SPATIAL AND TEMPORAL CHANGES OF URBAN FOREST IN JELI, KELANTAN

by

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A 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 hereby declare that the work embodied in this Report is the result of the original research and has not been submitted for higher degrees to any universities or institutions.

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Date : 26th January, 2021

I certify that the Report of this final year project entitled Spatial and Temporal Changes of Urban Forest in Jeli, Kelantan by Nur Zubaidah binti Baharudin, matric number E17A0099 has been examined and all correction recommended by the examiners have been done for the degree of Bachelor of Applied Science (Sustainable Science) with Honours Faculty of Earth Science, University Malaysia Kelantan.

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Spatial and Temporal Changes of Urban Forest In Jeli, Kelantan

ABSTRACT

The diverseness of land use purpose makes the landscape structure and planning are not well managed sustainably. The rapid growth of the residential and commercial areas in a country will affect an area's vegetation and ecosystem. For the time being, Jeli was facing the fact of losing its forest cover that had been a substitute with other purposes such as plantation and development. Therefore, this study was conducted to classify the land-use change of Jeli and analyze the urban forest changes of Jeli in year 1994, 2006 and 2018. In this study, three (3) satellite images of the study area in year 1994, 2006 and 2018 were processed and analyzed by conducting two methods that interconnected with each other; Remote sensing and Geographical Information System (GIS). The landscape patterns were analyzed using landscape metrics that were calculated by FRAGSTATS software. The analysis showed that the largest patch index (LPI) of Jeli in 2006 is higher, with 66.32% compared to year 1994 (60.86%) and 2018 (65.44%). The mean patch area (MPA) is decreasing throughout the year with 5.96 ha, 4.27 ha and 3.97 ha, respectively. The higher of LPI and increasing of MPS indicating that the patches is become fragmented. Moreover, the Euclidean nearest neighbor (ENN) value increased from year 2006 to year 2018, from 93.91 m to 109.42 m indicating that the distance patches is increased. The ANOVA test conducted within ENN and AREA's value shows that the ENN value of year 1994 is more significant ($p<0.05$) compared to year 2006 and 2018. Oppositely, the AREA's value was found significant for year 2006 and 2018. The results show that the green cover class was increased through years due to the changes of land use purpose where the land use such as vegetation and cleared land classes were replaced with green cover class. The outcomes from this study can be used to construct and improve a new and existing landscape planning by the decision-makers, stakeholders and sustainable planners.

Perubahan Ruang dan Temporal Hutan Bandar di Jeli, Kelantan

ABSTRAK

Kepelbagaian tujuan penggunaan tanah menjadikan struktur dan perancangan landskap tidak dikendalikan dengan baik secara lestari. Pertumbuhan pesat kawasan kediaman dan komersial di sesebuah negara akan mempengaruhi tumbuh-tumbuhan dan ekosistem suatu kawasan. Buat masa ini, Jeli berhadapan dengan fakta kehilangan tutupan hutannya yang telah diganti dengan kegunaan lain seperti perladangan dan pembangunan. Oleh itu, kajian ini dijalankan untuk mengklasifikasikan perubahan guna tanah di Jeli dan menganalisis perubahan hutan bandar di Jeli pada tahun 1994, 2006 dan 2018. Dalam kajian ini, tiga (3) gambar satelit kawasan kajian pada tahun 1994, 2006 dan 2018 telah diproses dan dianalisis dengan melakukan dua kaedah yang saling berkaitan antara satu sama lain; penginderaan jauh dan Sistem Maklumat Geografi (GIS). Corak lanskap dianalisis menggunakan metrik lanskap yang dihitung oleh perisian FRAGSTATS. Analisis menunjukkan bahawa indeks tampalan terbesar (LPI) Jeli pada tahun 2006 lebih tinggi dengan 66.32% berbanding tahun 1994 (60.86%) dan 2018 (65.44%). MPA menurun sepanjang tahun dengan masing-masing 5.96 ha, 4.27 ha dan 3.97 ha. Peningkatan LPI dan penurunan MPA menunjukkan bahawa tampalan menjadi berpecah-belah. Tambahan pula, nilai kawasan terdekat Euclidean (ENN) meningkat dari tahun 2006 hingga tahun 2018, dari 93.91 m menjadi 109.42 m menunjukkan bahawa jarak antara tampalan bertambah. Ujian ANOVA yang dijalankan menggunakan nilai ENN dan AREA menunjukkan bahawa nilai ENN tahun 1994 lebih signifikan ($p < 0.05$) berbanding tahun 2006 dan 2018. Sebaliknya, nilai AREA didapati signifikan bagi tahun 2006 dan 2018. Hasilnya menunjukkan bahawa kelas penutup hijau meningkat selama tempoh kajian kerana perubahan tujuan penggunaan tanah di mana penggunaan tanah seperti kelas tumbuh-tumbuhan dan kelas tanah bersih diganti dengan kelas penutup hijau. Hasil dari kajian ini dapat digunakan untuk membangun dan memperbaiki perancangan landskap baru dan sedia ada oleh pembuat keputusan, pihak berkepentingan dan perancang kelestarian.

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LIST OF ABBREVIATIONS

N	North
E	East
FAO	Food and Agriculture Organization
GIS	Geographic Information System
NIR	Near Infrared
NDVI	Normal Difference Vegetation Index
TM	Thematic Mapper
OLI	Operational Land Imager
TIRS	Thermal Infrared Sensor
GADM	Global Administrative Area
TIFF	Tagged Image File Format
AOI	Area of Interest
MLP	Multilayer Peceptron
PAREA	Percentage Area
PD	Patch Density
MPA	Mean Patch Area
LPI	Largest Patch Index
LSI	Largest Shape Index
LULC	Land Use Land Cover
ENN	Euclidean Nearest Neighbour
ANOVA	Analysis of Variance
SPSS	Statistical Package Social Science
LCM	Land Change Modeler

ENVI	Environment for Visualizing Images
REDD	Reducing Emission from Deforestation and Forest Degradation
ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System

LIST OF SYMBOLS

kha	Kilohectares
%	Percentages
ha	Hectares
m	Meter
<	Less than

CHAPTER 1

INTRODUCTION

The world nowadays is witnessing the population growth and rapid expansion of the cities. The process of urbanization drives towards the changes in the global environmental make the ecosystem services decreasing (Gómez-Baggethun & Barton, 2013; Amini et al., 2019). The urbanization altered and expanded the economies widely and made changes in population distribution, production mode, and the environment (Shang et al., 2018). The improper management of urban planning will greatly impact ecological, social, biophysical and climates, including urban forest (IPCC, 2007; Xian, 2016).

In many developing countries, more people will be moving into urban areas within years. Rosly (2013) stated that the populations of people in the world are expected to increase within 2050 and the population in the urban areas will be mounting from 3.3 billion in 2008 to 6.4 billion in 2050.

The urban area population rate in the world had increased by 4% after a decade where 4.3 billion of the world populations are living in urban areas in the first half of 2020 (Worldometers, 2020). The world populations are currently (2020) growing at a rate of 1.05% per year declining from

1.08% in 2019, 1.10% in 2018 and 1.12% in 2017. By the end of the century, the decreasing pattern of growth rate will be resulted in an annual growth with less than 0.1% and will be overloading with 10.1 billion people (Cilluffoo & Ruiz, 2019).

The effect of urban land use is more crucial towards the environment compared to the spatial extent because the urban land cover is substantial element for the regional and global environment (Xian, 2016). Urban land may affect land and water characteristics through the pollution of air, water and land (Yan et al., 2016; Battista & de Lieto Vollaro, 2017; Patra et al., 2018). Besides that, the residents in the cities are facing with the noise pollution produced by the vehicles and household heating system (Panagopoulos et al., 2015). Some of the cities in the world are facing with the aggressiveness of climate change where the changes in temperature happened and the occasion of coastal erosion, loss of wetlands and storm billow are taking place due to the improper urban planning (Panagopoulos et al., 2015).

Land use consists of crops, vegetation, grasslands, roads, buildings, water, forest and urban development. Many changes in the patterns of land use, motivated by a variety of social factors, result in land-based changes affecting biodiversity, water and radiation budgets, trace gas emissions and other processes that may influence climate and biosphere (Riebsame et al., 1994).

The urban forest is defined as the group of trees presented as the connection between all forests, groups of trees either in parks or city's gardens and individual trees at the streets and derelict corners in urban and suburban areas (Kanniah & Siong, 2017). Trees planted in urban areas can be fundamental in treating the environment since it can diminish climate change by removing contaminated air (Selmi et al., 2016). A study by Greene and Millward (2017) stated that urban forests could also deplete the air temperature via transpiration.

However, the world forest areas show a decreasing trend from 31.6% of the global land area in 1990 to 30.6% in 2015 because of urbanization, land-use change, agricultural activities and human needs (FAO, 2018). The forest areas in the world lost by 0.9% in the past 15 years from 2004 to 2019. This trend shows that every year, forests in the world will face the possibility of losing more forest areas. For example, Africa had the highest rate of urbanization between 1995 and 2015 and needed more land for development purposes (United Nations, 2014).

Urban planning is well known for focusing more on the growth of economic sectors than on natural worth and environmental sustainability. The designing and directing of landscape in the future remain difficult and inconsistent (Panagopoulos et al., 2015). Potschin and Haines-Young (2006) stated that the lands are impossible to be sustainable, except with the approach of proper planning and management are taken by decision-makers and planners.

1.1 Background of study

The rapid growth of residential and commercial areas will critically affect the vegetation and ecosystem of an area (Shojanoori & Shafri, 2016), leading to various environmental issues including soil degradation, water pollution and deforestation. According to the Global Environmental Performance Index (EPI, 2018), Malaysia had ranked 136th out of 151 countries in the world with a high loss of forest cover. This is primarily due to unsustainable planning of land-use and forest (Zulkofli et al., 2018).

WWF Malaysia (2020) reported about 4.9 million hectares of forest cover loss in Malaysia between 1983 and 2003, with the remaining forest cover is facing a threat from unsustainable logging, illegal discarding of forestry products and trespassing. The study conducted by Kanniah and Siong (2017) indicated decreases in the forest covers between 2000 and 2012 in Kuala Lumpur, Penang, Pasir Gudang and Johor Bharu with about 3.5 %, 6.9%, 17.4% and 9.5% of total land cover, respectively.

This study focused on the urban forest changes in Jeli, Kelantan. Statistic provided by Global Forest Watch (2018), the Jeli area was covered with 90% of natural forest which equivalent to 86.1 kha in 2010. Along with the development that occurred, the Jeli area is facing the loss of forest cover and in 2018, 248 ha of the natural forest had found loss. For the time being, Jeli lost 23.9 kha of natural forest and been replaced with a plantation (Global Forest Watch, 2018).

Rapid development has become the most significant concern toward the urban sustainability approach around the world, including Malaysia (Pili et al., 2017). The development of the metropolitan area with strategic planning will make sustainable development that can be approached by conserving and growing the ecosystem facilities (Askerlund and Almers, 2016; Rasli et al., 2019). Remote sensing and GIS are the necessary tools used in acquiring accurate and real-time spatial data of land use because it can record the situation of land use efficiently with an acceptable source of data and allocate a suitable platform for the processes of collecting, storing, displaying and analyzing the data (Singh et al., 2017; Liping et al., 2018).

1.2 Problem statement

Jeli district is known for the broad coverage of green landscapes and forests that covered the majority of the area. Many developments had occurred in Jeli, where many areas with buildings and facilities were expanded from the past few years (Jeli District Council, 2015). Along the process of development, many changes towards the land use had occurred. Due to urbanization, the eradication of forest will affect the flora and fauna habitat, conflict between human-wildlife will arise and changes in the ecosystem in the forest.

