LAND USE AND LAND COVER CHANGE IN KUALA LUMPUR USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM APPROACH

Nur Hakimah Asnawi
Faculty of Architecture, Planning and Surveying
Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
Email: nurhakimahasnawi@gmail.com

Puziah Ahmad
Faculty of Architecture, Planning and Surveying
Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
Email: puzia892@salam.uitm.edu.my

Lam Kuok Choy
Faculty of Social Science and Humanities
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
Email: lam@ukm.edu.my

Mohammad Syahir Aiman Abd Khair
Faculty of Architecture, Planning and Surveying
Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
Email: aiman_khair90@yahoo.com

ABSTRACT

The aim of this study is to detect the changes of land use and land cover (LULC) in Kuala Lumpur by using remote sensing and GIS approach for year 1990, 2000 and 2015. The data used in this study was Landsat satellite imagery (TM and OLI-TIRS) which obtained from the official website of United State Geological Survey (USGS). In this study, supervised classification was the major classification approach to produce thematic maps and three main categories of land uses included vegetation, water body and built-up area were identified and mapped. Accuracy assessment result between classified images with the published land use map based on Kappa statistic through error matrix method gave an overall accuracy of 0.751. This result indicated that interpretation through remote sensing data was substantial and could be reliable to continue with other data. Then, the cross-tabulation matrices between different periods which involving between years of 1990 and 2000, 2000 and 2015, 1990 and 2015 were carried out to identify and analyse the changes of land use pattern. The results recorded that vegetation and built-up area had undergone significant changes, while water body changed slightly within 25 years. Vegetation areas kept showing declining in size since 1990 until 2015 with approximately half of vegetation areas were converted into urban or built-up land. This scenario indicated that the loss of vegetation area was associated with the urban growth and built-up land and this was significantly proved in the study area. Consequently, a rapid urbanisation which took place in Kuala Lumpur contributed to the urban expansion that lead to the declining of green land and environmental problems. Overall, this study brought a different approach to understand the evolution of land use pattern using the analysis technique of remote sensing and GIS application.

Keywords: Satellite imagery, accuracy assessment, land use/land cover change

INTRODUCTION

Land use and land cover (LULC) study has become an important field study in understanding the interaction between human being and their environmental surrounding as its impact could affect the stability of ecosystem. The changes of LULC are one of the major issues of global environment change (Anil, et al., 2011). LULC changes are inherently spatial and dynamic as well as recognized as a change that is global in extent and impact due to its magnitude (Richard, 2008). Therefore, the data on LULC change could give important input to the environmental management and planning in the future (Fan et al., 2007; Prenzel, 2004). The dynamical of LULC are basically related to the diversity of development activities, particularly urbanisation process in which the transformation of land utilization is a significant component involved in the urbanisation process.

Urbanisation has been recognized as fundamental to the multidimensional structural transformation which those low income rural societies undergo to modernize and to join the ranks of the middle and high income countries (Annez & Buckley, 2009). The Malaysian societies are rapidly transforming into an urban society (Norhaslina, 2009) and the continuous population growth in the city is actually a driving factor to a rapid development and plays a significant role in modernizing the society. As in 2010, Malaysia ranked fourth largest in amount of built-up land in East Asia where its urban land grew from about 3.9 km^2 to 4.6 km^2 between 2000 and 2010 (World Bank, 2015). Eventually, the changes of LULC are an inevitable occurrence in Malaysia especially in the developed states such as in Kuala Lumpur, Penang, Selangor and Johor. Thus, this phenomenon should be monitored regularly to address the arising issues regarding the deterioration of environment due to the LULC change scenario.

There are varieties methods can be used for detecting and assessing the changes of LULC. Technically, remote sensing and geographic information system (GIS) are widely used by researchers worldwide in the study of LULC change (Divine et al., 2015; Rawat, 2013; Othman, 2008). Remote sensing and GIS is a tool for research in obtaining accurate information in a short period on spatial distribution of LULC in an area (Carlson & Azofeifa, 1999) and now also providing effective tools for advanced ecosystem and socioeconomic management study (Haque & Basak, 2017). The change detection of LULC by using multi-temporal satellite image data provided effective methods and accurate results to estimate the interaction between human activities and natural phenomena (Bakr et al., 2010). Indeed, the advent of high spatial resolution satellite imagery and more advanced image processing and GIS technologies have encouraged more routine and consistent monitoring and modelling of LULC pattern (Rawat & Kumar, 2015).

In Malaysia recently, studies on LULC are widely conducted by various scholars, especially by using remote sensing and GIS technique. Norzailawati et al. (2012) carried out a study on LULC change in Kuala Lumpur through integration of GIS and remote sensing technique. Their finding indicated that the green areas had undergone a declining in size due to the pressure of urban development within 20 years. Deilami et al. (2014) also implemented the same technique to detect and monitor LULC in Iskandar Malaysia between 2007 and 2014. Their analysis recorded that urban area increased while oil palm decreased in size. Aburas et al. (2015) applied Landsat images to detect the changes of LULC in Seremban by implementing Normalized Difference Vegetation Index (NDVI) method. Hua (2017) also applied remote sensing in detecting the magnitude of LULC change that took place in Melaka River watershed with the comparison between year 2001, 2009 and 2015. Zaidi et al. (2017) presented the implementation of remote sensing in change detection of LULC in Kuantan River Basin between 1993, 1999 and 2010 in attempt to enhance the performance of semi-supervised image classification compared to the standard NDVI technique. All the previous research findings indicated that the changes in LULC are related to the diversity of development activities which could affect the land utilisation pattern.

