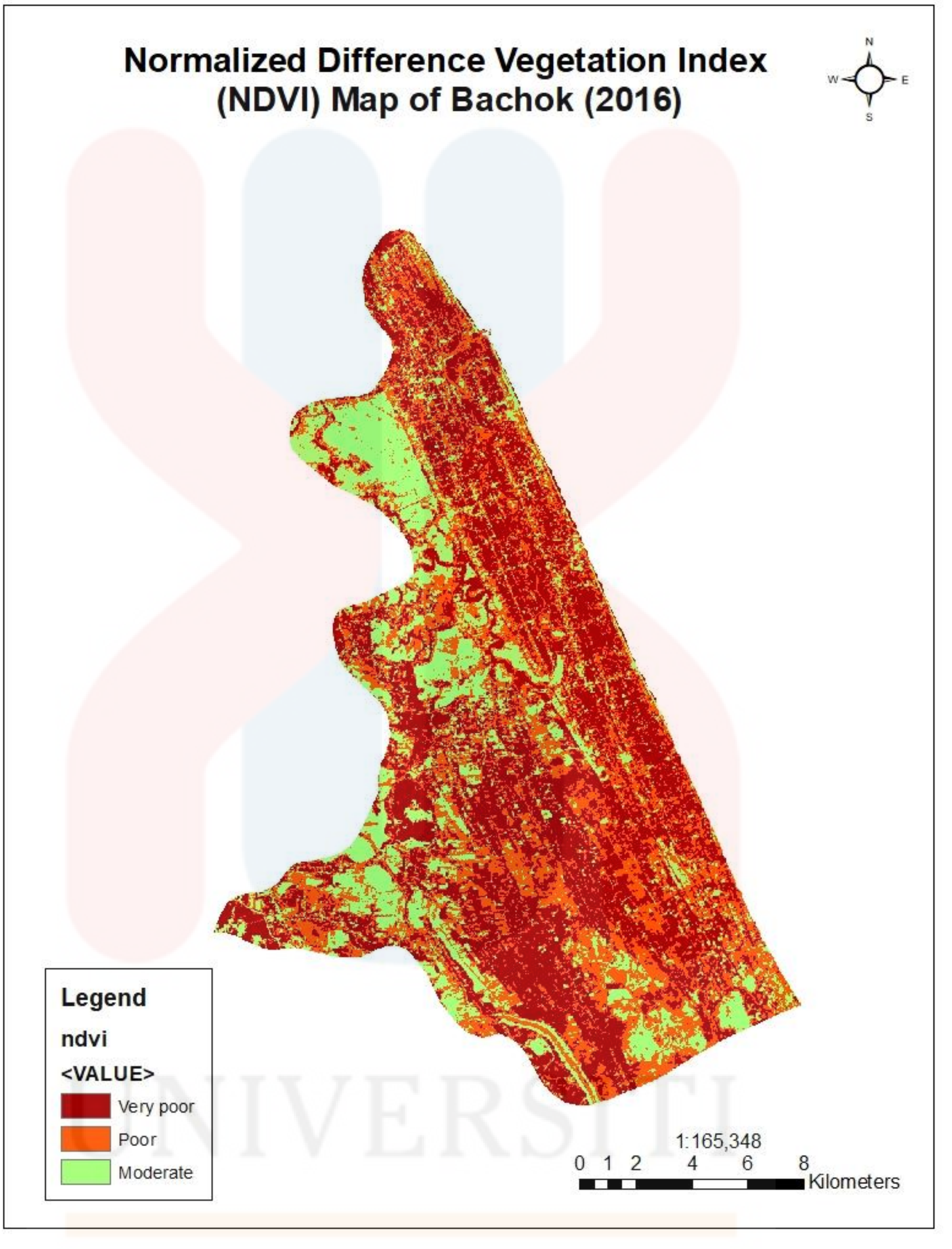

Figure 4.6: NDVI Map of Bachok (2016)

4.4 Land Use Map of Bachok in year 1994, 2004 and 2016

A total three land use maps were produced at the end of this study. These maps were standardized by using 1:250,000 of scale and data attributes from GIS database were transferred into FRAGSTAT software and Microsoft Excel for further statistical analysis. In this part, all of three land use map obtained from year 1994, 2004 and 2016 were discussed briefly on their data respectively.

4.4.1 Land Use Map of Bachok on year 1994

The total area of 28109 Ha of Bachok was made up of 44.90 % of agriculture land; follow by 25.38 % of urban/built up land, 18.68 % forest area, 10.30 % of clear land and the lowest contributed to water bodies 0.67 % of area. The highest of land use categories in year 1994 of Bachok was referring to the agriculture land due to main economy of Bachok people was based on agriculture. According to Department Land and District of Bachok, rice field covers an area of approximately 7,000 hectares and rice production ranges from 3.8 to 4.0 tonnes / hectare.

4.4.2 Land Use Map of Bachok on year 2004

In the year 2004, most land in Bachok dominated by agriculture that covers 43.57 % of total land use. Forest area was the second highest covering 39.96 % of land in Bachok. While follow by urban/built up land that consist of 9.56 % of land. The second lowest refer to water bodies which are 4.39 % and lowest is clear land 2.43% respectively.

4.4.3 Land Use Map of Bachok on year 2016

Dominating the highest land use in 2016 and over the years before at Bachok is agriculture land that consists of 49.89 % of total land and follow by clear land 22.88 % of land. A total of 15.20 % of total land area comprises of forest area which indicated the lowest forest total area compare year 1994 and 2004. Urban/built up land take up 9.90 % of total land area and the remaining categories are water bodies which consist of 1.81 % of land.