Urban planning is necessary for managing landscapes worldwide by applied more approaches towards the sustainable planning. Challenges in managing land use will arise along with the changes in the global climate, growing of societal anticipation and population. The improper urban planning in a country will have negative impacts on the country's environment. When urbanization is growing rapidly and deficiently planned, this can lead to the increasing of risk (UNDDR, 2015). For example, housing with inadequate sanitation, water resources, health care and education will affect the capability of urban residents to retrieve (UNDDR, 2015).

The previous study in analyzing the urban land use and forest areas in Jeli, Kelantan is limited. Therefore, this study is conducted using the remote sensing technique, Geographic Information System (GIS) and landscape ecological approach. The gap in the knowledge from the past research can be improvised by the use of Geographic Information System and remote sensing in the process of classifying the land use and analyzing the urban forest changes in Jeli area.

1.3 Objectives

The objectives of this study are:

i. To classify the land use of Jeli, Kelantan in year 1994, 2006 and 2018.
ii. To analyze the landscape changes of the urban forest in Jeli, Kelantan in 1994, 2006 and 2018.

1.4 Scope of study

This study aims to determine the changes over the past 25 years and the future planning of urban forests in Jeli, Kelantan. The issues of transformation of forest area to the urban area will lead to the forest loss and changes in ecosystems, which resulted from the construction materials and as land sources. By using remote sensing and GIS techniques, the changes of the land use and urban forest in Jeli, Kelantan was classified and analyzed. Below is the research framework (Figure 1.1):-

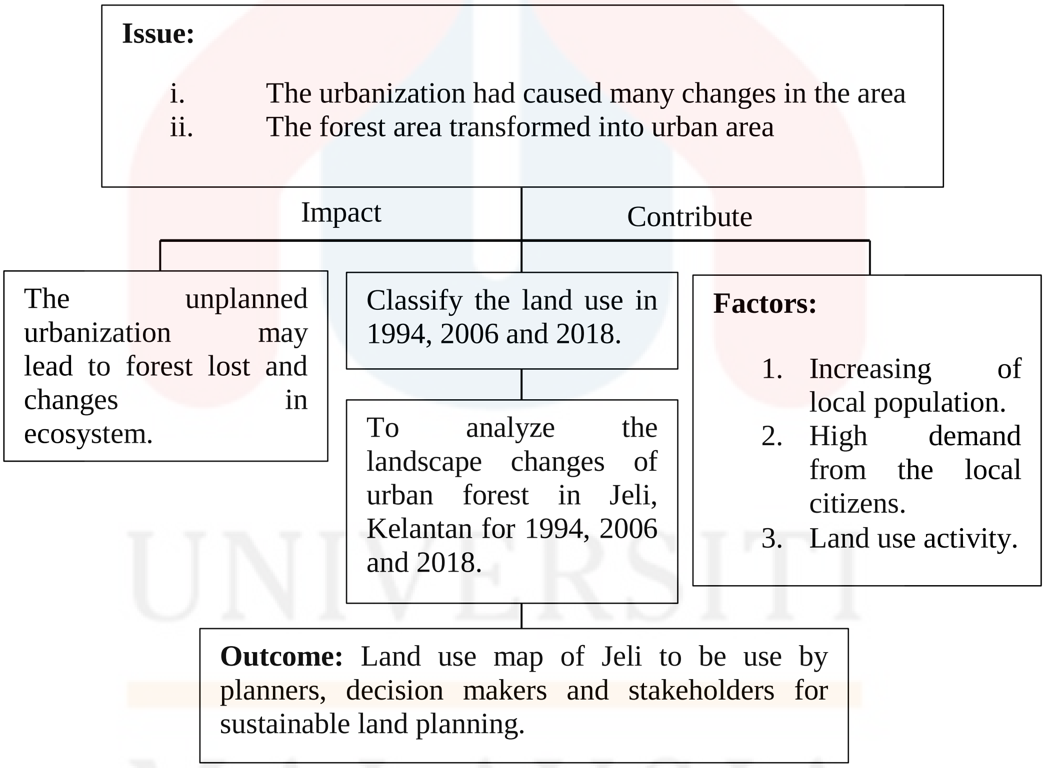


Figure 1.1: Research Frameworks for urban forest changes study.

1.5 Significant of study

The main goal of this study to be conducted in Jeli, Kelantan is to classify the land-use change and to analyze the pattern of the urban forest in year 1994, 2006 and 2018. In the present situation of Jeli area, deforestation activity tends to happen because Jeli area is still in the developing phase. Despite that, many forest areas are cleared to develop a new building, facilities, road and more.

This research is conducted to achieve the target of future planning for conserving forests in the Jeli district along with the development that happens. The finding of this study can be used for strategic sustainable land planning to have a good plan for development in the future while conserving the environment, in line with the goal of Sustainable Cities and Communities (Goal 11) in Sustainable Development Goals (SDGs).

CHAPTER 2

LITERATURE REVIEW

2.1 Urbanization

Urbanization is the process of where a country will going through the phase of increasing urban share and experiencing economic growth which is a fundamental component in the concept of industrialization (Fan, 2017; Shang et al., 2018). All countries that facing the urbanization process will be experiencing the changes in the population array, production trend, lifestyle and ecological of mother earth (Shang et al., 2018).

Urban areas will enlarge widely to hold the increase of population growth and migration tendency (Endreney, 2018). The high attention gain by the urban areas because of investors from many countries and the job occasion had become the greatest contributor to urban development due to the migration from rural to urban areas (Shang et al., 2018).

A city with a population ranging from 500,000 to 1 million will become a home for more than 365 million people (Xian, 2016). The increasing of the world population in the next four decades may contribute to an extensive range of urban development processes along with the development in rural areas (Rosly, 2013**).**

Malaysia constitutes 0.42% of the world population (32.3 million people) in 2020, of which 78.2% of the total population are living in urban areas (Worldometers, 2020). The trend of population growth in Malaysia has decreased by 0.59% over the past 10 years from 2010 to 2020, with the growth rate of 1.89% and 1.30%, respectively (Worldometers, 2020). However, it is predicted that 89.9% of the Malaysian population will be living in urban areas in 2050 (Worldometers, 2020).

Kelantan is one of the states in Malaysia, consists of ten districts. Jeli is one of the districts in Kelantan that facing development with many facilities built in the city (Karim, 2013). The total population in Jeli, Kelantan was 50,900 in 2018, with 2.1% of growth rate. The pattern of growth rate from 2016 to 2018 is decreasing (DOSM, 2018). Approximately 0.16% of the Malaysian population are from Jeli, Kelantan. The decreasing pattern of populations in Jeli can lead to a higher demand for land use by the residents.

2.2 Urban forest

Urban forests consist of trees planted along the street of the urban area, which comprises city parks and urban forests of more than 15 hectares, pocket parks and gardens with trees (Endreney, 2018). The urban forest significantly can reduce stormwater runoff, lowering wildfire threat and sternness, depleting urban heat island and capable of cutting off the carbon dioxide (CO_2) in the atmosphere and can help in reducing the climate changes (Papa & Cooper, 2019).

Trees are often removed for the development purpose. The study conducted by Kanniah and Siong (2017) shows that the main cities in Malaysia; Pasir Gudang, Johor Bharu, Penang and Kuala Lumpur were facing with trees loss from 2000 to 2012 due to the development process. The loss of tree covers in Malaysia can be related to the discordancy of policies between economic development and environmental protection (Kanniah & Siong, 2017). Lack of strategies and planning can also be one of the barriers slowing the amplification of an urban forest.

The study conducted by Karim (2013) shows a declining trend for the distribution of the forest in Jeli, Kelantan from the year 1994 to 2012. According to the study, the process of urban land accretion also occurred throughout the years with many expansion and refinements of facilities happen. The distribution of forest areas in Jeli had shown a drastic dropped with -0.76% in 2014 compared to the year before.

The study conducted by Kanniah (2017) had shown the changes in green cover in Kuala Lumpur between 2000 and 2012 (3.5%). The study was lacking with the information in identifying the urban pattern changes and structure for prediction. The policies and legislation in Malaysia are not specifically relevant to protect and manage the urban forest, although the green cover in the urban area is more recognizable lately (Kanniah, 2017).

It is important to quantify the land-use change and urban forest pattern for Jeli to provide the land use map information for the municipal district of Jeli. Remote sensing and GIS application can be used to classify and analyze the changes in land-use change and the urban forest in this study.

2.3 Remote sensing and geographical approach (GIS)

Remote sensing is the acquisition of the images of targeted objects in the form of visible and near-infrared using the borne camera such as aircraft or spacecraft (Owoeye & Ashaolu, 2017). American Society of Photogrammetry (ASP; 1983) and Sabin (1986) stated that remote sensing is the accession of data about things without doing any physical contact. The process of remote sensing is engaged with the electromagnetic energy, either light, heat or radio waves to ascertain and analyze the object features.

Geographical Information System (GIS) is the system that capturing, storing, querying, analyzing and displaying geo-spatial data (Cheng, 2012; Owoeye & Ashaolu, 2017). The geo-spatial data of GIS differ from other information systems because of the credentials of GIS to operate and assimilate the data obtained.

Remote sensing and GIS can generate real-time geospatial data and support sustainable development activities (Acharya & Lee, 2019). Both remote sensing and GIS are power tools that are very important to be used in many different fields such as geology, environment, agriculture, disaster management, hydrology and urban planning.

The analysis and quantification of a spatial-temporal study conducted by Rawat & Kumar (2015) indicated that remote sensing and GIS are essential tools to conduct the spatial-temporal dynamic study of land use or land cover in comparison with the conventional mapping approach (Owoeye & Ashaolu, 2017). That is, the tools were used to show the difference in the distribution of vegetation, agriculture, barren, built-up and water body for selected years.

Urban planning can be categorized into administration, development control, plan-making and strategic planning as it constitutes many sectors and roles at different scales and levels (Owoeye & Ashaolu, 2017). Remote sensing and GIS have been widely used for a variety use of analysis, including urban growth (Rosly, 2013), land use or land cover changes (Karim, 2013), urban sprawl mapping and measurement (Fabiyi, 2006) and urban hazard assessment (Jiang et al., 2018). The use of remote sensing and GIS will support in the planning of landscape ecology for future development.

2.4 Landscape ecological approach

The landscape is a land that consists of a specific pattern that affects and affected by the ecological process (Turner et al., 2001). Landscape ecology is the study of the arrangement and interaction of the ecosystem with the area of interest and effects of the interaction on the ecological process, particularly the impact of spatial heterogeneity towards the interaction (Clark, 2010).

The approach of patch-corridor-matrix is constitutionally promoted by imaging and mapping technology to landscape ecology (Clark, 2010). The matrix is the majority surrounding of the landscape and the large ratio of a landscape (Clark, 2010). Landscape metrics are one of the fundamental tools for detecting the changes in the landscape.

Landscape metrics tools are used as a supporting landscape planning and landscape management decision (Gkyer, 2013). The knowledge of metrics covers the visual, ecological and cultural perspectives of the landscape. These metrics can be used to evaluate the area, shape, core area, nearest neighbor distances, isolation and connection in patch, class or landscape level (Kumar et al., 2018). Previous researchers have proved the applications of landscape metrics to illustrate the spatial-temporal dynamic study of landscape change (Singh et al., 2016; Kumar et al., 2018).

Many advantages to landscape ecology studies have been made by using landscape metrics. As reported by Letiao and Ahern (2002) and Miller and friends (2005), the connection between landscape layout and landscape feature with landscape metrics is identified, whereas the impact of planning practices on ecological processes is calculated. Landscapes metrics also can be are used to determine the alterations in the landscape structure over time (Letiao & Ahern, 2002; Miller et al., 2005).