GIS and remote sensing technologies have shown their great capabilities to solve the study issues in various fields. Therefore, this study also look into the changes of LULC pattern in Kuala Lumpur for year 1990, 2000 and 2015 with the application of remote sensing and GIS approach. Significantly, this study is expected contributing to the decision maker in making a better emergency response and plan towards sustainable land development action as well as mitigating the challenges of rapid growth of urbanisation.

OBJECTIVES

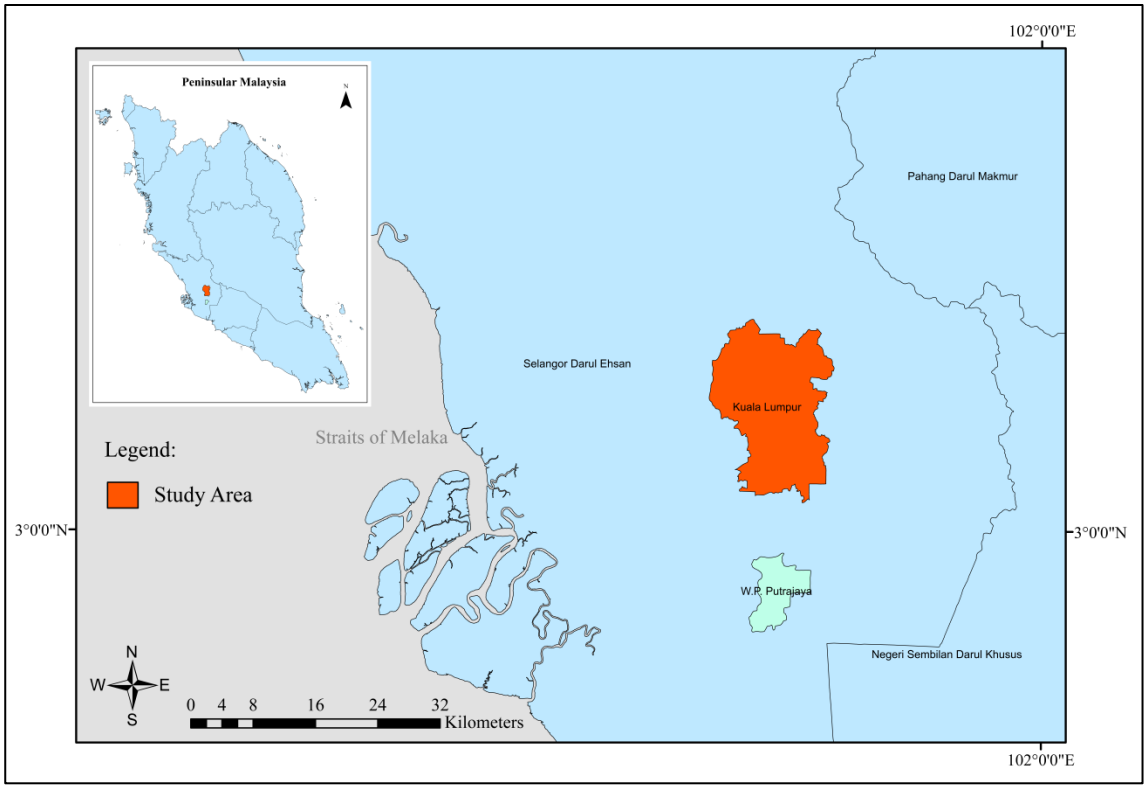
The aim of this study is to analyse the LULC change in the urbanized state of Kuala Lumpur by using GIS technologies and remote sensing data. The following specific objectives are pursued in order to achieve the aim.

- To identify the urban changes of Kuala Lumpur based on the satellite image of year 1990, 2000 and 2015 using remote sensing and GIS application.
- To analyse the matrix of LULC changes in Kuala Lumpur for year 1990, 2000 and 2015 through GIS analysis.
- To discuss the factors of the LULC change in Kuala Lumpur.

STUDY AREA

Kuala Lumpur is the capital city of Malaysia and being the most developed as well as denser city in Malaysia. Kuala Lumpur is located in Peninsular Malaysia in the center of Selangor state which lies in latitude of 3° 8’ North and longitude of 101° 41’ East (Figure 1). Kuala Lumpur has more of wider flat land with an average elevation of 21.95 meters above the sea level. In the hilly area, the range of its elevation is between 100 to 300 meters above the sea level. The total land area of Kuala Lumpur is 243.6 km^2 with a high density of population in the city. Basically, Kuala Lumpur is one of among three Federal Territories of Malaysia beside Putrajaya and Labuan. The city is administered by an agency under the Federal Territories Ministry of Malaysia which is the Kuala Lumpur City Hall. With a strategic location of Kuala Lumpur in the Klang Valley or Kuala Lumpur Conurbation, it is well connected with the surrounding areas by highways, roads and railways which promising intercity high connectivity. Kuala Lumpur as the capital city has witnessed remarkable expansion and growth of development activities in which resulting its sharp dynamic change of land use since its establishment.