Figure 4.7: Land Use Map of Bachok 1994

Figure 4.8: Land Use Map of Bachok 2004

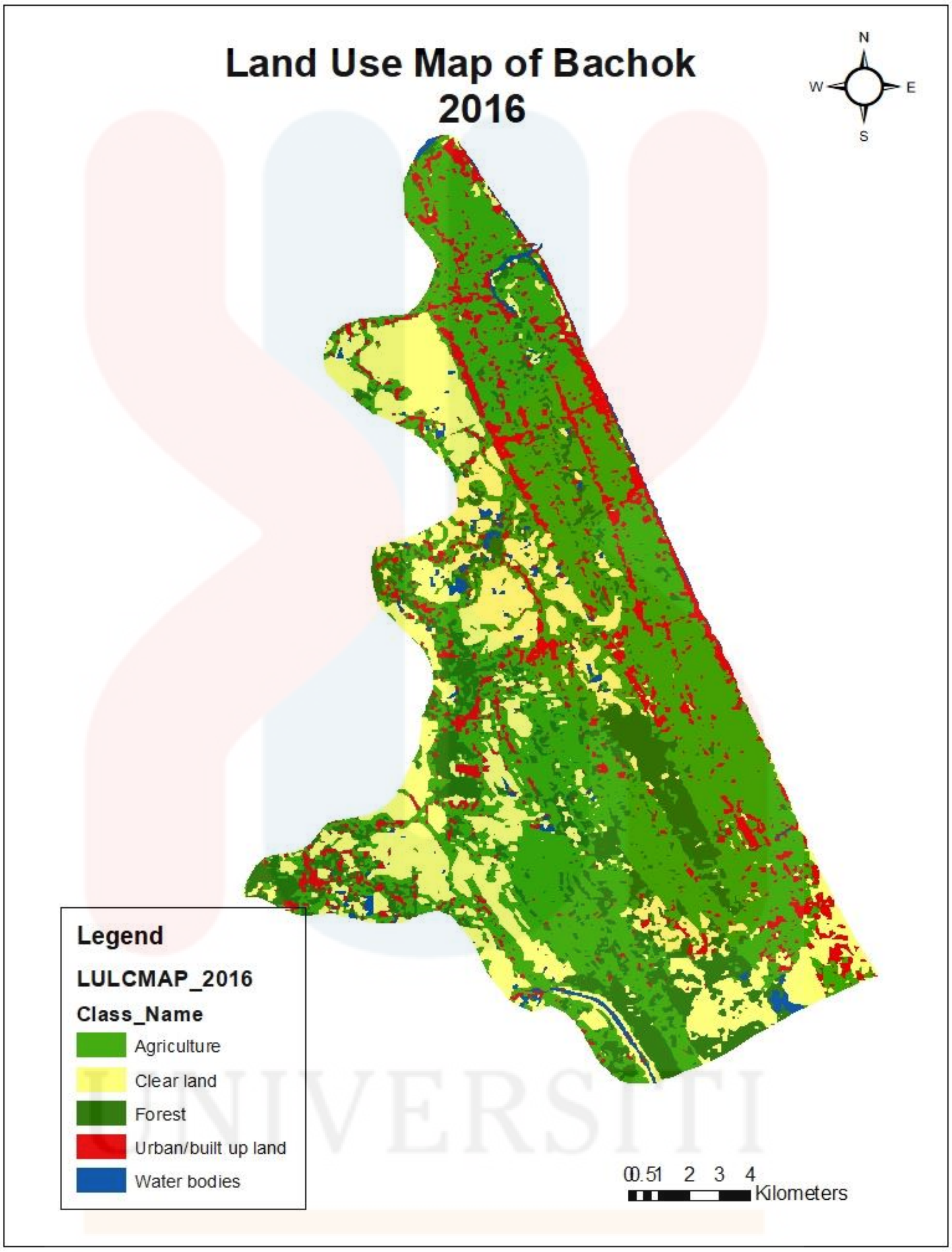

Figure 4.9: Land Use Map of Bachok 2016

4.5 Land Use Change in Bachok

Spatial changes of landscape and statistical analysis were carried out to describe LULC changes. The results of LULC change in year 1994, 2004 and 2016 were represented and tabulated in Table 4.2 respectively. The change detection technique that was used post classification comparison. The land use maps of 1994 and 2004 and land use maps of 2004 & 2016 were overlays through ArcGIS software.

LULC change and the transition matrix of LULC in year 1994, 2004 and 2016 were tabulated in Table 4.2 and Table 4.3 respectively. Agriculture class contribute to the highest land use in Bachok. From the Table 4.2, it shows the decrease percentage of agriculture area in year 1994 and year 2004 (44.90 and 43.57%). However, in year 2004 and year 2016, the agriculture area increases by 43.57% and 49.89% of agriculture area. These changes of land in Bachok probably due to agriculture were labelled by Dr. Mahathir Mohammed stated in Vision 2020 as the “sunset industry”, since early 1980’s (Baki B. Bakar, 2009). Agriculture also remains an essential part of the national economy, contribute to cope with the challenge in order to full fill basic need and safety, and sustainable development in increasing human population nowadays.

The second highest land use in Bachok was forest class. Forest plays a vital role in maintaining ecosystem of a place. In year 1994 and 2004, tables 4.2 shows an increasing hectare of forest area which were 5252.04 Ha in 1994 and 11231.23 Ha in year 2004. However, forest area rapidly decreases in percentage of year 2004 and year 2016 (39.96% and 15.20%). According to Carol Yong (2014), Malaysia was announced as 9th in the world of highest area of forest loss and contributes lost 14.4%

of its forests through years that indicated the world highest rate. Rapid deforestation in Kelantan was one of the major causes that lead to the forest loss.