2.5 Sustainable planning

Globally, the fight for sustainability is fundamental (Liang et al., 2020). Over two decades ago, small and medium-sized cities worldwide had experienced urban growth, leading to a dramatic rise in metropolitan areas (Angel et al., 2016; Soria et al., 2019). The process of development is faster, with an increasing rate of poverty and weak charges of land-use change (Glaeser, 2014).

Sustainable urban planning encompasses a wide variety of disciplines such as transportation, education, medication, economics, environment, government, energy, and technology. This trend of planning introduces inventive and realistic solutions to land use and its effect on natural resources. The effective sustainable planning of land use helps to enhance people's welfare and their communities as well as to make the urban areas and neighborhoods healthier.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

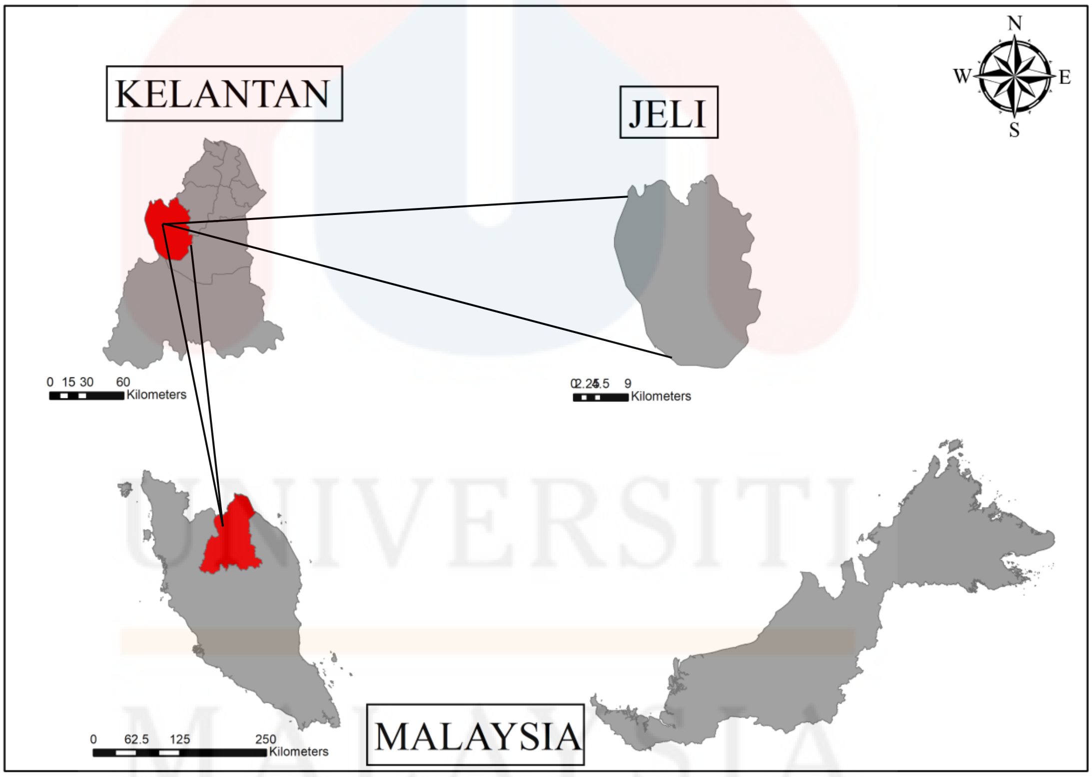


Figure 3.1: The study area of Jeli in Kelantan, Malaysia.

Kelantan is one of the states in Malaysia which consists of ten districts. It is located in the north of Peninsular Malaysia (Figure 3.1). The capital and royal seat of Kelantan is Kota Bharu. The total area of Kelantan is 1,510,868.72 hectares and is located at coordinates of 6° 8' 23.5392" N and 102° 14' 31.9308" E.

One of the districts in Kelantan is Jeli. The total area of Jeli is 13,300 hectares and located in the north-west of Kelantan (coordinate of 5° 42' 2.516” N and 101° 50' 35.344” E). Jeli area can be entered from the west via Gerik, from the east via Tanah Merah and Kuala Krai from the south. Based on the Department of Statistic Malaysia (2018), the total population of Jeli in 2018 is 50, 900, which is 0.16% of Malaysia’s total population.

Jeli is one of the districts that is still facing the development process and have high coverage of forest area. Thus it is chosen as the study area to achieve the objectives of this study, which are to classify and to analyze the land use and urban forest changes in 1994, 2006 and 2018.

3.2 Methodology

This study involves four major stages comprising data collection, pre-processing of the image, post-processing of image and the analysis of data (Figure 3.2).

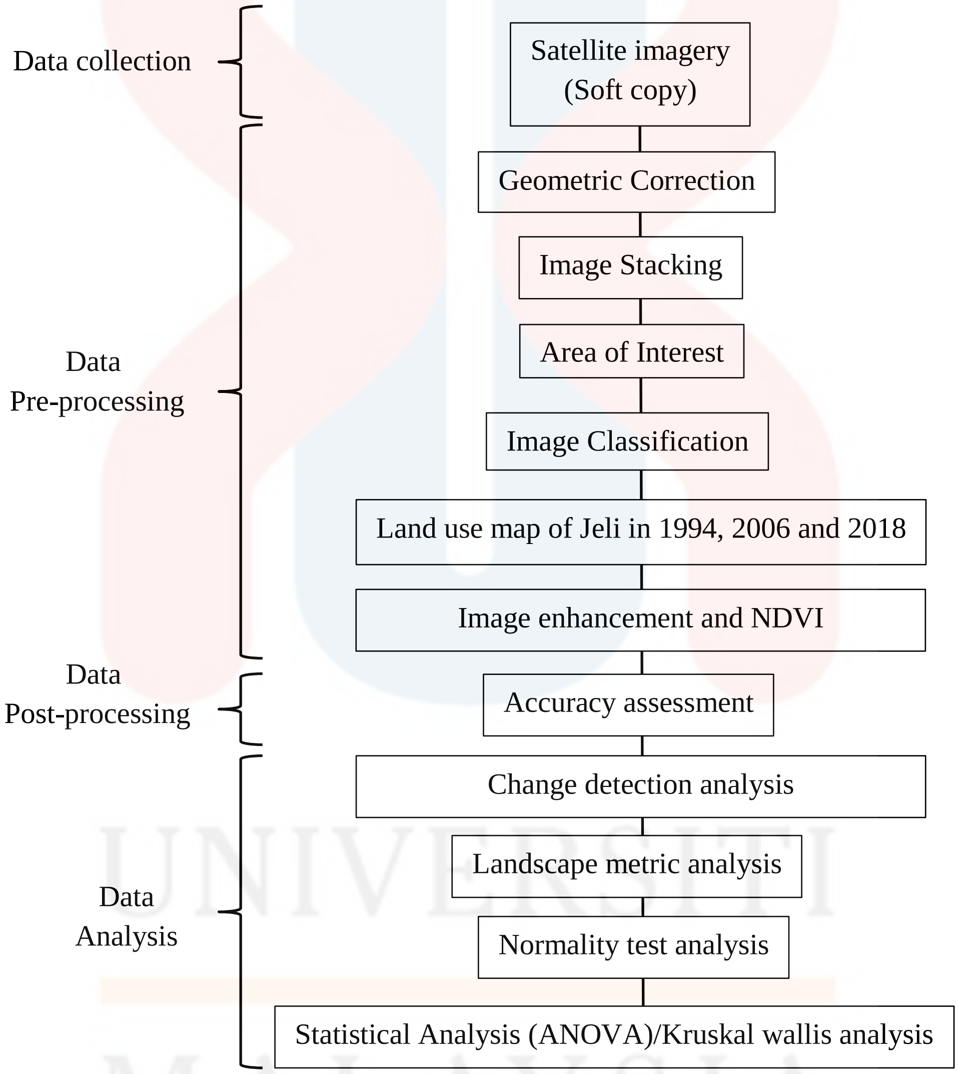


Figure 3.2: Methodological framework for urban forest changes study.

3.2.1 Data collection

Data of Jeli, Kelantan was collected from the Landsat satellite imagery for the years of 1994, 2006 and 2018, giving 12-years interval over the study period. The satellite imagery had been downloaded from the United States Geological Survey (USGS; https://earthexplorer.usgs.gov/). The satellite imageries for 1994 and 2006 were obtained from the Landsat-4 Thematic Mapper (TM), while the satellite imagery for 2018 was obtained from the Landsat-8 Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). The boundary of the Jeli District for all three images was obtained from the Global Administrative Area (GADM) in shapefile (.shp) format. The elevation data of Jeli was downloaded from the Earth Explorer in GeoTIFF format.

3.2.2 Data pre-processing

The geometric correction was used for pre-processing in pre-process remotely sensed data to decrease the geometric distortion (Baboo and Thirunavukkarasu, 2014). The data pre-processing involved image stacking, image subset, image enhancement and image classification by using ENVI Classic software and also ArcGIS. The image stacking made several images combined becoming an image. This refers to the combination of Band 1, 2, 3, 4, and 5 of the images in one image compromising both spatial and temporal components (Amrita & Rashmi, 2012) and had been used in this study. After that, the images were converted into a tagged image file format (TIFF). The data of the Jeli district boundary that had been collected from

GADM contain a high-resolution database of the country administrative area and had been used to subset the images into the area of interest (AOI).

After the images were processed, the image classification process was done. Image classification was a process where the images were sorted and classified into their specific group by generating thematic maps (Xie et al., 2015; Abu et al., 2019). The architecture of Multilayer Perceptron (MLP) was one of the algorithms that had been used frequently in image classification (Manaf et al., 2018). The input layer presented the image used which corresponded to one band while the hidden layer was used for computation where the number of the layer was decided by the researcher and the output layer presented the classification image (Mustapha et al., 2010; Manaf et al., 2018).

The supervised classification was the method that had been used in this study. This method had been constantly used by researchers for quantitatively analyze the satellite images (Richard, 2013; Rwanga and Ndambuki, 2017). Land use classification was the process of sorting the uses of land based on their natural environment and urbanization (Mahmon et al., 2015). Land use classification in Jeli had been classified into a built-up area, green space, waterbody, agriculture and cleared land (Table 3.1). Google Earth (https://earth.google.com/web/) was used for references in the classification process of land use and for the determination of coordinate accuracy of the land use classification by the coordinate system in Google Earth.

Table 3.1: Definition of land use classification.

Land use classification	Description
Built-up area	Areas categorized by buildings, asphalt, concrete, sub-urban garden and systematic street pattern. Urban development includes residential, commercial, industrial, transportation and utilities.
Greenspace	The term urban forest often used to describe green space. Made up from the primary forest, naturally regenerated forest and planted forest.
Waterbody	Areas that occupied by major rivers, lakes and reservoirs
Agriculture	Sum of arable land, permanent crops, permanent meadow and pastures including oil palm, livestock, fishery, forestry, logging, rubber and paddy.
Cleared land	Land with less than one-third of the areas cover with vegetation or other covers and also have thin soil, sand and rock.

(Source: FAO, 2020)

Image enhancement was conducted for image adjustment and made it suitable for human vision. Image enhancement techniques included the gray-scale conversion, histogram conversion, color composition and color conversion between red, green and blue (RGB) and habitat suitability index (HIS) (Amrita & Rashmi, 2012). Besides that, the contrast manipulation is also necessary to be done and had been used in the most visual analysis (Amrita & Rashmi, 2012). Normalized Difference Vegetation Index (NDVI) in ENVI Classic software was used to differentiate the vegetation and non-vegetation area. It involves the function of a ratio from near-infrared (NIR) and red bands to detect the green vegetation (Morawitz et al., 2006) and can improve the result from classification. The vegetation density was identified from the value of NDVI.