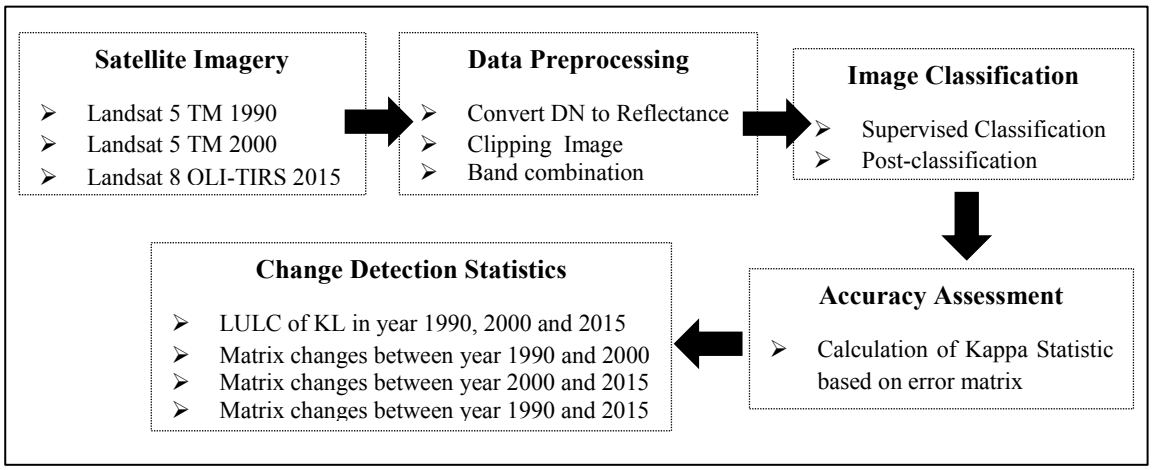
Figure 1: The location map of study area



DATA AND METHODS

Change detection of LULC is an important aspect in this study. Therefore, remote sensing and GIS approach was being applied in this study to detect the LULC change in Kuala Lumpur through the interpretation of Landsat images of 1990, 2000 and 2015. In general, methodology of this study can be divided into five main stages which consisting of data acquisition, data preprocessing, image classification, accuracy assessment and the final products. Figure 2 described the methodology stages applied in this change detection study.

Figure 2: Method of change detection of Kuala Lumpur through satellite image interpretation using remote sensing and GIS application



SATELLITE IMAGERY

The main data used in this change detection study was satellite images which were obtained from the official website of United State Geological Survey (USGS). The data from year 1990, 2000 and 2015 were obtained from Landsat satellite. Specifically, the data from 1990 was acquired by Landsat 5 TM on 9th May, while the data from 2000 was acquired by Landsat 5 TM on 17th March. Meanwhile, the data for 2015 was obtained by Landsat 8 OLI-TIRS on 30th May. Basically, the date of image taken was chosen based on their quality of image throughout the study year. The image with spotless and minimum interference in the

image was being considered and chosen. All the existing satellite images had been projected to the projection system of WGS_1984_UTM_Zone_47N.

DATA PREPROCESSING

There were several techniques being taken in data preprocessing stage for every satellite images. The conversion of Digital Number (DN) into reflectance was performed to give physical meaning units and quantitative value to the image. Then, the process of image clip was took place to separate and segregate the area that was not needed for the study to ensure the accuracy of the analysis of respective study area according to the right boundary. For band combination, the band combination of 4, 5, 3 worked best for Landsat TM image, while band combination of 5, 6, 4 was the best combination for the Landsat 8 image in identifying the pattern of LULC in the study area.

IMAGE CLASSIFICATION

The process of image classification was implemented to classify each pixel in the image into several categories by the researcher (Lillesand, 2004). The image data had been classified through supervised classification technique which being conducted in Erdas Imagine 9.2 software. The process of supervised classification was involving the selection of different pixel as a training sample in the image to represent various land use types. Through supervised classification, the satellite images had been divided into three main land use category comprised of vegetation, water body and built-up area. Then, post-classification involved pixel filtering was applied to combine scattered pixels into the dominant group.

ACCURACY ASSESSMENT

Accuracy assessment had been conducted to identify the validation of the image classification and to examine to which extent the classified image was true according to the ground truth for better understanding of classified image interpretation (Nur Hakimah & Lam, 2016). This accuracy task was attained by compiling an error matrix which was a table of values that compares the value assigned during the classification process to the actual value of ground truth data. The important component of accuracy assessment based on Cohen's Kappa co-efficient was calculated from the error matrix to obtain its accuracy rate (Campbell & McGee, 2010). Kappa statistic is one of the measures for the accuracy where it shows the difference between actual agreement and agreement expected by chance (Nain & Kumar, 2016) as formula followed:

$$k = \frac{P_o - P_e}{1 - P_e} \quad \text{.....(1)}$$

k = Kappa Coefficient
P_o = Observed accuracy determined by diagonal in error matrix
P_e = Chance agreement incorporates off-diagonal

The Land Use Map of Kuala Lumpur in 2000 published by Kuala Lumpur City Hall authority was being used to compare with the classified Landsat image of year 2000. A set of random points was generated on the classified image and then tabulated as error matrix so that the accuracy calculation could be performed.

CHANGE DETECTION STATISTICS

After obtaining the value of Kappa co-efficient, the statistic of LULC in Kuala Lumpur for year 1990, 2000 and 2015 was calculated. The change detection of LULC in Kuala Lumpur was calculated based on the changes matrix by using *Change Detection Statistic* tool in ENVI 5.1 software which would convey the information on the total area for each types of land use category for the selected years study. For the changes matrix, overlay two years image using *Matrix* tool in Erdas Imagine 9.2 was applied to get an overlay thematic maps. The results of image analysis were presented in the form of tables and maps to simplify the reading and image interpretation clearly.