In this case study, biggest forest conversion was shifting to agriculture class which involved 4687.23 Ha of forest area were been shifting in year 1994 and year 2004. According to Rossetti de Paula (2018) in densely forested regions across the world, forests can recover rapidly from agricultural area or clear area because of natural disturbances as long as remnant patches or seed banks keep stay. Means, co-existence between forest and agricultural takes place in Bachok has been converted/ treated forming new patches of new forest and agricultural area alternative also known as secondary forest. Due to these natural processes, forest area can be increased or decreased throughout years.

As the result shown in table 4.2, urban/ built up land decrease 25.38% and 9.65% percentage of area in year 1994 and year 2004. However, in year 2004 and year 2016, the percentage urban/built up land slightly increase (2713.16 Ha and 2783.40 Ha). Urban/build up land mostly concentrated on district and nearby coastal area that have been shown in land use map of Bachok in year 1994, 2004 and 2016. However, rapid urbanization and building of development in coastal zone yield some changes in LULC and has bad impact for the landscape ecology such as climate change hence contribute flooding to occur in such area (Patra et al., 2018).

The lowest land use class amongst five land use class in Bachok was contributes to water bodies' class. Water bodies class increase 0.67% in year 1994 and 4.39% in year 2004. Conversely, pattern decreased on year 2004 and year 2016 which were involved 4.39 % of and 1.81% in year 2016. The small shifting water bodies' area includes shift to agriculture area (34.45%) and forest area (24.77%) in year 1994 and year 2004. Water bodies in Bachok area showing the lowest class area due to geography and demographic of Bachok area did not have a huge river and mostly residents in Bachok depend on groundwater as their sources of water for daily life activities and irrigation for agriculture.

Based on the visual interpretation inconsistent increase and decrease especially on clear land because these area are being cleared for development purpose and development pattern in Bachok area is dynamic and continuously. Clear land have shown decrease in year 1994 and year 2004 (10.30% and 2.43% Ha) while increasing pattern in year 2004 and year 2016 (2.43% and 22.88% Ha). The shifting or conversion clear land area showed increment and depletion at unusual manner either from clear land changes to urban/ built up land or clear land changes to agricultural area and else. However, in this study method that was being used is supervised classification cannot distinguish the road/highway due to poor image resolution and the diversity of land use change is too high that road has less prioritized or seen in land use study.