3.2.3 Data post-processing

The quality of the classification result was determined by conducting the accuracy assessment procedure in the ENVI Classic software. The accuracy assessment generated the statistic of the output based on the presence error matrix, overall accuracy and Kappa statistic (Jog & Dixit, 2016). Data of accuracy obtained from Google Earth was used in the accuracy assessment process. Accuracy assessment is vital to compare the existing data with the results obtained. The raster data obtained from the accuracy assessment method was converted into the shapefile (.shp) format to analyze the change detection easily.

3.2.4 Data analysis

a) Change detection analysis

The amount of forest converted to the built-up area and other land uses year 1994, 2006 and 2018 was determined by using the change detection analysis in ArcGIS software. This analysis consists of two steps; the first one was the spatial changes that determined the percentage of area for land use classification for each year. The second step was the transition changed that determined the changes in the percentage area between different and same classes for that respective year. The overlay was done between the year 1994 with 2006 and 2006 with 2018. The percentages obtained were calculated and transformed into transition matric and spatial changes graph. The changes in spatial structures of the green area of Jeli in 1994, 2006 and 2018 were analyzed at landscape, class and levels (Nor et al., 2017).

b) Landscape structure analysis

The landscape metrics that were used in this study are patch density (PD), mean patch area (MPA/ha), largest patch index (LPI/%), landscape shape index (LSI; m/ha), Euclidean nearest neighbor distance (ENN/m) and percentage of the area (PAREA/%). Those metrics were analyzed using FRAGSTATS software. The significance of landscape metrics had undergone the normality test and Analysis of Variance (ANOVA)/ Kruskal Wallis in SPSS software to analyze the level of fragmentation in land use.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Pre-processing results

The seven subtopics highlighted include the research area, data collection, processed data, land use map of Jeli in three years (1994, 2006 and 2018), land-use change in Jeli, spatial pattern changes and land use prediction of Jeli in year 2030. All of these subtopics were discussed in more specified and cover the crucial part of the research finding. The satellite imagery of Jeli in year 1994, 2006 and 2018 undergoes the geometric correction to improve the quality of the image during pre-processing.

4.1.1 Geometric correction

The geometric correction was conducted to make the satellite image can match correctly with the projection conducted, prevent any error from occurring and have correct coordinates for each pixel (Baboo and Thirunavukkarasu, 2014). The image needs to correct based on the geo-referencing data that was available. This study had allocated the image metadata correctly, including the types of projection, size of pixels, scales, resolutions and Landsat imagery layer. Multispectral data involved in this study were Landsat layer 1, layer 2, layer 3, layer 4, layer 5, layer 6 and layer 7 for the layer stacking image processed.

4.1.2 Image subset and boundary

The satellite image obtained from the USGS had a wide coverage area which beyond the study area. Therefore, the image subset process was carried out by clip only the area of interest. The boundary polygon of research area was imported from the GADM to distinguish the area of interest for one location. The results of image subset before and after the process were shown in Figure 4.1 and 4.2.

4.1.3 Image enhancement

The process of image enhancement was needed to improve the appearance of image data in the visual excellence between features in the scene as shown in Figure 4.3. Satellite images that presence with noised and blurred was undergoing the image enhancement process to improve the quality of the image. Image enhancement was applied to the selected satellite image by using the image enhancement technique through spatial filtering by using the median filter (3x3).

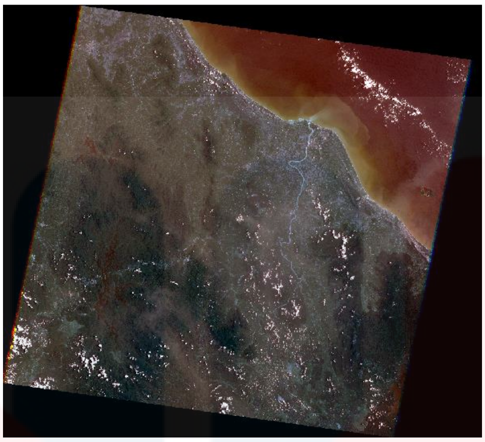


Figure 4.1: Raw image of satellite image before subset.

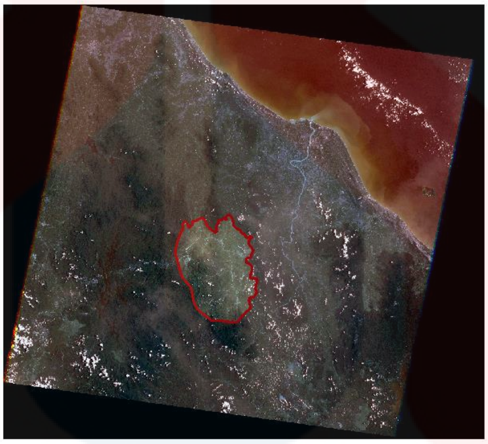


Figure 4.2: Satellite image after subset.

Figure 4.3: Satellite image after image enhancement.

4.1.4 Normalized Difference Vegetation Index (NDVI)

The vegetation indices method that mostly be used is NDVI. This method enabled to monitor between the vegetation and non-vegetation features in the satellite image. The performance of NDVI was based on the density in the range of -1 until +1. From the density, NDVI through the year 1994, 2006 and 2018 were classified into five groups which were very poor, poor, moderate, high and very high. The healthier vegetation has higher vegetation density which near +1 on NDVI. From Figure 4.4, 4.5 and 4.6, the best NDVI performance can be seen from year 2018 compared to year 1994 and 2006 due to the good quality of the satellite image used in the study.

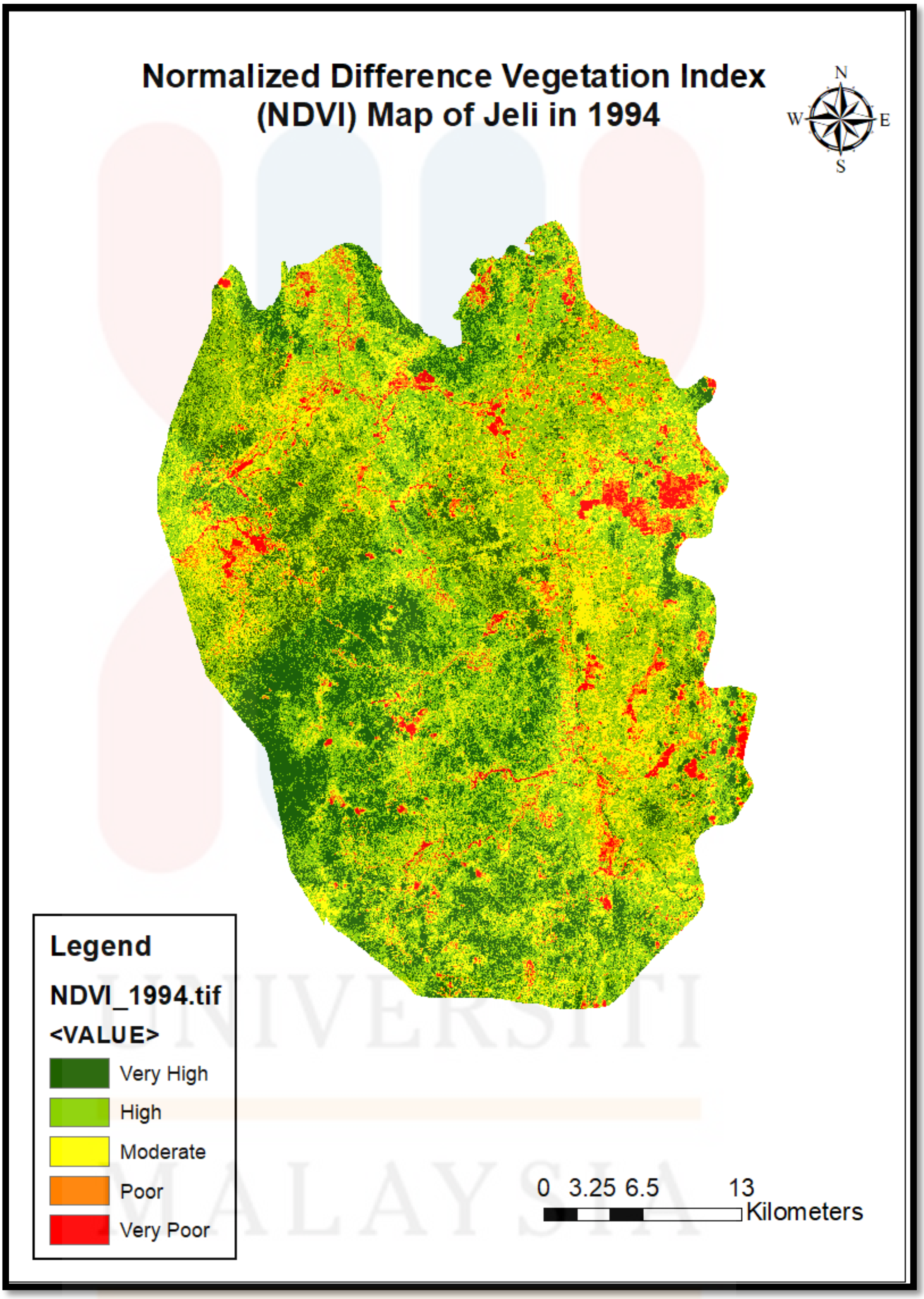


Figure 4.4: NDVI Map of Jeli in 1994.

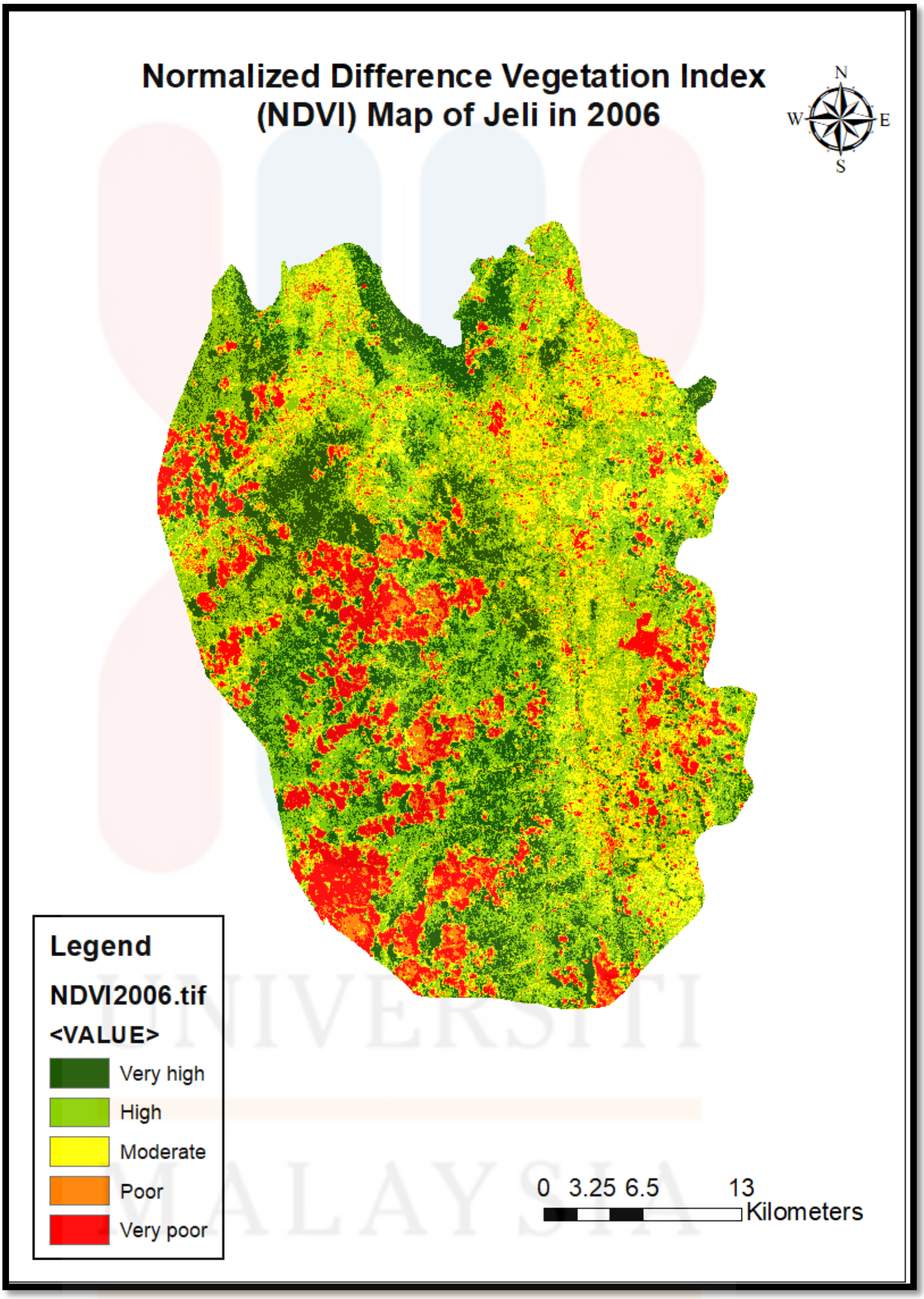


Figure 4.5: NDVI map of Jeli in 2006.