RESULTS AND DISCUSSION

ACCURACY ASSESSMENT

The comparison between Land Use Map of Kuala Lumpur 2000 published by Kuala Lumpur City Hall authority with the classified Landsat image of year 2000 was being performed for accuracy assessment. There was 159 random points sampling generated on the classified image of year 2000. The result accounted that 146 out of 159 random points sampling in classification image of year 2000 was accurate based on the classification of land use in the authorized land use map of 2000 as shown in Table 1. Thus, this sampling amount was used in calculating Kappa statistics based on formula (1) with the results of:

$P_o = 0.918$, $P_e = 0.671$, $k = 0.751$

Table 1: Error matrix accuracy totals for the classified image of 2000

Image Classification		Land Use Map			
		Vegetation	Water Body	Built-Up	Total
	Vegetation	**18**	0	6	24
	Water Body	0	**5**	0	5
	Built-Up	7	0	**123**	130
	Total	25	5	129	**159**

This overall kappa coefficient result interpreted as that image classification was 75.1% better agreement than by chance alone. The kappa coefficient was rated as substantial, therefore the classified image was found to be fit for further research and the study on other Landsat images were considerably could be continued.

LAND USE AND LAND COVER OF KUALA LUMPUR

The results of thematic maps of LULC for year 1990, 2000 and 2015 in Kuala Lumpur were shown in Figure 3. The results from supervised classification of Landsat image for 1990, 2000 and 2015 had shown that some particular land use type dominated Kuala Lumpur area in those years. Statistic of total area for the land use based on post-classification for each year can be referred in Table 2. There were changes happened for every land use category in Kuala Lumpur with useful information on the development trend.

Based on Table 2, the LULC distribution of Kuala Lumpur was still dominant with built-up land by covering more than 50% of total area for every study year as it increased tremendously with 54.53% increased within those 25 years. In 1990, the total area of built-up land was almost the same as the vegetation area with a slightly higher of 3,000 hectares. After 10 years, built-up area went up suddenly to more than 20,000 hectares and continues to rise steadily in 2015 into 21,228 hectares.

Unlike built-up category, vegetation cover in Kuala Lumpur recorded a significant decline in which more than 70% decreased since 1990 until 2015. Even though vegetation was the second dominant land cover in 1990, but it decreased dramatically in year 2000 with more than 60% declining and continuously dropped with 11.41% left in 2015. Before and in 1990, there was not much damage on the natural environment due to human activities. However, the situation got worse in a decade when the area of vegetated land showing a drastic decline.

Meanwhile, water body was a minor category of land use distribution in Kuala Lumpur which represented only less than 3% of the total area of Kuala Lumpur for every study year. Water body category was included any reservoir like river, ponds and lakes. Water body recorded a different total area for every study area where it first increased to 558 hectares in 2000 from 416 hectares in 1990 and then declined suddenly in 2015 with only 1.22% left. Some water body area had been redeemed for development purpose which could be seen slightly. In general, built-up area indicated a significant growth pattern since year 1990 until 2015, meanwhile vegetated land was declined significantly within 25 years.

Figure 3: Distribution of land use and land cover of Kuala Lumpur in year 1990, 2000 and 2015

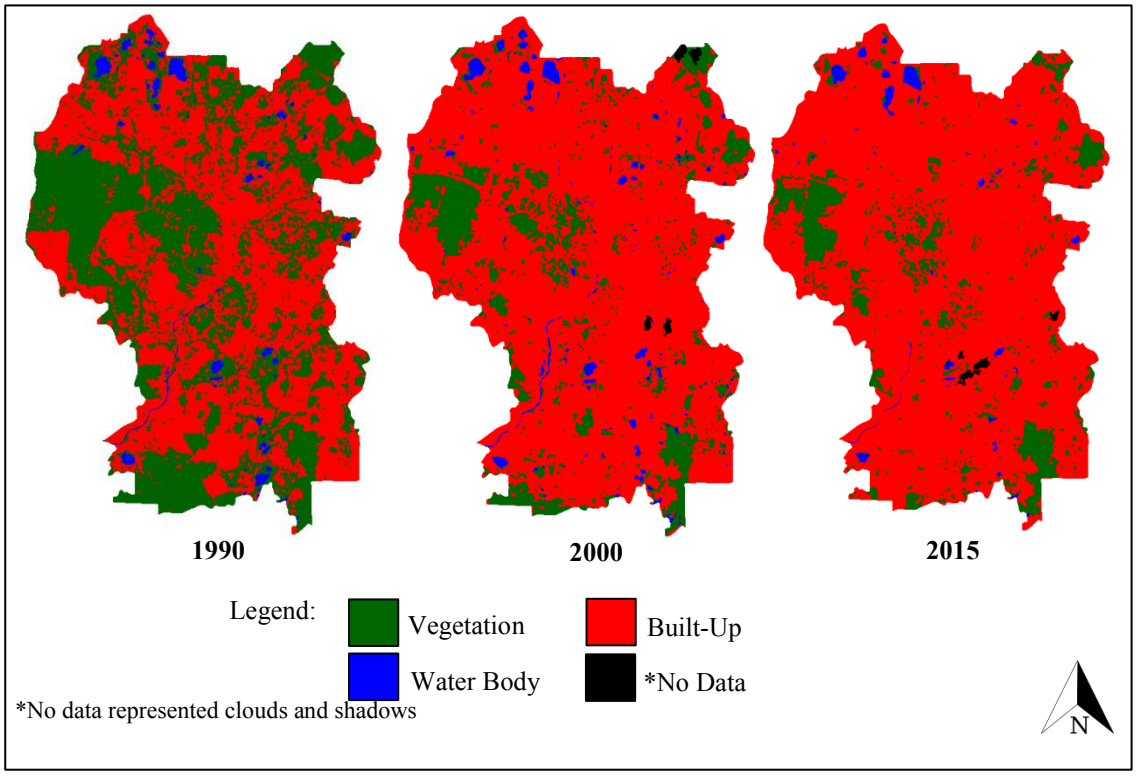


Table 2: Statistics of total area of land use and land cover in Kuala Lumpur in 1990, 2000 and 2015 by interpreting Landsat image