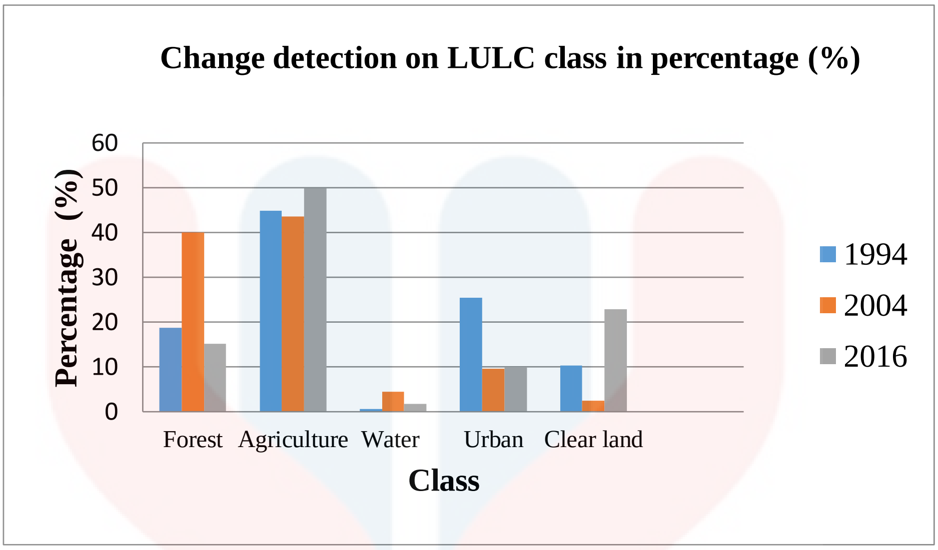

Figure 4.10: Change detection of LULC class in percentage

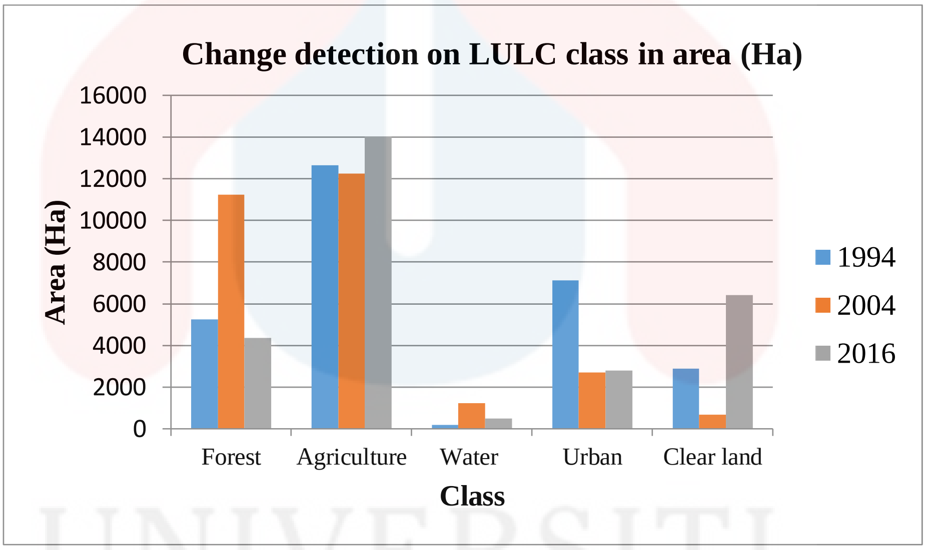

Figure 4.11: Change detection of LULC class in area

Table 4.2: Land use change in Bachok in Year 1994, 2004, 2016

Class name	Land use change in Bachok in Year 1994, 2004, 2016					
	1994 (%)	1994 (Ha)	2004 (%)	2004 (Ha)	2016 (%)	2016 (Ha)
Forest	18.68	5252.04	39.96	11231.23	15.20%	4362.51
Agriculture	44.90	12640.37	43.57	12246.88	49.89%	14024.15
Water Bodies	0.67	188.25	4.39	1234.10	1.81%	508.44
Urban/built up land	25.38	7134.10	9.65	2713.16	9.90%	2783.40
Clear land	10.30	2894.69	2.43	684.08	22.88%	6430.94
Total	100	28109.45	100	28109.45	100	28109.45

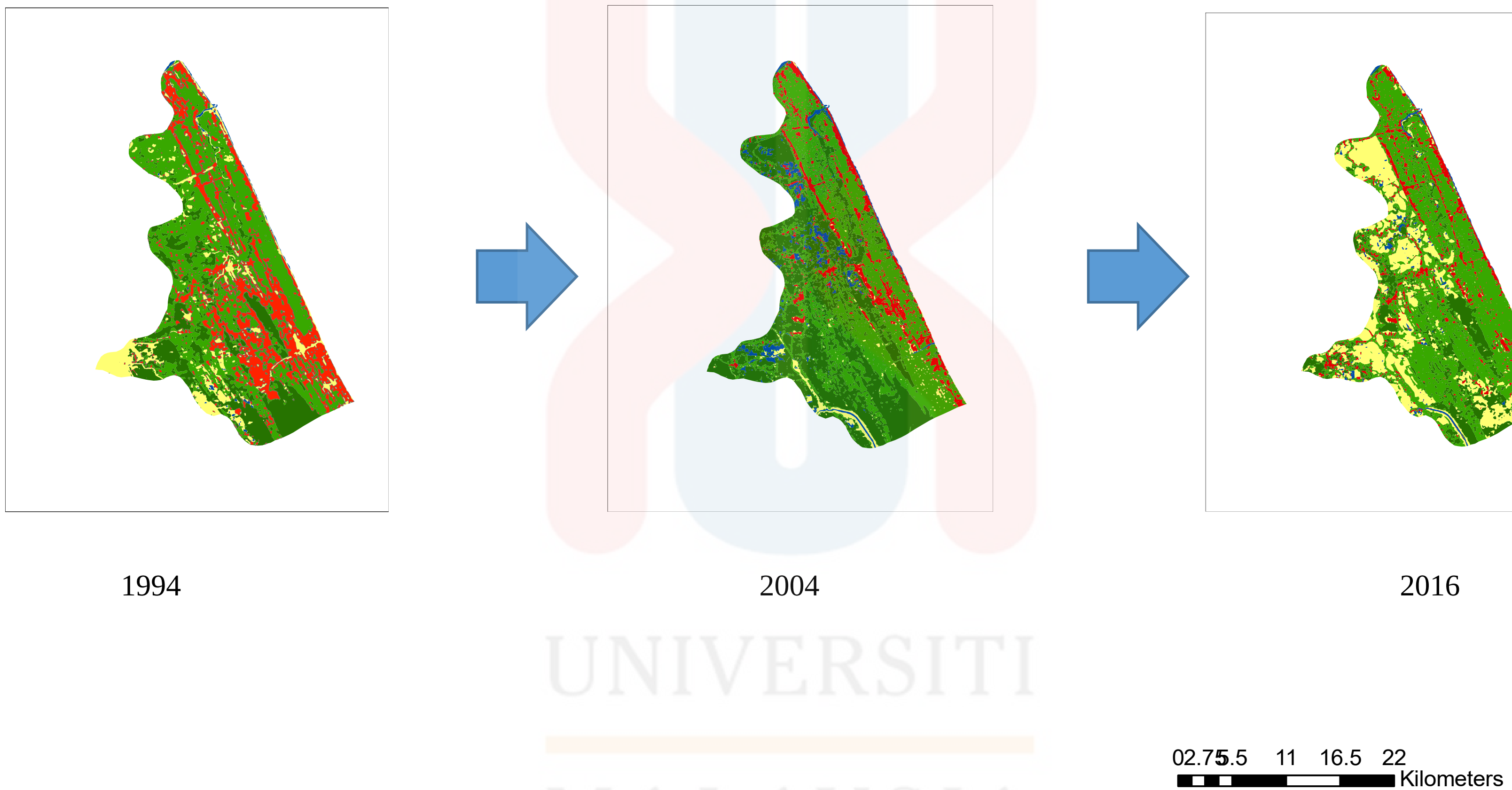

Figure 4.12: Land Use Change of Bachok (1994, 2004, 2016)

Table 4.3: Land Use Change Data Analysis of Transition Matrix Year 1994&2004 and Year 2004&2016