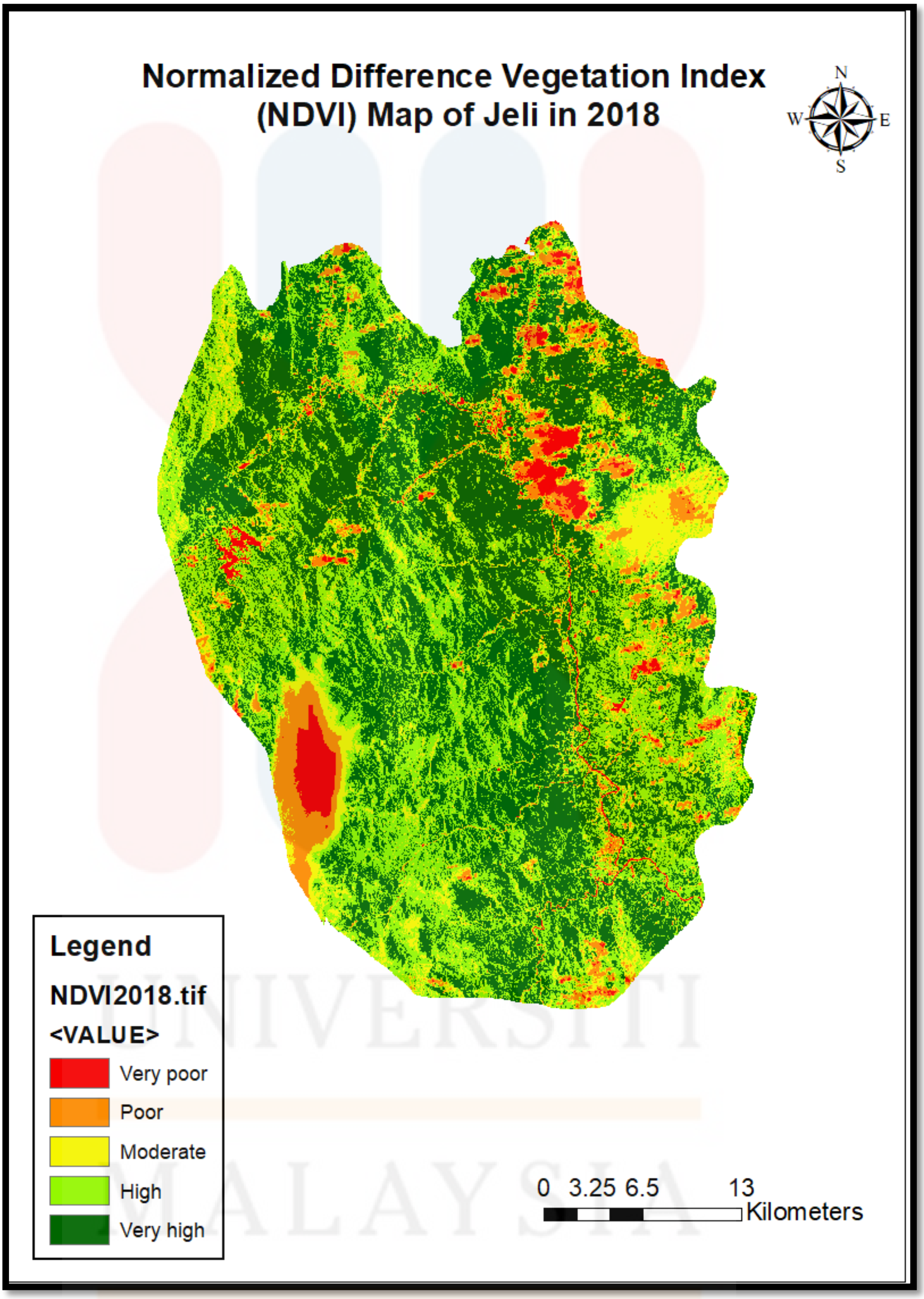


Figure 4.6: NDVI map of Jeli in 2018.

4.2 Accuracy assessment

Accuracy assessment is compulsory in the evaluation of the final image quality that produced from the process of image classification. The method of accuracy assessment conducted in this study was Error Matrix. This assessment was done to identify the overall misclassification and error that occurred for each classification category by sorting them into user and producer accuracy. Table 4.1 shows that 76.67% of pixels were classified correctly in Landsat TM 1994, compared to Landsat TM 2006 and Landsat 8 2018 with 83.33% and 90%, respectively. The highest accuracy shown from Landsat 8 because of the satellite imagery used was the latest version. However, the lowest accuracy showed by Landsat TM 1994 probably because the presence of clouds cover or error occurred during the training selection.

Table 4.1: Overall accuracy and Kappa statistic.

Satellite image/Year	Landsat TM 1994	Landsat TM 2006	Landsat 8 2018
Overall Accuracy (%)	76.67	83.33	90.00
Kappa Statistic	0.97	0.96	0.91

4.3 Land use map of Jeli in year 1994, 2006 and 2018

There were three land use maps produced by the end of this study (Figure 4.7, 4.8 and 4.9). The attribute data from the GIS database were transferred into Microsoft Excel and FRAGSTATS software for further statistical analysis. The three maps produced from year 1994, 2006 and 2018 were discussed briefly on their data in this part, respectively.

4.3.1 Land use map of Jeli in year 1994

The total area of 143234 ha of Jeli was made up of 3.19% of green cover and 2.13% of the land in Jeli was covered with vegetation which was found as the lowest covered of land in Jeli for year 1994. The cleared land was identified to be 5.30% of the total land in Jeli with the coverage of built-up area 2.17% from the land use. The highest land use in Jeli was found to be water body with 87.21%. The total coverage of land use in 1994 may undergo with an error during the classification process which resulted in the accuracy to be 76.67%.

4.3.2 Land use map of Jeli in year 2006

In year 2006, most of the area in Jeli was covered with 73.44% of the vegetation. Green cover was the second-highest coverage with 17.73% of land in Jeli, while followed by a water body which consists of 6.72% of the land. The lowest covering is cleared land and built-up area with 1.83% and 0.29%, respectively.

4.3.3 Land use map of Jeli in year 2018

The total area of Jeli in 2018 was dominated by green cover with 76.80% and followed by vegetation with 9.52% of the land. A total of 2.63% of total land use was complied with the built up area, with the highest total of the built up area compared to year 1994 and 2006. The cleared land in year 2018 indicated the lowest coverage of land use with 0.30% of the land. The remaining categories are water bodies with 0.58%.

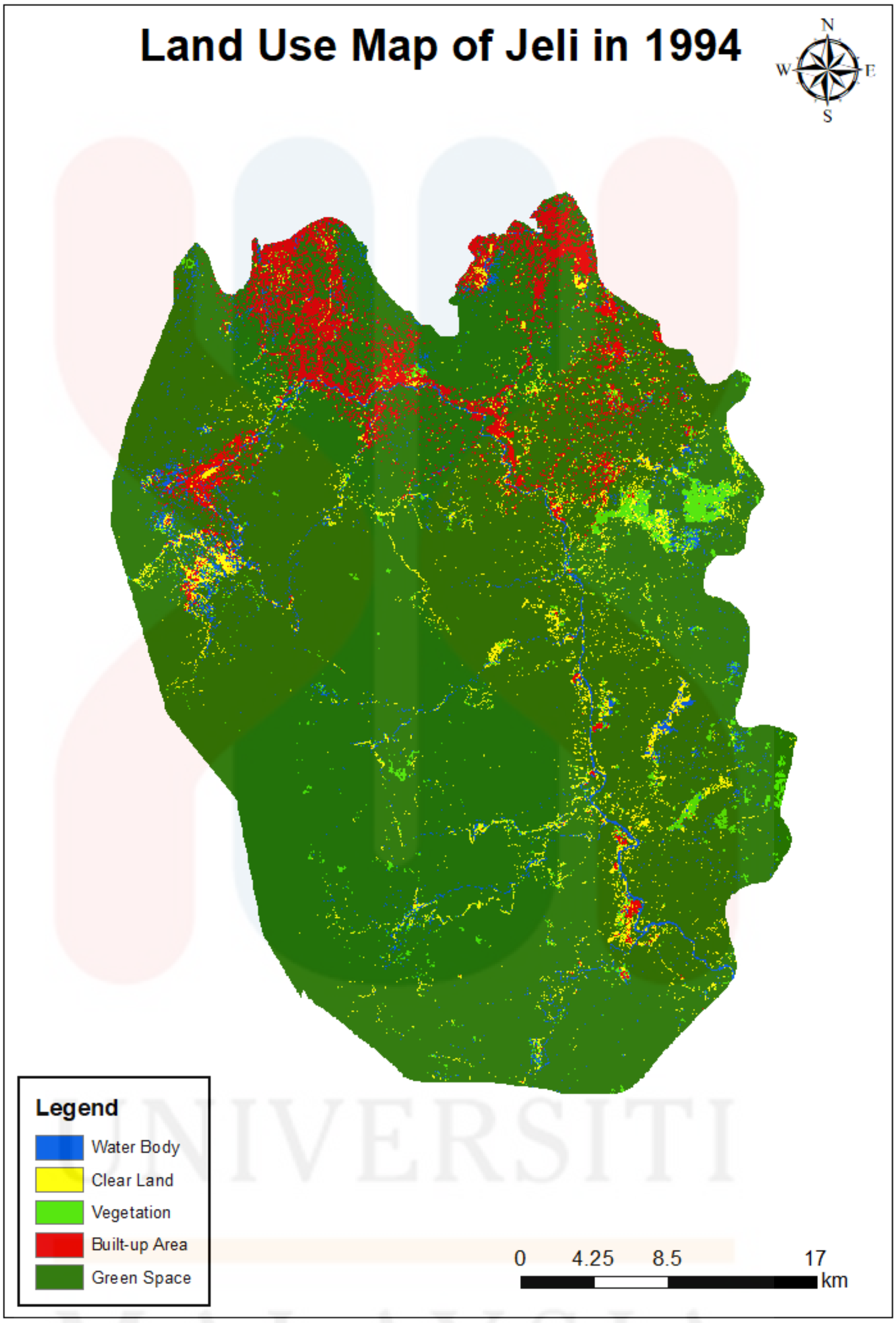


Figure 4.7: Land Use Map of Jeli in 1994.

