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## Spatial and temporal changes of urban forest in Jeli, Kelantan

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**Abstract.** The rapid growth of urban development in a country affects vegetation and ecosystem area. Nowadays, 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 satellite images of the study area in year 1994, 2006 and 2018 were processed and analyzed using 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 the year 1994 (60.86%) and 2018 (65.44%). The mean patch area (MPA) decreases throughout the year with 5.96 ha, 4.27 ha and 3.97 ha, respectively. The higher of LPI and increase 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. 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.

### 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 [1]. The urbanization altered and expanded the economies widely and made changes in population distribution, production mode, and the environment [2]. The improper management of urban planning will greatly impact ecological, social, biophysical and climates, including urban forest [3].

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 [4]. Urban land may affect land and water characteristics through the pollution of air, water and land [5]. Besides that, 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. 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 [6].

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 [7]. Trees planted in urban areas can be fundamental in treating the environment since it can diminish climate change by removing contaminated air [8]. Food and Agriculture Organization [9] 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 [10]. 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 [11].

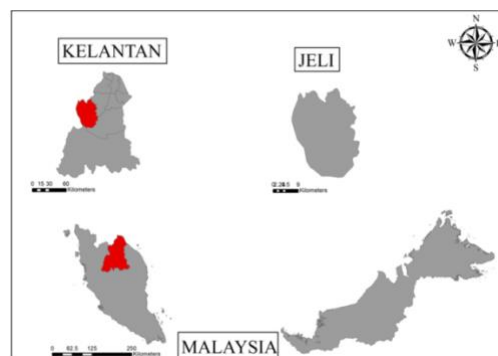
Rapid development has become the most significant concern toward the urban sustainability approach around the world, including Malaysia [12]. This study focused on the urban forest changes in Jeli, Kelantan. Statistic provided by Jeli District Council [13], the Jeli area was covered with 90% of natural forest which equivalent to 86.1 kha in 2010. For the time being, Jeli lost 23.9 kha of natural forest and been replaced with a plantation [12] and many developments occurred with buildings and facilities were expanded from the past few years [13].

The previous study in analyzing the urban land use and forest areas in Jeli, Kelantan is limited. Therefore, this study was conducted to classify the land use and analyze the landscape changes of the urban forest in Jeli, Kelantan in year 1994, 2006 and 2018 and can be useful for strategic sustainable land planning for a better 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).

## 2. Materials and methods

### 2.1. Study area

Kelantan is located in the north of Peninsular Malaysia (Figure 1). This study focused on the Jeli district in Kelantan with the total area of 13,300 hectares and located in the north-west of Kelantan (coordinate of 5° 42' 2.516" N and 101° 50' 35.344" E). Based on the Department of Statistic Malaysia [14], the total population of Jeli in 2018 is 50, 900. 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.



**Figure 1.** The study area of Jeli in Kelantan, Malaysia.

## 2.2. 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 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.

## 2.3. Data processing

The data pre-processing involved image stacking, image subset, image enhancement and image classification by using ENVI Classic software and also ArcGIS. 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 [15]. The data of the Jeli district boundary that had been collected from GADM and had been used to subset the images into the area of interest (AOI).

The supervised classification was conducted and had been constantly used by researchers for quantitatively analyze the satellite images [16]. Land use classification in Jeli had been classified into a built-up area, green space, waterbody, agriculture and cleared land.

Image enhancement was conducted to adjust the image and made it suitable for human vision. The vegetation and non-vegetation area were differentiate into five groups which were very poor, poor, moderate, high and very high by using Normalized Difference Vegetation Index (NDVI) in ENVI Classic software for the best results of classification [17].

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 [18]. Data of accuracy obtained from Google Earth was used in the accuracy assessment process which was vital to compare the existing data with the results obtained.

## 2.4. Data analysis

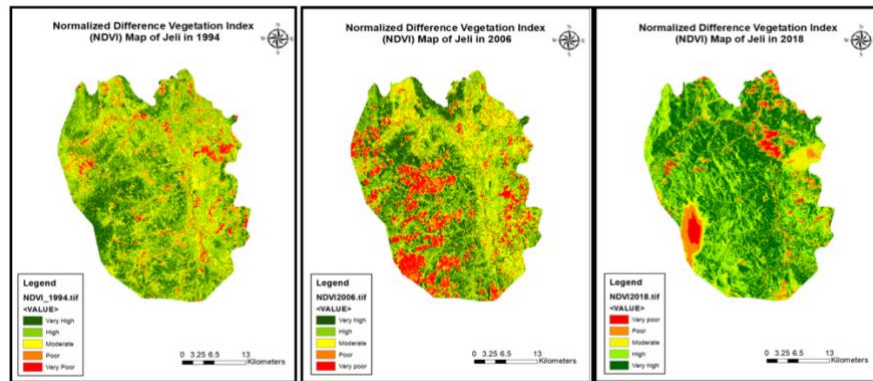
**2.4.1. Change detection analysis.** The amount of forest converted to the built-up area and other land uses year 1994, 2006 and 2018 was determined by using the change detection analysis in ArcGIS software. This analysis consists of two steps; the first one was the spatial changes that determined the 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 matrix and spatial changes graph.