Year/ Type of Land Use	1990		2000		2015		Percentage of Changes (25 years)
	Area (Hectares)	Percentage (%)	Area (Hectares)	Percentage (%)	Area (Hectares)	Percentage (%)	
Vegetation	10,212	41.91	3,670	15.06	2,779	11.41	-72.79
Water Body	416	1.71	558	2.29	298	1.22	-28.37
Built-Up	13,737	56.38	20,066	82.36	21,228	87.12	+54.53
*No Data	0	0	71	0.29	60	0.25	-
Total	**24,365**	**100**	**24,365**	**100**	**24,365**	**100**	-

*No data represented clouds and shadows

LAND USE AND LAND COVER CHANGE OF KUALA LUMPUR BETWEEN YEAR 1990 AND 2000

Table 3 showed LULC change matrix between year 1990 and 2000 with 29.87% changes was recorded. From the statistical table, vegetation received a significant impact of changes with 66.74% changes, followed by water body (22.12%) and built-up area (2.83%). The result indicated that vegetation coverage was going through a significant change from year 1990 to 2000 with 66.74% of it had been converted into other use of land. Most of vegetation coverage had been taken over by built-up activities with 6,647 hectares (65.5%) and only 128 hectares (1.26%) of it had been taken over by water body. This dramatic shifted of vegetation to built-up area had caused a sharp decrease of green area in Kuala Lumpur by year 2000. The real changes of vegetation indicated that vegetated land dropped 50% that only 3,670 hectares (15.1%) of vegetation area left in year 2000.

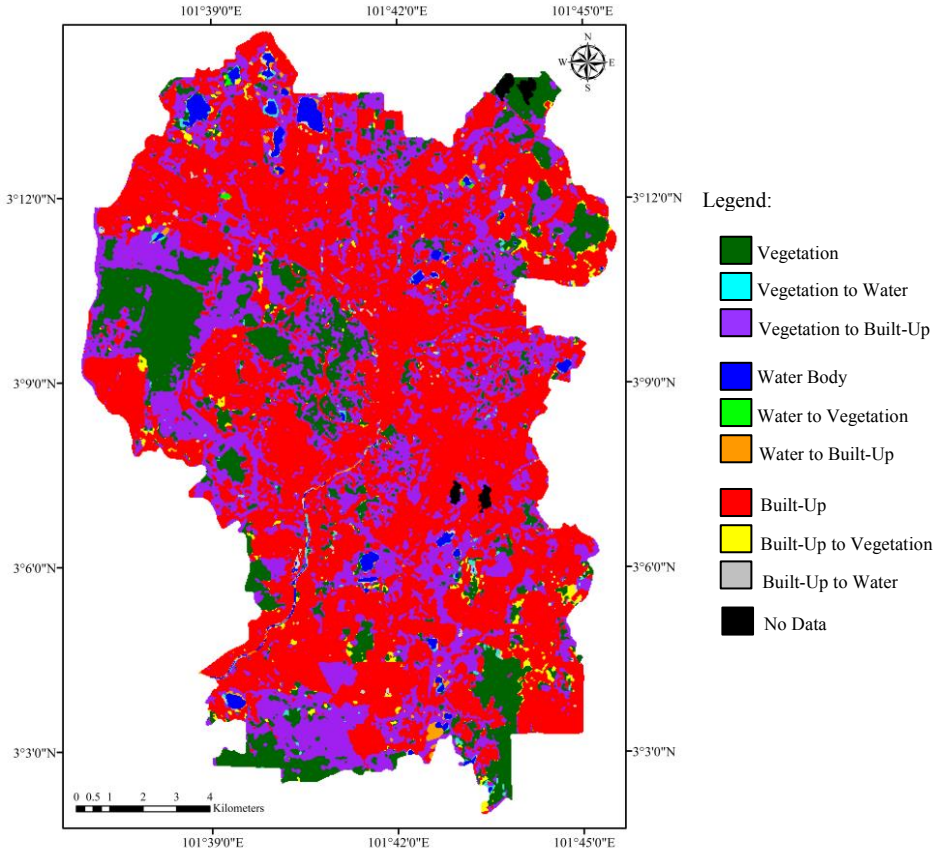
Since most of vegetation area had been converted into built-up coverage, thus built-up area indicated a sudden rise by year 2000 with 48.90% (6,340 hectares) increase from year before. This scenario affected that most of Kuala Lumpur had been covered by built-up land with more than 80% out of total area of built-up coverage in year 2000. The statistics recorded that the land conversion of vegetation had contributed the most to the rising of built-up area within that 10 years gap.