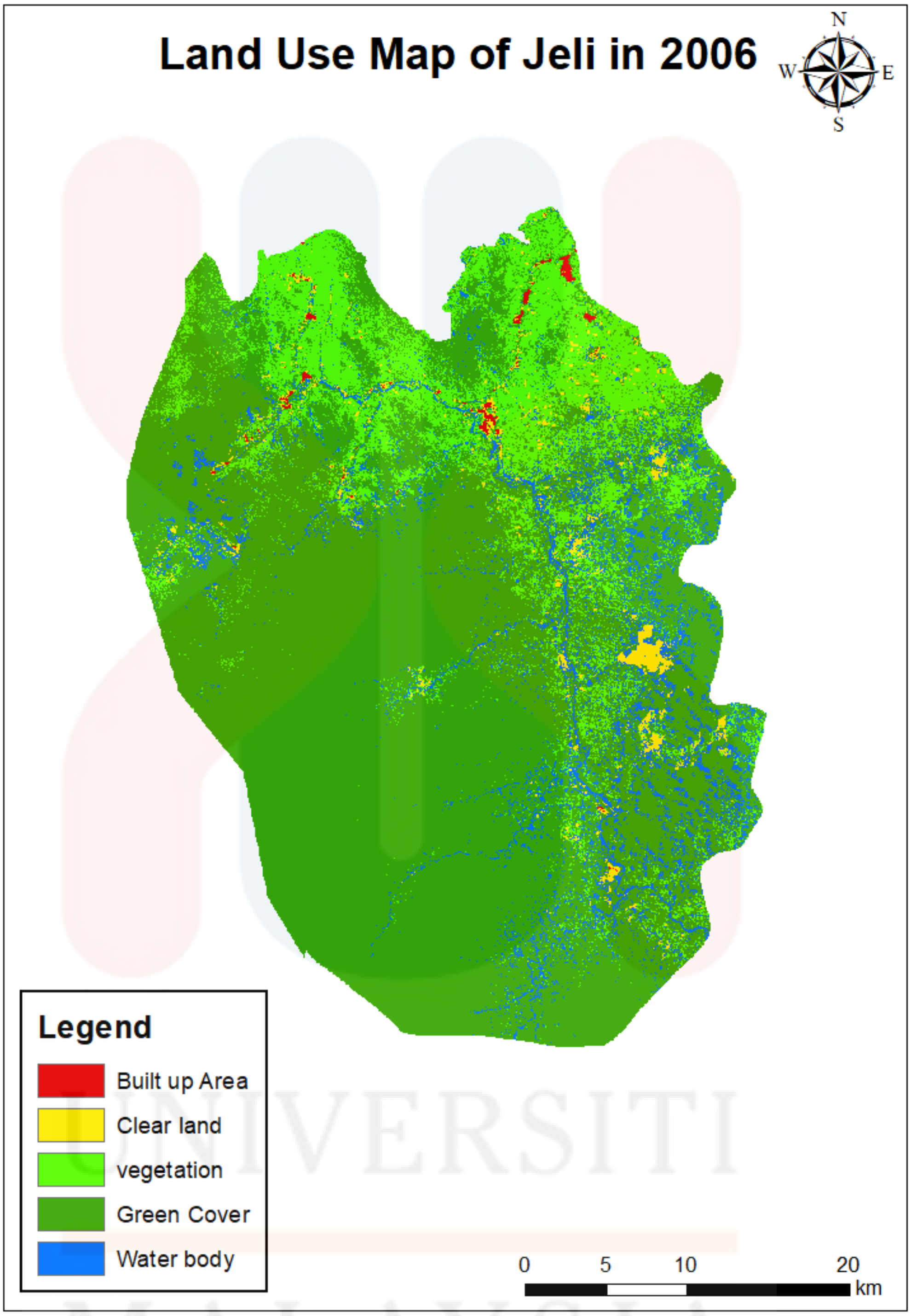


Figure 4.8: Land Use Map of Jeli in 2006.

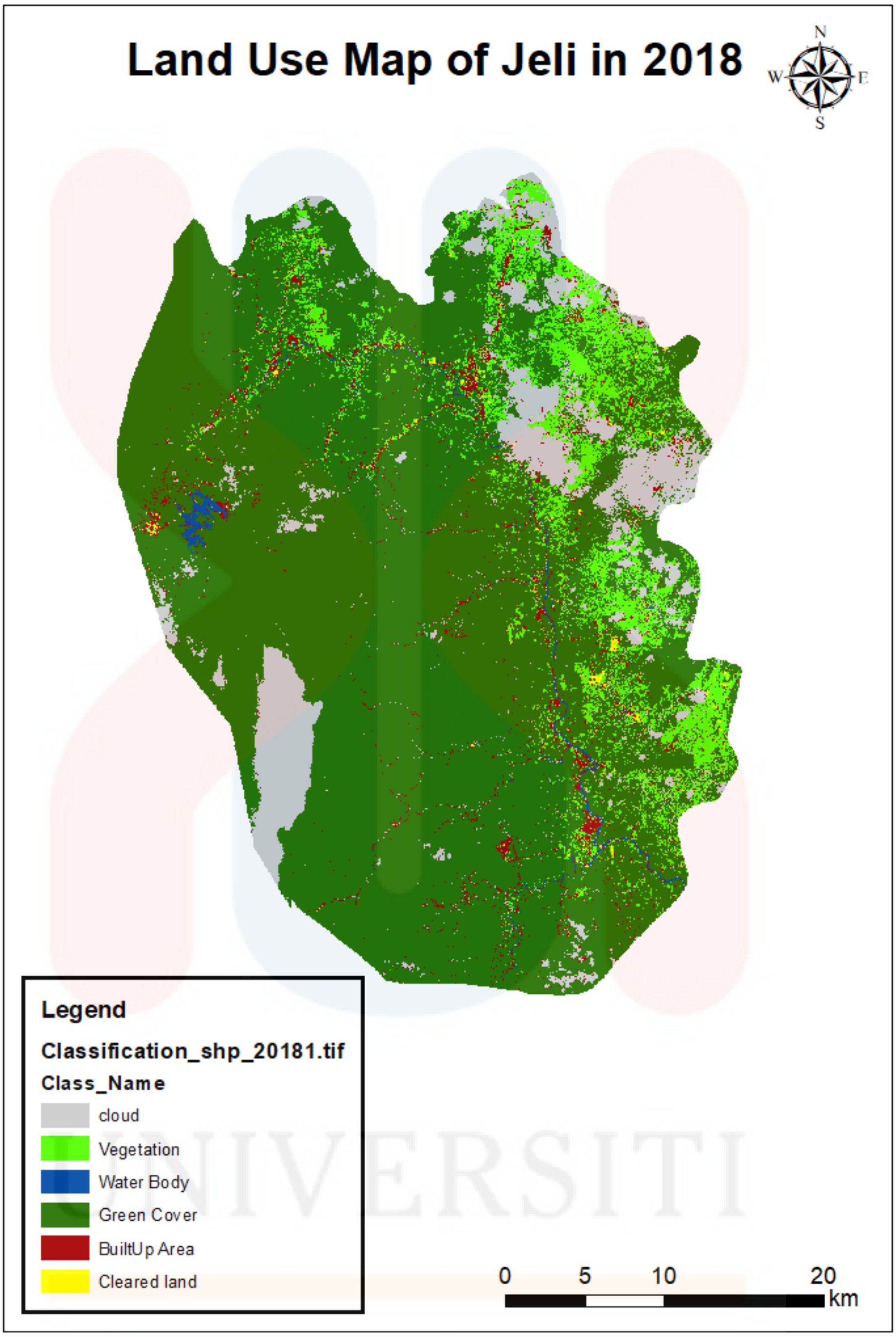


Figure 4.9: Land Use Map of Jeli in 2018.

4.4 Land use change in Jeli

The changes in land use land cover (LULC) were described by carried out the spatial changes of landscape and statistical analysis. The results of LULC change in year 1994, 2006 and 2018 were tabulated in Table 4.2. The land use map of 1994 and 2006 and the land use map of 2006 and 2018 were overlays to quantify the change detection through ArcGis software.

Green cover class contributed to the highest land use in Jeli. Green cover is essential to maintain the ecosystem of a place. From Table 4.2, green space classes have shown an enormous increase percentage throughout the three years (1994, 2006 and 2018) with 3.19%, 17.73% and 76.80%, respectively. The biggest replacement of vegetation to green cover happened in year 1994 and year 2018 where 2855.84 ha of green cover were shifting.

The second highest land use in Jeli was water body. In year 1994, 2006 and 2018, Table 4.2 shows the decreasing pattern of water body classes in Jeli. The declined pattern of water body class was rapidly happened in year 1994 (87.21%) and 2006(6.72%). The decreasing coverage of water body in Jeli occurs rapidly in year 1994 and 2006 because 77.61% of water body was replaced with vegetation class.

As the results shows in Table 4.2, the vegetation land use increased from 2.13% to 73.44% of the area in year 1994 and 2006. However, in year 2006 and 2018, the percentage of vegetation land decreased from 73.44% to 9.52%. The transition of green cover in year 2006 and year 2018 was resulted in the inconsistency increased and decreased of vegetation class pattern. Green cover was shifted to 83.42% from the vegetation class and this can be a natural process where the green cover can be increased or decreased throughout the years (Rossetti de Paula, 2018).

In year 1994 and 2006, the declined in the area of built-up land can clearly be seen from Table 4.3. The decreasing of built-up area in those years can happen because of the vegetation land. More vegetation land can be found from year 1994 to 2006. However, the built-up area class shows the increased peak in year 2006 and 2018, from 0.29% to 2.63% from the land in Jeli. The increased in built-up area has resulted from the increasing population in Jeli. Study conducted by Karim et al. (2020) shows that the increasing of built-up area in Jeli had been influenced by the increasing number of population in Jeli.

Cleared lands class has shown a declining trend in year 1994 and 2006, and also year 2006 and 2018 as shown in Table 4.3 and 4.4. The decreased of cleared land from 5.3% (1994) to 0.3% (2018) prove that more lands were used as vegetation and built-up area. In year 1994 and year 2006, most of the cleared land area was recovered by the green cover class which involved 4244.07 ha of green space have been shifted. However, the declined of cleared land area in year 2006 and year 2018 was resulted from the shift of green cover and vegetation class with 32.97% and33.99% from the cleared land. This may resulted because of the inclining of population in Jeli through the years (Karim et al., 2020).