Transition Matrix of Year 1994 & 2004										
Class Name	Clear land	%	Built up land	%	Water bodies	%	Forest	%	Agriculture	%
Clear land	214.04	31.29	142.82	20.88	5.86	0.86	241.75	35.34	79.61	11.64
Built up land	453.61	16.72	1731.78	63.83	5.39	0.20	28.98	1.07	493.40	18.19
Water bodies	311.66	25.25	72.65	5.89	118.96	9.64	305.68	24.77	425.14	34.45
Forest	1279.11	11.39	1201.53	10.7	44.73	0.4	4018.62	35.78	4687.23	41.73
Agriculture	636.28	5.20	3985.32	32.54	13.31	0.12	657.00	5.36	6954.97	56.79

Transition Matrix of Year 2004 & 2016

Class Name	Clear land	%	Built up land	%	Water bodies	%	Forest	%	Agriculture	%
Clear land	325.46	5.06	256.28	3.99	767.64	11.94	4037.39	62.78	1044.17	16.24
Built up land	73.05	2.62	1240.35	44.56	85.10	3.08	266.25	9.57	1118.64	40.19
Water bodies	8.13	1.60	4.43	0.87	223.58	43.97	233.60	45.94	38.70	7.61
Forest	26.48	0.60	73.25	1.68	45.20	1.04	3275.49	75.08	942.10	21.59
Agriculture	250.96	1.79	1138.85	8.12	112.58	0.8	3418.5	24.38	9103.27	64.91

4.6 Spatial pattern changes of Bachok

Landscape metrics such as PAREA, PD, MPA, LPI, LSI, and ENN metrics were used in accessing landscape configuration of a country by using images. Relationships between landscape structures and ecological processes such as isolation, fragmentation and aggregation have only little changes and lack of explanation value and do not translate into easier mechanism that can be simply understand(Mitchell M., 2014). This research attends to fill the gap by quantifying spatial pattern changes at all level consist of patch, class and landscape level throughout three years of study period (1994, 2004 and 2016).

At landscape level, LPI increased on year 1994 (18.27%), year 2004 (26.84%) and in year 2016 (43.67%) over the study period in Bachok. According to Jinliang Huang et.al (2009), landscape pattern metrics increase in value during the study period represent fragmentation process was occur in landscape tended to strengthen, and spatial variability of the landscape increased in Bachok during 1994, 2004 and 2016. Increasing value of LPI (%) proved that some land use classes of patches become larger on landscape throughout these periods. Resulting, urban/built up land might have become larger in area and resulting increase also in agricultural area were also put under cultivation especially between 2004 and 2016. However, there was decreasing of MPA in year 1994 (13.82 ha) and year 2004 (7.59 ha). The MPA continues to decrease in year 2004 (7.59 ha) and year 2016 (7.32 ha). Decreasing of MPA throughout the study period indicated a fragmented landscape consist of many small patches.

The pattern of ENN was decreasing over the two years (1994 & 2004) of study period in Bachok which were 167.59 m and 135.16 m respectively. Conversely, ENN values were increased significantly between year 2004 and 2016 in Bachok (135.16 to 139.98 m). In Bachok, concurrently, the population increased substantially along with the corresponding spatial urban extension trends especially on development area and agricultural area in Bachok. According to Chao Li et al. (2013), there is a long term relationship between population growth and vegetation cover in the region where there are catalysed by human activities and the influence of climate change has disturbed the originality of vegetation such s forest. Decreasing in ENN values in this case study proved that, distance from patch to nearest neighbouring patch in a landscape become smaller and hence contribute to loss in forest fragmentation. The spatial urban extension and cultivation of crop in a massive way at Bachok need to be controlled to prevent forest loss through years.

At class level, changes in green spaces structure in three years (1994, 2004 and 2016) of period study at Bachok were similar. In all period of study, PD increased (1 to 3 patches/100 ha; year 1994 to year 2004, 3 to 4 patches/100 ha; year 2004 to year 2016) and MPA decreased (17.45 ha to 10.40 ha) in year 1994, year 2004 and 10.40 ha decreased to 3.17 ha in period of year 2004 and year 2016. This result proved that the green space was fragmented. From all period of study, the declining values in MPA were significant. Fragmentation in Bachok was evidenced by larger PD and smaller MPA values during period of study (1994, 2004 and 2016) suggesting rapid expansion of agriculture activity during these periods. The green space in Bachok was in inevitably turned over to agriculture area and urban/built up land for development in urban area. According to Shiyi Guo et.al (2018), green space planning should implement by the local government as a guide of green space management. Therefore, Bachok local government should produce these plans in order to planning the most successive way to mitigate landscape fragmentation.

LSI keep increasing in year 1994, 2004 and 2016 which from 18.80 m/ha and 35.61 m/ha (1994 to 2004) and from 35.61 m/ha and 37.40 m/ha (2004 and 2016). More dispersed patch types indicated the increase of LSI value. Peters et al., (2010) had stated the increase in shape variation and patch size of green space probably may induce more people to use those spaces and investment to make large park and attractive design. Means, overall geometric complexity of forest class in Bachok was undergoes landscape disaggregation process. This happen probably due to highest human activity in forest area.

The patch size was bigger (LPI increased) in the period of 1994 and 2004 at Bachok (3.72 % and 12.55 %). However, in the period of 2004 and 2016, the patch size was smaller (LPI decreased) which were from 12.55 % decreased in 2.32 %. From the result, it shows that urban class and agriculture class contribute to the decrease in the green space fragmentation or loss. In Bachok, ENN was decreased (205.90 and 108.94 m) between years 1994 and year 2004 however in year 2004 and 2016 having increasing value of ENN (108.94 m and 127.11 m). This result indicated that green space inter patch distance decreased then increased.