**2.4.2. Landscape structure analysis.** The changes in spatial structures of the green area of Jeli in 1994, 2006 and 2018 were analyzed at landscape, class and levels [19]. 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.

## 3. Results and discussion

### 3.1. Normalized Difference Vegetation Index (NDVI)

The healthier vegetation has higher vegetation density which near +1 on NDVI. From Figure 2, 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 2.** NDVI map of Jeli in year 1994, 2006 and 2018.

**3.2. Accuracy assessment**

The overall accuracy shows that 76.67% of pixels were classified correctly in Landsat TM 1994, compared to Landsat TM 2006 (83.33%) and Landsat 8 2018 (90%) (Table 1). 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.

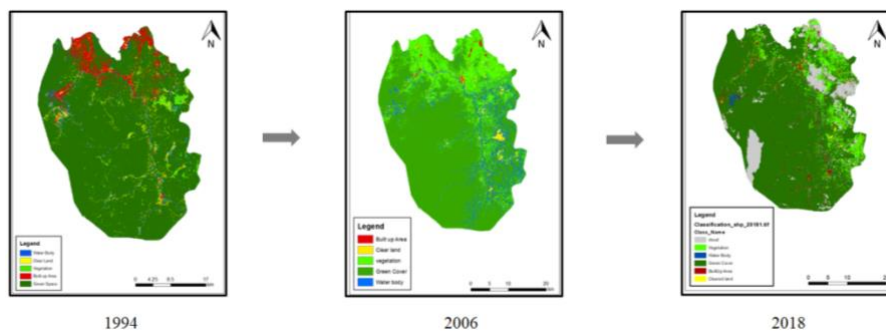
**Table 1.** Overall accuracy and Kappa statistic.

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

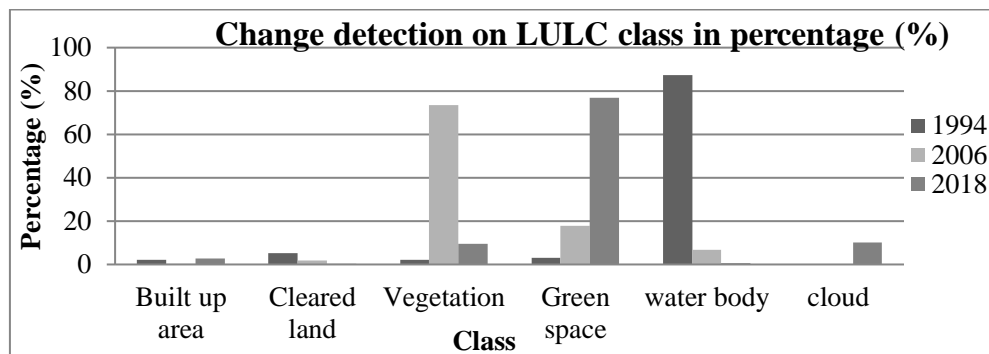
**3.3. Land use change in Jeli**

Green cover class contributed to the highest land use in Jeli where it is essential to maintain the ecosystem of a place. From Figure 4, 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.

As the results shows in Figure 4, 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 [20].



**Figure 3.** Land use change of Jeli in 1994, 2006 and 2018.



**Figure 4.** Land use change in Jeli in year 1994, 2006 and 2018.

The decreasing of built-up area in 1994 and 2006 can happen because of the vegetation land (Table 2). 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 because of the increasing population in Jeli.