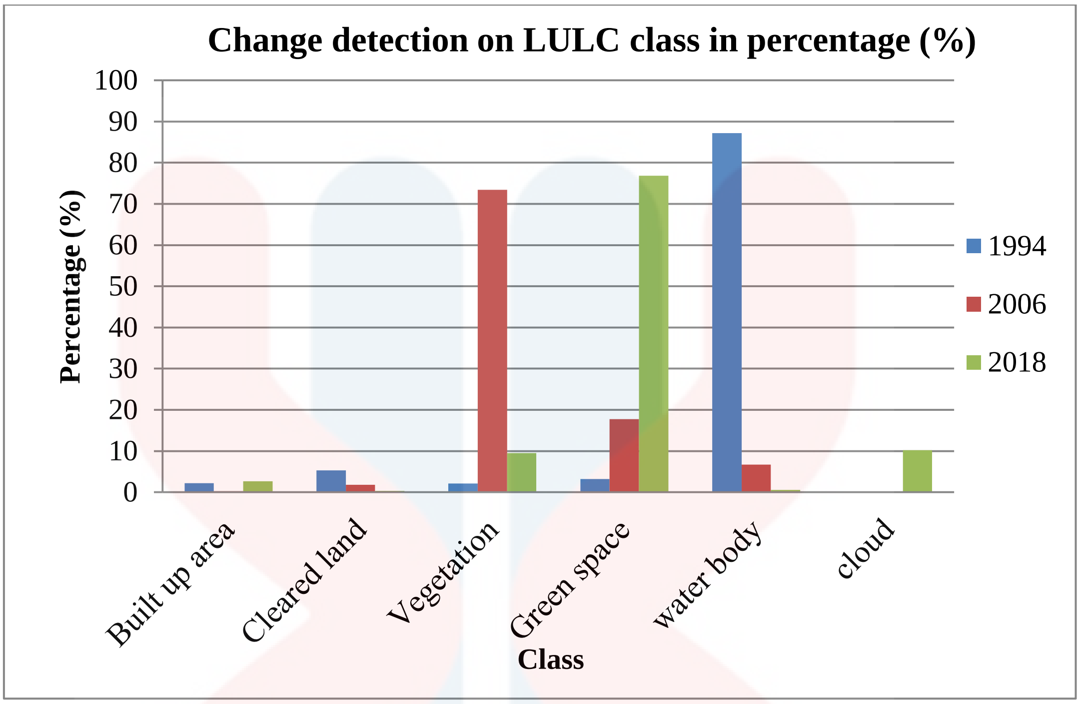


Figure 4.10: Change detection on LULC class in percentage.

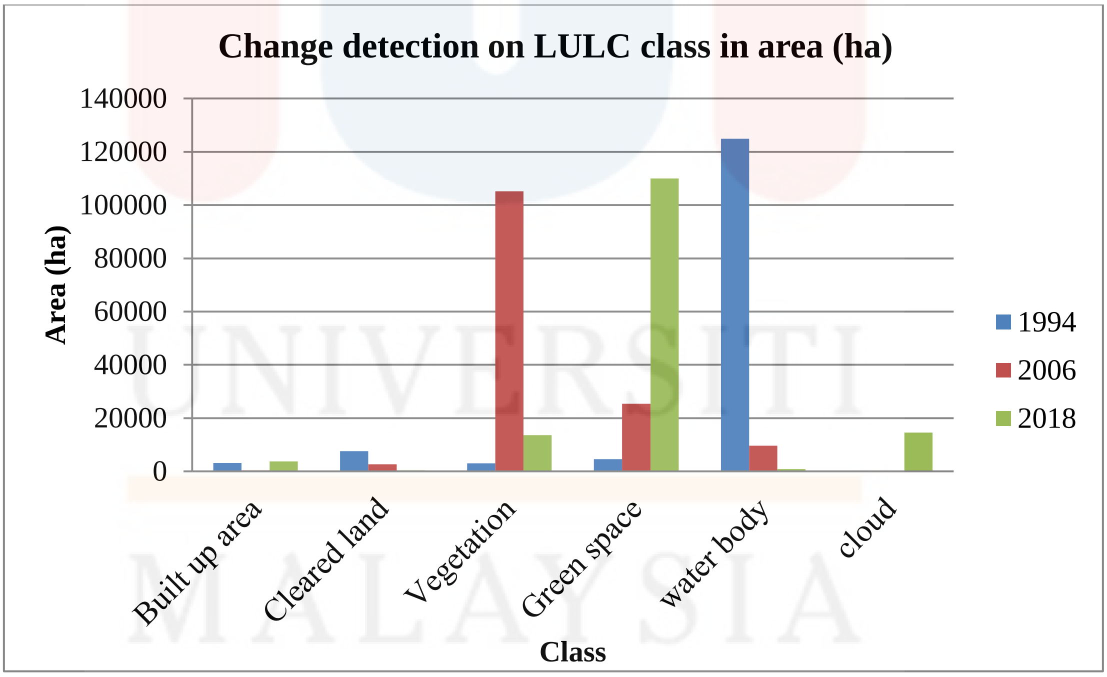
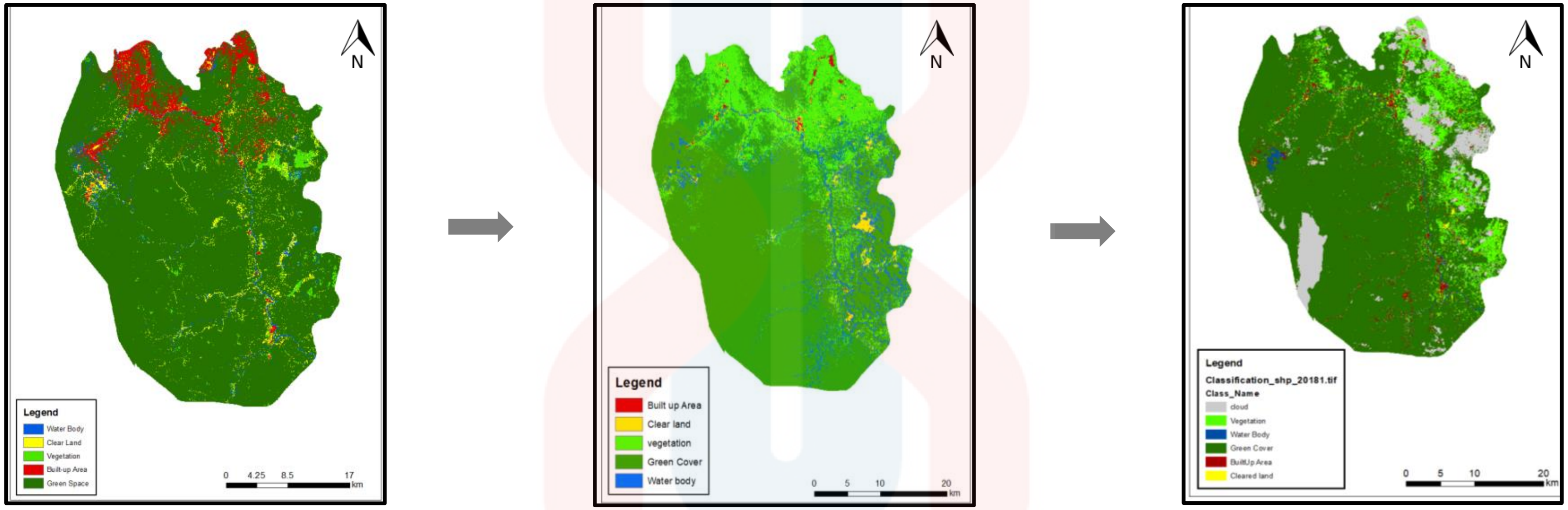


Figure 4.11: Change detection on LULC class in area.

Table 4.2: Land use change in Jeli in year 1994, 2006 and 2018.

Class name	Land use change in Jeli in year 1994, 2006 and 2018					
	1994 (%)	1994 (ha)	2006 (%)	2006 (ha)	2018 (%)	2018 (ha)
Built up area	2.17	3105.63	0.29	411.57	2.63	3764.48
Cleared land	5.3	7588.67	1.83	2615.72	0.30	431.95
Vegetation	2.13	3050.67	73.44	105185.33	9.52	13638.32
Green cover	3.19	4572.75	17.73	25395.89	76.80	110006.30
Water body	87.21	124916.89	6.72	9625.07	0.58	832.23
Cloud	0.00	0.00	0.00	0.00	10.17	14562.10
Total	100	143234.61	100	143233.59	100.00	143235.38



1994 2006 2018

Figure 4.12: Land use change of Jeli in 1994, 2006 and 2018.

Table 4.3: Land use change data analysis of transition matrix year 1994 and 2006.

Transition Matrix of Year 1994 And 2006

Class Name	Built-Up Area (ha)	%	Cleared Land (ha)	%	Green cover (ha)	%	Vegetation (ha)	%	Waterbody (ha)	%
Built Up Area	7.34	0.24	114.86	3.70	392.47	12.64	1563.33	50.36	1026.50	33.06
Cleared Land	330.26	4.35	453.58	5.98	4244.07	55.96	2102.53	27.72	454.27	5.99
Green Cover	28.11	0.61	280.14	6.13	734.40	16.06	2855.85	62.46	673.72	14.74
Vegetation	8.70	0.29	86.01	2.82	889.30	29.16	1713.46	56.18	352.27	11.55
Water Body	37.08	0.03	1680.62	1.35	19124.57	15.31	96931.25	77.61	7115.11	5.70

Table 4.4: Land use change data analysis of transition matrix year 2006 and 2018.

Transition Matrix of Year 2006 And 2018												
Class name	Built-up Area (ha)	%	Clear land (ha)	%	Green cover (ha)	%	Cloud (Ha)	%	Vegetation (Ha)	%	Waterbody (ha)	%
Built up Area	249.74	60.70	5.29	1.29	26.72	6.49	72.42	17.60	56.63	13.76	0.65	0.16
Clear land	513.16	19.62	28.08	1.07	862.11	32.97	278.27	10.64	888.96	33.99	44.47	1.70
Green cover	502.49	1.98	132.29	0.52	15906.45	62.66	3384.74	13.33	5455.25	21.49	4.29	0.02
Vegetation	1803.19	1.71	187.28	0.18	87729.46	83.42	9467.93	9.00	5713.13	5.43	263.94	0.25
Water body	695.44	7.23	78.85	0.82	5457.33	56.72	1350.64	14.04	1520.84	15.81	518.88	5.39

4.5 Spatial pattern changes of Jeli

The landscape configuration of a country can be accessed by using landscape metrics such as PAREA, PD, MPA, LPI, LSI, and ENN with theusage of the image. The spatial pattern changes of this study was conducted at all level which consists of patch, class and landscape level throughout the three years of study period which were 1994, 2006, and 2018.

As shown in Figure 4.13, the landscape level, LPI increased from 1994 to 2006 with 60.86% and 66.32%, respectively, but slightly decreased in 2018 with 65.44%. The increased in landscape pattern metrics value during the study period may be due to the fragmentation process that occurred in the landscape in Jeli during 1994, 2006 and 2018 (Huang et al.,2009). The increased of LPI can be proved that the area of patch classes on the landscape level have become larger throughout the study periods. However, the MPA of landscape pattern metric in Jeli decreased over the study period with 5.96 ha in 1994, followed by 4.27 ha in 2006 and 3.97 ha in 2018 (Table 4.5). The presence of small patches throughout the study period was resulting in the decreased of MPA.

The pattern of ENN was decreasing in year 1994 to 2006 from 125.26 m to 93.91 m. Oppositely, the ENN was increasing in year 2018 by 109.42 m. The decreasing of ENN because of the loss of forest fragmentation and the distance from patch to near neighborhood become smaller. The inclining of ENN shows the highest distance increment of the built up patches with the nearest patches (Nor et al., 2017). In Jeli, the population increased along with the development and expansion of the land.

Concurrently, the expansion of cleared land was increasing. Therefore, the land clearing activities without any proper plans and designs should be controlled to prevent any loss of forest cover through the years.

At the class level (Figure 4.16), the changes of green cover over the three years (1994. 2006 and 2018) were similar. Throughout the period of study, PD was increasing for the two years (1994 and 2006) which were 5 to 7 patches per 100 ha, respectively. However, the PD was found decreasing over the year 2006 and 2018 from 7 to 3 patches per 100 ha. The results of the study show that the MPA was increasing during the period of the research. The MPA was rapidly increased from 0.54 ha to 24.84 ha in year 1994 to 2018. Fragmentation in Jeli can be proven with the larger values of PD and smaller values of MPA (Nor et al., 2017). Therefore, the fragmentation in Jeli can only be identified for year 1994 and 2006.