Statistical analysis was performed at patch level due complexity to interpret patch level data. SPSS software was being chosen to perform normality test in patch data and result had shown normal distribution (<0.05) and thus indicated ANOVA was need to being performed. Two landscape metrics had been chosen which ENN and AREA were in order to compare significant changes throughout three years in period of study (1994, 2004 and 2016).

Dependent variables in Analysis of Variance (ANOVA) were AREA and ENN while independent variables were class area. From table of Analysis of Variance (ANOVA) below, the result landscape metric of AREA was not significant in three years of study period which were 0.143, 0.579 and 0.274 respectively. However, the result landscape metric of ENN in ANOVA shows a significant value (<0.05) in three year period of study. These can be concluded that ENN proved significant changes in the LULC change while AREA proved a not significant change in the LULC changes throughout the study periods.

Table 4.4: Result of Analysis of Variance (ANOVA)

Landscape metric	**Year**		
	1994	2004	2016
AREA	0.143	0.579	0.274
ENN	0.000	0.000	0.000

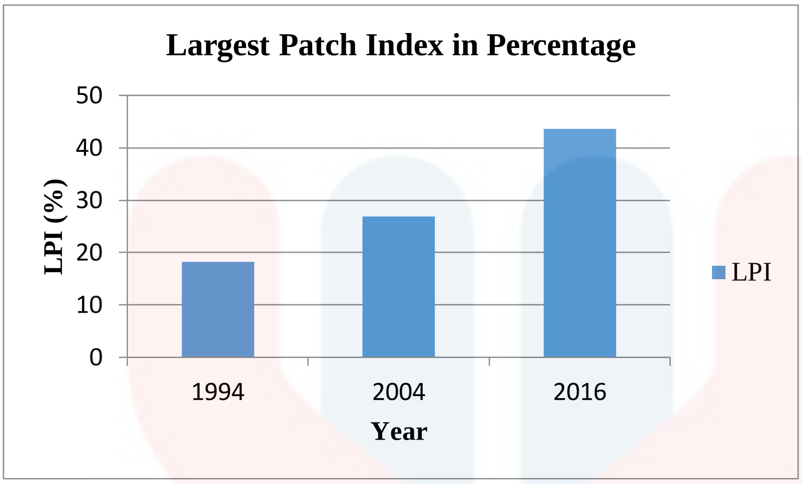

Figure 4.13: LPI in percentage at landscape level

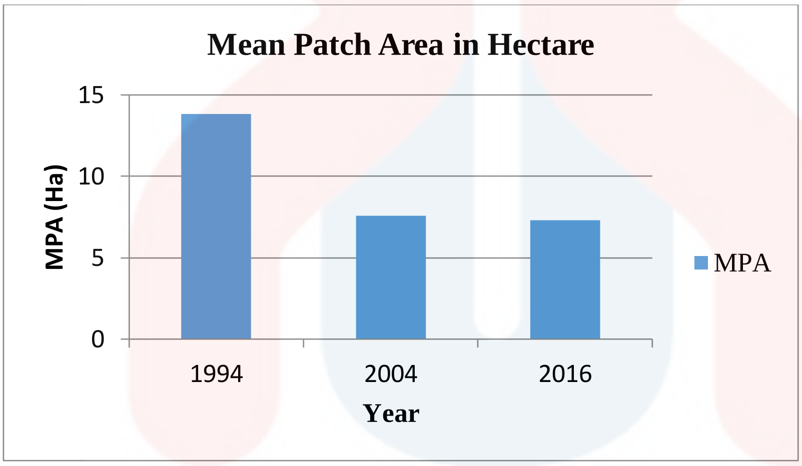

Figure 4.14: MPA in hectare at landscape level

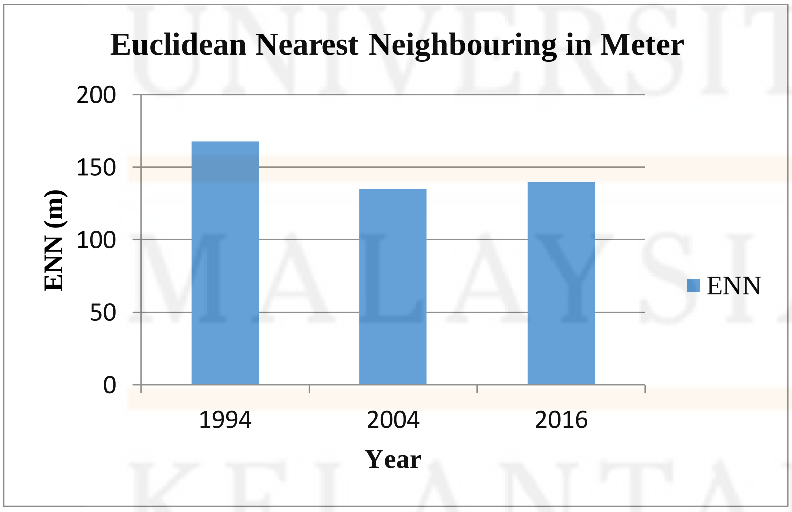

Figure 4.15: ENN in meter at landscape level

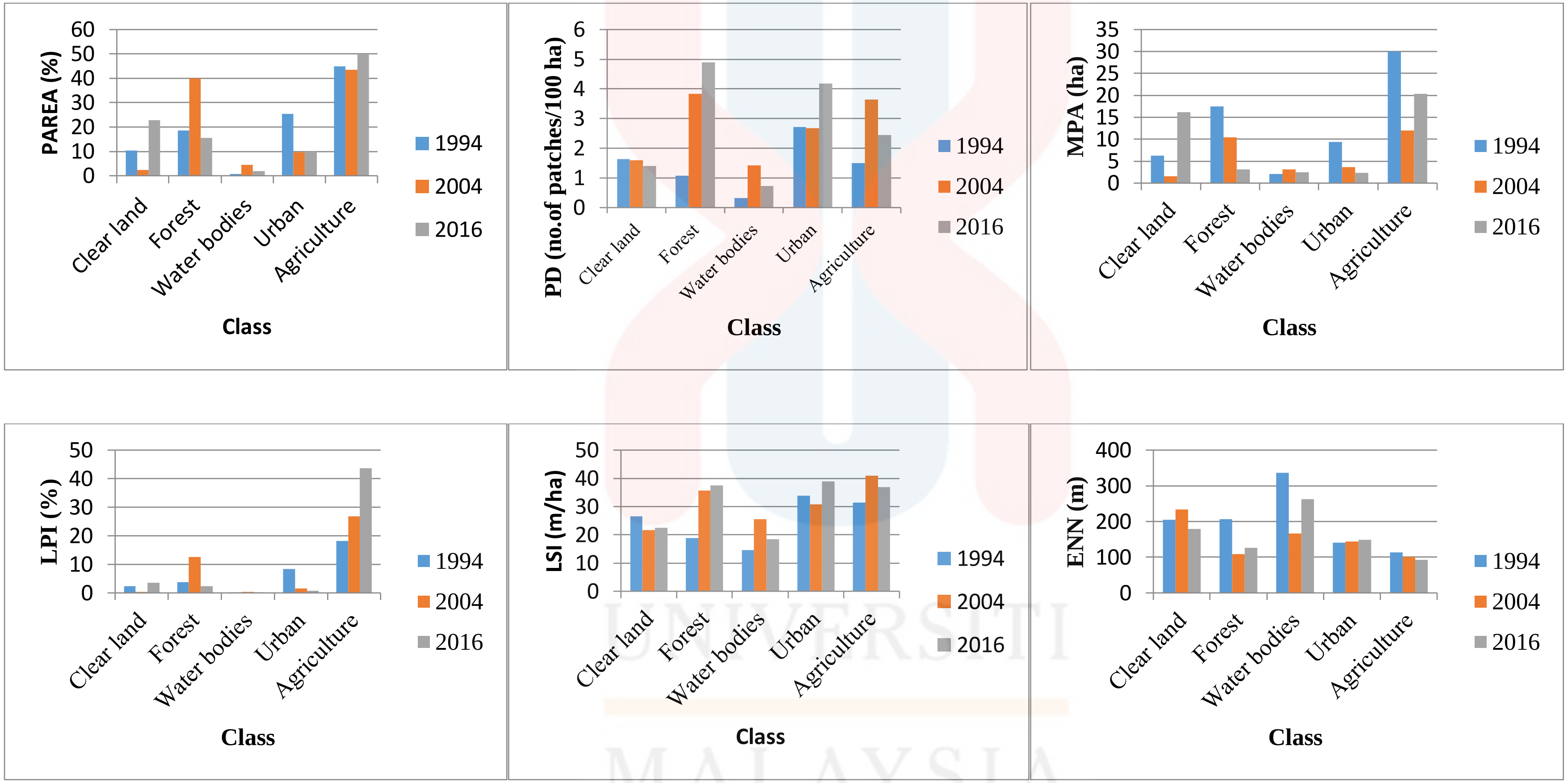

Figure 4.16: Comparison of metrics in class level at years 1994, 2004 and 2016

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 Conclusion

From this study, two outlined objectives have been achieved. Firstly, land use land cover in Bachok in 1994, 2004, and 2016 have been identified and classified in Chapter 4. Three land use maps and three NDVI maps also have been produced starting in year 1994, year 2004 and year 2016. The LULC of Bachok