For the water body, the results recorded a steadily increased from 416 hectares in year 1990 to 558 hectares in year 2000. It seemed like some vegetation and built-up area had changed into water body with the conversion of 234 hectares from that both land use type into water body. Even though the water body indicated a slightly increased of only 1.10%, but it was still the main part of land use. Based on Figure 4, it perceived that every part of Kuala Lumpur had been through land transformations especially at the western and southern part in which significant changes had occurred. At these areas, it seemed like most of vegetated land had converted into built-up area in a large scale within a decade. Overall, vegetation coverage had undergone a significant change since year 1990 until 2000 which contributed to the increasing of built-up area by 2000.

Table 3: Matrix of land use and land cover change of Kuala Lumpur between year 1990 and 2000

Year/ Land Use Type		1990 (Hectares)			
		Vegetation	Water Body	Built-up	**Total**
2000 (Hectares)	Vegetation	3,377	10	283	**3,670**
	Water Body	128	324	106	**558**
	Built-up	6,647	82	13,337	**20,066**
	Total	**10,152**	**416**	**13,726**	**24,294**
	%Unchanged	33.26	77.88	97.17	-
	%Changed	66.74	22.12	2.83	7,256 (29.87%)
	%Real Changes	-50.0	+1.1	+48.9	12,964 (53.36%)

Figure 4: Distribution of land use and land cover change in Kuala Lumpur between year 1990 and 2000



LAND USE AND LAND COVER CHANGE OF KUALA LUMPUR BETWEEN YEAR 2000 AND 2015

From the matrix Table 4 between year 2000 and 2015, there was only 2,996 hectares (12.36%) out of total area of the region had changed. For these changes, it calculated that vegetation and water bodies had undergone substantial changes from year 2000 to 2015 with more than 50%, while most built-up area remain unchanged with over 90%. Based on the results, the water body category recorded the largest change of use of land compared to other land use types with 51.44% changes. Most of that land use conversion was shifting to built-up area with 232 hectares been changed and only a slightly of 54 hectares changed to vegetated land within 15 years. This situation had contributed to the declining of water body in year 2015 with 1.23% left.

Vegetation coverage holds the second highest percentage of change with 49.77% changed. From this statistic, 1,822 hectares of it had converted into built-up land and a slightly of 4 hectares took over by water body. With this huge land conversion situation, the vegetation area in Kuala Lumpur kept showing a declining coverage with barely 11% left in year 2015. For built-up land, the area indicated a constant increased since year 2000 until 2015 with 5.84% increase. The growth of this built-up area was due to the transformation from most vegetated land and a slight from water body. For this built-up category, there was only a slightly changes occurred to the built-up area where 4.42% changed while the rest remain unchanged.

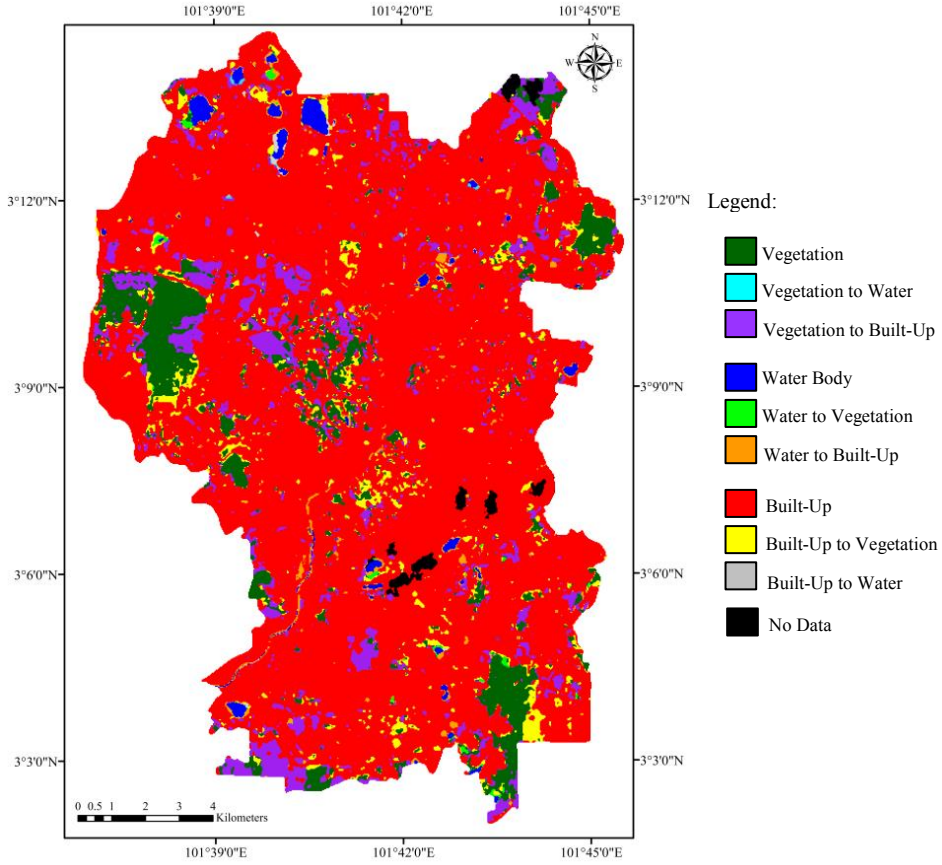
The real changes indicated that built-up area had undergone the most notable changes with the increasing of 50% out of 2,340 hectares. Meanwhile, vegetation area recorded a negative change with 38.97% declining from the real changes and 11.03% dropped for water body category. Based on Figure 5, the map displayed that some part of vegetated land had transformed into built-up coverage and some part of built-up area had converted into vegetation coverage which might due to the landscaping activities in particular areas. Overall, the changed area scattered everywhere in a small scale of areas with a gradually constant pattern of development activities.