**Table 2.** Land use change data analysis of transition matrix year 1994 and 2006.

Class Name		Built Up Area	Cleared Land	Green Cover	Vegetation	Water Body
Built-Up Area	(ha)	7.34	330.26	28.11	8.7	37.08
	%	0.24	4.35	0.61	0.29	0.03
Cleared Land	(ha)	114.86	453.58	280.14	86.01	1680.62
	%	3.7	5.98	6.13	2.82	1.35
Green cover	(ha)	392.47	4244.07	734.4	889.3	19124.57
	%	12.64	55.96	16.06	29.16	15.31
Vegetation	(ha)	1563.33	2102.53	2855.85	1713.46	96931.25
	%	50.36	27.72	62.46	56.18	77.61
Waterbody	(ha)	1026.5	454.27	673.72	352.27	7115.11
	%	33.06	5.99	14.74	11.55	5.7

**Table 3.** Land use change data analysis of transition matrix year 2006 and 2018.

Class Name		Built Up Area	Cleared Land	Green Cover	Vegetation	Water Body
Built-Up Area	(ha)	249.74	513.16	502.49	1803.19	695.44
	%	60.7	19.62	1.98	1.71	7.23
Cleared Land	(ha)	5.29	28.08	132.29	187.28	78.85
	%	1.29	1.07	0.52	0.18	0.82
Green cover	(ha)	26.72	862.11	15906.45	87729.46	5457.33
	%	6.49	32.97	62.66	83.42	56.72
Cloud	(ha)	72.42	278.27	3384.74	9467.93	1350.64
	%	17.6	10.64	13.33	9	14.04
Vegetation	(ha)	56.63	888.96	5455.25	5713.13	1520.84
	%	13.76	33.99	21.49	5.43	15.81
Waterbody	(ha)	0.65	44.47	4.29	263.94	518.88
	%	0.16	1.7	0.02	0.25	5.39

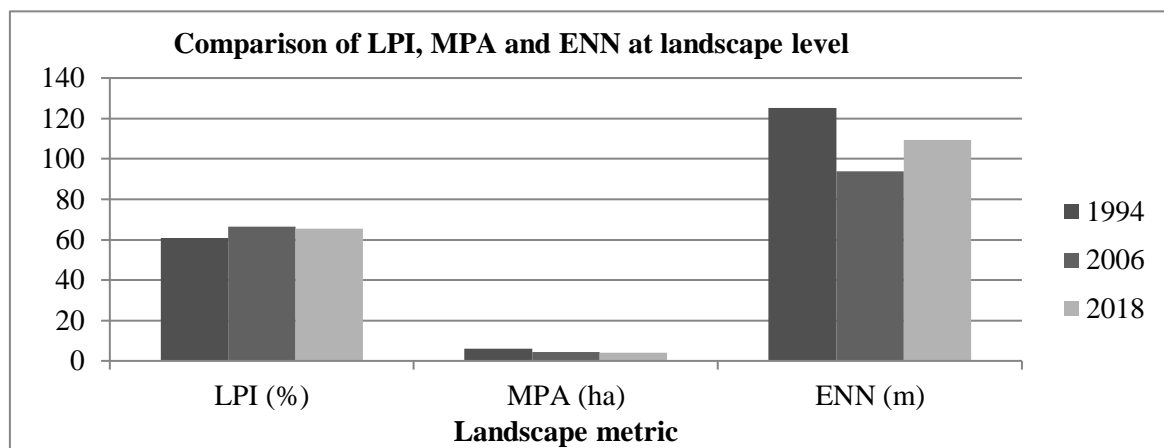
The decreased of cleared land from 5.3% (1994) to 0.3% (2018) prove that more lands were used as vegetation and built-up area (Table 2 and 3). In year 1994 and year 2006, 4244.07 ha of cleared

land area have been shifted with green space area. 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% and 33.99% due to the inclining of population in Jeli. This finding is similar with the results from [20]. The study proves that Jeli is facing with the development process every year.

### 3.4. Spatial pattern changes of Jeli

As shown in Figure 5, 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 the period. However, the MPA of landscape pattern metric in Jeli decreased over the study period with 5.96 ha (1994), followed by 4.27 ha (2006) and 3.97 ha (2018) because of the small patches presence.

The pattern of ENN was decreasing in year 1994 to 2006 from 125.26 m to 93.91 m and increasing in year 2018 by 109.42 m which shows the highest distance increment of the built up patches with the nearest patches [20]. In Jeli, the population increased along with the development and expansion of the land. Therefore, the land clearing activities without any proper plans and designs should be controlled to prevent any loss of forest cover through the years.



**Figure 5.** Comparison of LPI MPA and ENN at landscape level.

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 ( $p > 0.05$ ) (Table 4). 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, 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.** 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

## 4. Conclusion

From this study, the results of the land use maps in Jeli for year 1994, 2006 and 2018 show that the green cover class was found increased throughout the study period. 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 for future sustainable planning.

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