was classified into forest, agriculture, urban/built up land, clear land and water bodies. Secondly, change detection and spatial pattern changes on land use land cover also were quantified. The results show that forest class was decreased due to human activities of agriculture and built up area in Bachok. Finally, data analyses have been conducted by using statistical analysis. Landscape metric of ENN show the significant changes of LULC in Bachok. This study has shown and proved a change in land utilisation across Bachok in year 1994, 2004 and 2016. In this chapter, there are three outlines that were discussed which are land use change pattern in Bachok, limitation of study and recommendation.

5.2 Land Use Change Pattern

LULC in Bachok mostly predominant by agriculture class over these years and the number increases from year to year. Agriculture is one of the major sources of income and employment for residents in Bachok. The virgin or primary forest in Bachok has decreased significantly over the years with an unpredictable pattern conversion in other form of land utilization urban/built up land and clear land in

Bachok. Rapid utilization of land in term of crops plantation such as rubber and paddy consistently grow over the years. This changes in land use pattern indicated that socioeconomic activity in Bachok is primarily agriculture Other than that, utilization of land in Bachok by improving facilities especially in tourism development such as homestay or chalet nearby coastal area consistently grows over the years hence providing a side income by tourism sector to the resident in Bachok. It is because Bachok Town recently declared as The Islamic Tourism Town by the incumbent Menteri Besar Kelantan on December 2010. Implementation of a new policy focus on improving income of state by tourism attraction and at the same time to ensure the socioeconomic activity is safeguard in Bachok residents.