Table 4: Matrix of land use and land cover change of Kuala Lumpur between year 2000 and 2015

Year/ Land Use Type		2000 (Hectares)			
		Vegetation	Water Body	Built-up	**Total**
2015 (Hectares)	Vegetation	1,843	54	860	**2757**
	Water Body	4	270	24	**298**
	Built-up	1,822	232	19,125	**21,178**

Total	**3,669**	**556**	**20,009**	**24,234**
%Unchanged	50.23	48.56	95.58	-
%Changed	49.77	51.44	4.42	2,996 (12.36%)
%Real Changes	-38.97	-11.03	+50.0	2,340 (9.66%)

Figure 5: Distribution of land use and land cover change in Kuala Lumpur between year 2000 and 2015



LAND USE AND LAND COVER CHANGE OF KUALA LUMPUR BETWEEN YEAR 1990 AND 2015

Based on Table 5, the changes of land use in Kuala Lumpur was involving 8,325 hectares (34.25%) out of total area within 25 years since year 1990 until 2015. Vegetation category received the most drastic changes within 25 years which more than 75% of it had undergone a rapid change. Most part of vegetated land had been taken over by built-up activities with 76% of vegetated land had transformed into built-up area, while 22 hectares converted into water reservoir.

Meanwhile, water body had undergone significant changes with 39.86% changes with 147 hectares (35.5%) had changed into built-up area and 18 hectares (4.35%) became vegetated land by 2015. Even though water bodies had decreased a lot, but most of its part was remained unchanged with more than 60% coverage within 25 years development growth. For built-up land, it had changed slightly of 2.76% with 97.24% of built-up area remain unchanged. There was a slightly transformation of built-up area into vegetation and water body with 378 hectares by year 2015. Even though built-up area recorded a large scale of unchanged area, but it was still the main land use category that had experienced a significant expansion.

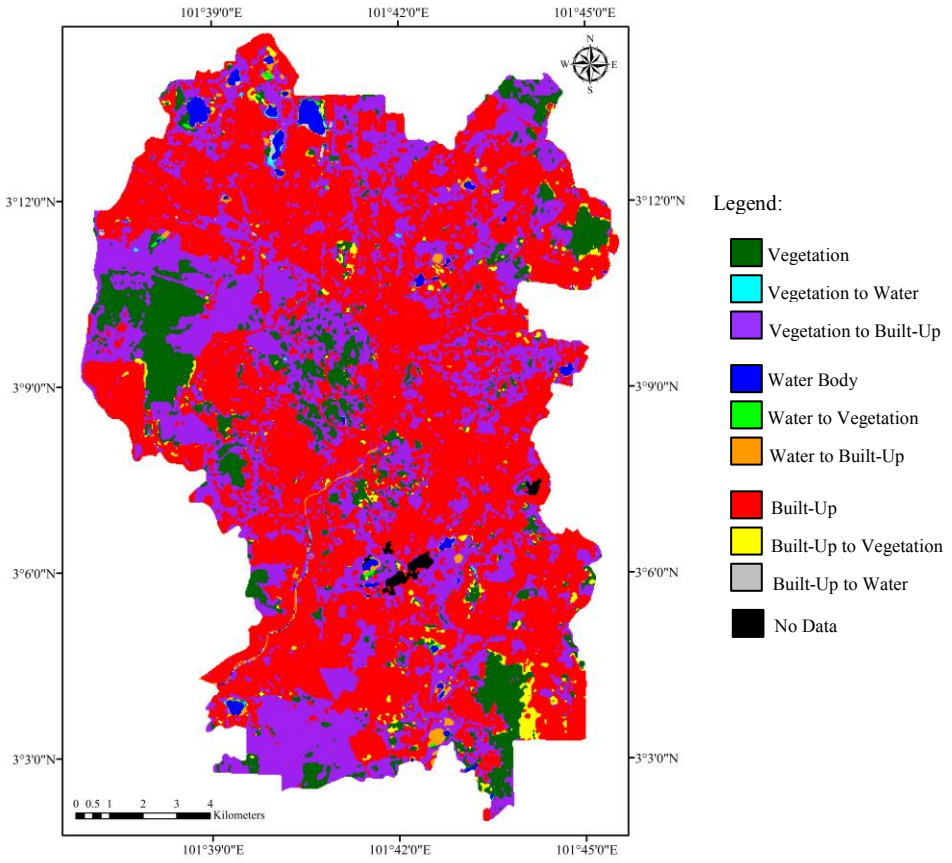
The statistic of real changes recorded that vegetation area had undergone a significant lost by year 2015 since 1990 with 49.23% dropped, while water body also indicated a small scale declining pattern with 0.77% fell. Unlike vegetation and water body categories, built-up area recorded a sudden rise by year 2015 with 50% growth. From the distribution of LULC changes in Figure 6, most vegetated land had shown a drastically change since year 1990 until 2015 which obviously could be seen at the western, southern and the centre part of Kuala Lumpur where it converted into built-up land in a large scale of area. It seemed like those areas had undergone a significant land conversion where most of the green areas had diminished in a large scale.