The LPI (patch size) was becoming bigger along the period of 1994, 2006 and 2018 at Jeli with 0.06%, 4.90% and 65.44%, respectively. From the results, it shows that the green cover was recovering from the previous contribution of vegetation class and water body class. The replacement of both classes indicates the reposition of the green cover over the study period. The ENN value in Jeli was decreased for the past of the study period with 123.03 m in year 1994 and 88.36 m in year 2006 and continuously declined in year 2018 with 75.55 m. This indicates that the green cover patch distance was invariably decreased.

The patch level data was interpreted by conducting the statistical analysis that was performed at patch level because of the complexity to interpret it. SPSS software was chosen to conduct this analysis by performing the normality test in patch data and the result shown the normal distribution ($p<0.05$). Therefore, ANOVA had been performed with the chosen metric landscape as dependent variables which were ENN and AREA. The table of ANOVA analysis below shows that the landscape metric of AREA in year 1994 (0.304) and the landscape metric of ENN in year 2006 (0.22) and year 2018 (0.291) were not significant ($p>0.05$). However, the results of ANOVA shows that the landscape metric of AREA in 2006 (0.003) and 2018 (0.021) were found significant ($p<0.05$) as well as the landscape metric of ENN (0.001) which mean that the neighbouring patches distance of those class was significantly change. From Table 4.6, it shows that the value of the landscape metric of AREA in year 2006 and 2018 are significant to the green space class or forest changes in Jeli area.

Table 4.5: FRAGSTAT results of landscape level.

Landscape metric	Year		
	1994	**2006**	**2018**
LPI (%)	60.86	66.32	65.44
MPA (ha)	5.96	4.27	3.97
ENN (m)	125.26	93.91	109.42

Table 4.6: Results of Analysis of Variance (ANOVA).

Landscape metric	Year		
	1994	**2006**	**2018**
AREA	0.304	0.033	0.021
ENN	0.001	0.22	0.291

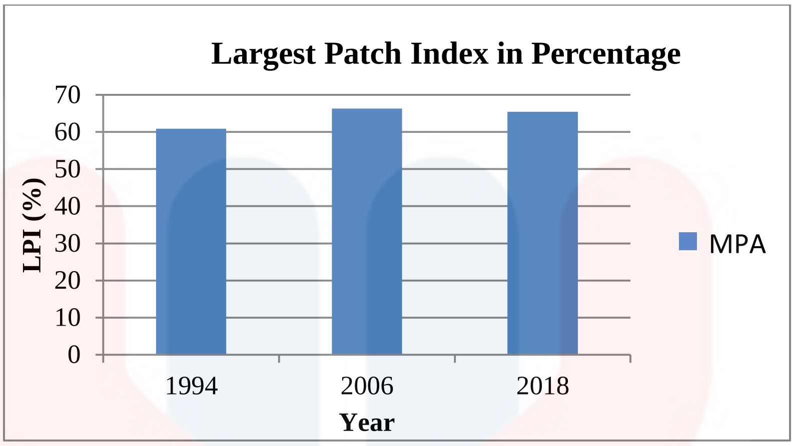


Figure 4.13: Comparison of LPI (%) at landscape level.

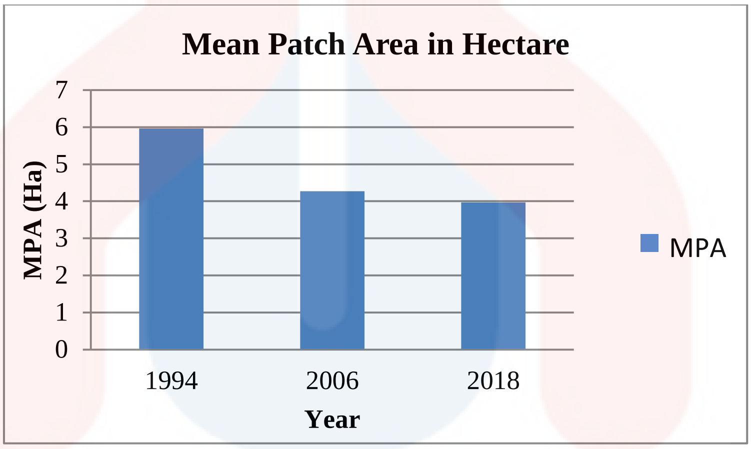


Figure 4.14: Comparison of MPA (%) at landscape level.

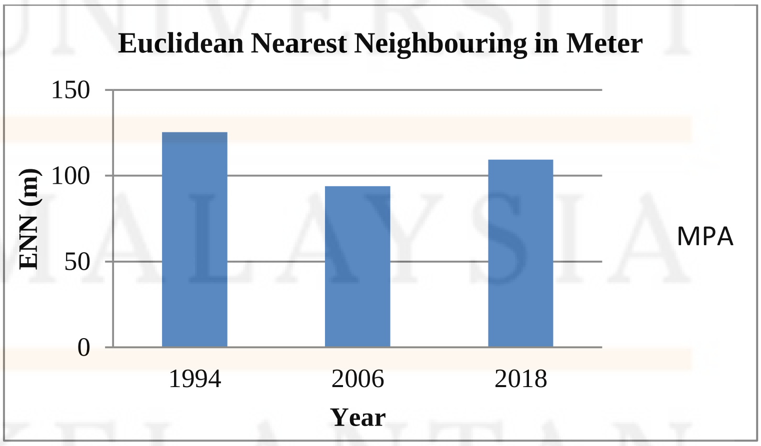


Figure 4.15: Comparison of ENN (m) at landscape level.

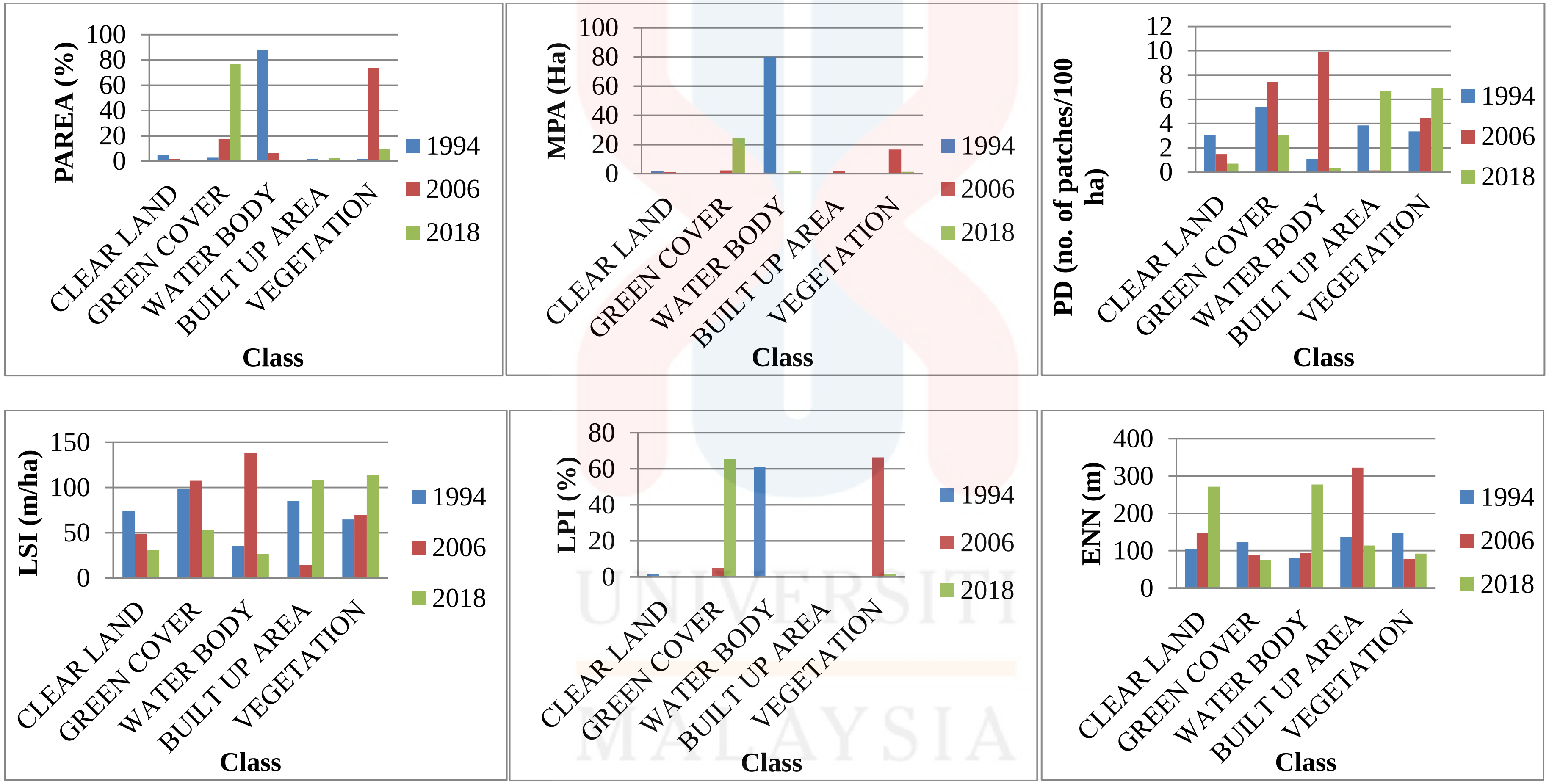


Figure 4.16: Comparison of metrics in class level at years 1994, 2006 and 2018.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From this study, the objectives outlined have been achieved. Firstly, the spatial and temporal changes of the urban forest in Jeli in year 1994, 2006 and 2018 have been identified and classified in Chapter 4. Three NDVI maps and land use maps have been produced from the data processing starting in year 1994, 2006 and 2018. The land use of Jeli was classified into five classes: green cover (2.63%), vegetation (9.52%), waterbody (0.58%), built-up area (2.63%) and cleared land 0.30%). It shows that the green cover class have higher percentage compared to other classes. Finally, the data analyses were conducted by using statistical analysis.

Green cover class or forest area was found increased (2.63%) throughout the study period. The changes and increasing in green cover along the years may be resulted due to the fragmentation of land use that occurred. Landscape metrics of AREA have been identified to be significant to the green space or forest changes in Jeli in year 2006 and year 2018 as well as the landscape metric of ENN in year 1994.

The outcome of this study can be used by the decision-makers, stakeholders and planners to organize and design a sustainable planning of a development in an area. The effective sustainable urban planning can help to initiate a realistic solution towards land use and the effects on natural resources.

5.2 Limitation of study and recommendation

In this study, there are few limitations that can be identified when conducting this study, including the time constraints and data error. Firstly, the limitation of time in completing the data processing was the main challenged with many technical steps. The processing of data involves many types of software that needed long time consumption to run and understanding the techniques involved in the process. This will make the researcher consume more time which resulted in dragging the period of the analysis. Then, the data will be challenging to analyze correctly, accurately and in detail. The accurate outputs of data need to undergo several repeating processes for about two or three times.

Secondly, the error in this study existed when the coordinates of Google Earth that acts as references data in supervised classification in order to replace the Groundthruthing method. Groundthruthing technique cannot be complied in this study due to the pandemic, which makes the coordinate of some areas were not accurate. Besides that, the outcomes of the study might be affected because of the skills performed by the researcher was limited. Remote sensing and GIS software need to have good basic skills to get right and accurate results.

Lastly, the low quality of Landsat imagery especially Landsat TM 1994 and Landsat TM 2006, have made the image classification process limited to be supervised precisely. Therefore, the researcher in the future is recommended to use the satellite imagery with high resolution from the Agency Remote Sensing Malaysia (ARSM) to produce a detailed image classification and precise land use maps. A few strategies and designs need to be made up as a guide in Jeli to better sustainable planning in urban management.

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