5.3 Limitation of study and recommendation

In this study, there are a few limitations which include time constraint, variability of available data from various sources, and data error. Firstly, time constraints are the major challenge in completing the process of many data through many technical steps. In order to process data, it involved many types of software that required long time span to learn and understands the various techniques involved. This will lead to a researcher consume plenty of time which later drag time to analyze the collected data in details and more accurate. Accurate output or data need to undergo repeating crucial process two or three times more.

Secondly, is the existing data such as land use maps of Bachok or Kelantan from different source are lack due to this study site never been study for land use land cover through previous research. This condition make the researcher's faced difficulty to formulate a standardized land use categories to make comparison over the past data and the present data. Besides, high probability also to produce error during classified land use land cover due to lack of readily maps that contain variety of land use attributes. As a recommendation, to support and strengthen reference data from satellite imagery, interview session at related department of land use land cover study need to been applied. For examples are Department of Agriculture, Department of Town and Village Planning other related agency.

Next limitation in this study is the error exists when coordinates from Google Earth that act as reference data in supervised classification through Erdas Imagine. Ground truth technique marked by certified GPS devices helps the classification result to be more accurate. Last but not least, low resolution quality of satellite imagery limits ability to perform accurate image classification hence produce a low quality of land use maps. Researcher be recommended to apply for high resolution satellite imagery from Agency Remote Sensing Malaysia (ARSM) in order to produce a detailed classification image and accurate of land use maps. Lastly, is few amendments regarding land use need to been construct in order to guide the Bachok land use planning in sustainable manner.

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APPENDICES

APPENDIX A Detail of satellite imagery information

Location	Satellite imagery	Path/ Row	Resolution	Date
Bachok	Landsat TM1994	127/56	30m	02/04/1994
	Global Land Survey	127/56	30m	03/08/2004
	Landsat 8	127/56	30m	03/07/2016

APPENDIX B Result of metrics in class level on year 1994, 2004 and 2016

Metric / Class	CA	PAREA	PD	LPI	LSI	MPA	ENN
Clear land	2893.68	10.29	1.64	2.42	26.62	6.29	205.13
Forest	5252.58	18.69	1.07	3.72	18.80	17.45	205.90
Water bodies	189.81	0.67	0.32	0.09	14.63	2.11	335.73
Urban	7134.66	25.38	2.71	8.47	33.84	9.37	140.26
Agriculture	12638.79	44.96	1.50	18.27	31.41	29.95	112.78

Metric / Class	CA	PAREA	PD	LPI	LSI	MPA	ENN
Clear land	686.88	2.44	1.59	0.41	21.72	1.54	233.20
Forest	11222.46	39.92	3.84	12.55	35.61	10.40	108.94
Waterbodies	1237.77	4.40	1.43	0.43	25.51	3.09	166.54
Urban	2725.47	9.69	2.67	1.48	30.81	3.63	144.50
Agriculture	12236.94	43.53	3.64	26.84	40.91	11.95	100.84

Metric / Class	CA	PAREA	PD	LPI	LSI	MPA	ENN
Clear land	6428.9	22.87	1.41	3.47	22.45	16.19	178.84
Forest	4363.5	15.52	4.89	2.32	37.40	3.17	127.11
Waterbodie	511.5	1.82	0.72	0.19	18.53	2.53	262.99
Urban	2790.5	9.93	4.19	0.82	38.93	2.37	148.24
Agriculture	14015.2	49.86	2.45	43.67	36.90	20.34	93.11

APPENDIX C Accuracy assessment

Accuracy assessment of year a) 1994, b) 2004 and c) 2016 of Bachok (the bold value indicate the number correct)

a) Year 1994

Types of land use land cover								
Classification	Forest		Urban/ built up	Clear land	Water bodies	Classified Total	Producer Accuracy (%)	User Accuracy (%)
Forest	**18**	Reference Data	1	1	3	20	73.91	85.00
Agriculture	2	Agriculture	2	2	7	47	75.00	82.98
Urban/built up	1	2	**23**	3	2	30	75.86	73.33
Clear land	1	3	2	**39**	2	50	80.43	74.00
Water bodies	1	1	1	1	**91**	108	99.05	96.30
Reference Total	23	52	29	46	105	255		
Overall accuracy (%) = 85.94 Kappa statistic = 0.8085								

a) Year 2004

Types of land use land cover	Reference Data							
Classification	Forest	Agriculture	Urban/ built up	Clear land	Water bodies	Classified Total	Producer Accuracy (%)	User Accuracy (%)
Forest	**53**	5	1	1	8	71	88.89	90.14
Agriculture	10	**41**	2	2	4	50	80.77	84.00
Urban/built up	3	2	**10**	2	2	11	64.71	100.00
Clear land	2	1	3	**9**	5	19	93.33	73.68
Water bodies	4	3	1	1	**81**	105	96.00	91.43
Reference Total	72	52	17	15	100	256		
Overall accuracy (%) = 88.67 Kappa statistic = 0.8415								

b) Year 2016

Types of land use land cover	Reference Data							
Classification	Forest	Agriculture	Urban/ built up	Clear land	Water bodies	Classified Total	Producer Accuracy (%)	User Accuracy (%)
Forest	**26**	7	2	1	6	35	88.24	85.71
Agriculture	4	**40**	1	2	5	48	80.00	91.67
Urban/built up	2	2	**28**	4	3	31	75.00	87.10
Clear land	1	3	3	**24**	2	34	90.63	85.29
Water bodies	1	3	2	1	**83**	108	100.00	91.67
Reference Total	34	55	36	32	99			
Overall accuracy (%) = 89.45 Kappa statistic = 0.8584								