Table 5: Matrix of land use and land cover change of Kuala Lumpur between year 1990 and 2015

Year/ Land Use Type	1990 (Hectares)			
	Vegetation	Water Body	Built-up	**Total**
Vegetation	2,410	18	351	**2,779**

Water Body	22	249	27	**298**
Built-up	7,760	147	13,321	**21,228**
Total	**10,192**	**414**	**13,699**	**24,305**
%Unchanged	23.65	60.14	97.24	-
%Changed	76.35	39.86	2.76	8,325 (34.25%)
%Real Changes	-49.23	-0.77	+50.0	15,058 (61.95%)

Figure 6: Distribution of land use and land cover change in Kuala Lumpur between year 1990 and 2015



DISCUSSION

Every part of Kuala Lumpur had undergone significant changes, especially at the city center, western and southern part of the region (refer Figure 3). This scenario actually proved that Kuala Lumpur had undergone a rapid urbanisation and kept undergoing advancement in developing its city. From the statistic results, more development activities had been implemented significantly between years 1990 to 2000 where the expansion of built-up area occurred rapidly in a decade. A continuous development expansion had affected the pattern of LULC in Kuala Lumpur as more built-up areas could be noticed towards 2015 as it kept recording an increasing pattern of its total areas in which described its expansion.

A rapid expansion of built-up areas in Kuala Lumpur was somehow showcased that the city had undergone urbanisation with rapid development took place ever since its establishment. As more development of built-up areas in which involved residential, commercial, road networks and others related human development in the city, it indicated a sprawl phenomenon started to rise. Built-up land tend to expand outward to the outskirt and the growing built-up areas in Kuala Lumpur by taking over most of vegetation areas had caused the declining of green space in the area significantly. Generally, the declining pattern of green areas and water body were associated with the increasing pattern of built-up areas. Most of the LULC pattern in Kuala Lumpur was covered by built-up areas, followed by less vegetation areas and water body. As urbanisation took place in the city, thus more undeveloped and green areas had been transformed and converted into built-up land due to massive development activities. Therefore, it was undoubted that the vegetation areas kept recording a negative distribution pattern in the study area.

Developed city had always been undergone a rapid urbanisation with several new developments took place. Urbanisation directly contributed to the increasing of human activities in the city. Since Kuala Lumpur is the national capital, its role as the nation economic engine was promising many opportunities to the locals and outsider in every aspects of life including economic benefits, social, political and cultural elements that could benefits the people in improving their life status. Thus, those factors

encouraged implementation of more developments and enhancements in the city to meet the needs. Therefore, it was undeniable that built-up areas in Kuala Lumpur kept showing an increase and expansion area to the extent that it became a compact city and beyond its capacity.

The increasing pattern of built-up area in Kuala Lumpur became an indication of implementation of rapid development continuously. Commonly, it seemed that several government policies played a crucial role in affecting the LULC change in Kuala Lumpur. A rapid growth of Kuala Lumpur economic had changed the skyline of the city as more modern buildings and large scale developments now fill the urbanscape of Kuala Lumpur. The development in Kuala Lumpur is still progressing until today as more development and enhancement activities keep going in order to cater the development demands for the urban dweller advantages. Recently, the development of the city tends to develop vertically as land availability is decreasing. There are many skyscraper towers and buildings in the city and there is still several of it being developed until today. Rapid development activities definitely have potential in changing the landscapes of urban areas and more land transformation will occur. The growth of economy in urban areas has encouraged more new developments within the city either physically nor economically. The changes in LULC are indicators of urban growth as well as indicators for future direction of urban development and management.

CONCLUSION

There were some limitations throughout the study. The limitation of data resources made this land use study in Kuala Lumpur could not be more specific. The details type for every land use category was unable to be conducted due to its satellite images resolution of 30 meter and could only differentiate three main land use types which consisting of vegetation, water body and built-up areas. Besides that, some phenomena which were not meant to be measured could interfere with the image classification and must be accounted such as the existence of cloud and shadow. The limitation of available published land use map also affected the accuracy assessment process for every study year even though its operational work for one year was just enough to be accepted.

Overall, the three stages period study clearly indicated a varying rate of changes for LULC in Kuala Lumpur. The results recorded that built-up areas had experienced the most changes with a tremendous increase of total area since year 1990 until 2015. Meanwhile, vegetation areas recorded a significant declining pattern within 25 years with almost 50% area decreased because of the transformation of vegetation into built-up areas in large scale where most of vegetation coverage completely diminished in certain areas. In other hand, water body recorded a slightly changes with less than one percent declining since year 1990 to 2015. In general, the growth of development in Kuala Lumpur had greatly affected the land use changes and encouraged the expansion of built-up areas in the city. As urbanisation took over the city, every part of the city had undergone rapid changes and affected its origin land function. The intention of the development is definitely for the people benefits. However, uncontrolled and unplanned development could reverse the benefits and give negative implication. Thus, it is important to emphasize the development planning to reduce the potential of negative impacts.

Therefore, the attempt in integrating remote sensing and GIS in this LULC change detection study actually can be used by the authorities, urban planners or other related stake holders to get updated information about land use and urban phenomenon that occur as well as improve the development framework within a short period and with less amount of cost invested. Significantly, the information from this research is really helpful and valuable for urban planners who would be much better in managing Kuala Lumpur development or they can apply similar analysis method to other regions to improve and apply better management for future development. Eventually, the identification of arising environmental problem through this technology has potential in assessing the effectiveness of policy implementation and encouraging the improvement of governance strength and quality. In the field of academic, this study important as a reference and knowledge sharing on the review of LULC change study as well as expanding knowledge associated with advance technology. In addition, this study can contribute ideas and information needed by researchers and scholars in their research on LULC changes that are appropriate to the current issues. To sum up, this study demonstrated the ability of remote sensing and GIS in interpreting spatial-temporal data in urban development and management.

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