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MONITORING LAND USE PATTERN AND BUILT-UP EXPANSION IN KUALA LUMPUR CITY CENTRE

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Abstract

The urban development in the City Centre of Kuala Lumpur contributed to the Gross National Income of Malaysia. Current practice in Malaysia tends to set an allocation of high-intensity development that is mostly focusing on City Centre Commercial (CCC) while setting different priority allocated for other Centers. Compounding this issue, Malaysia is now experiencing unbalanced land use distribution and changes within the urban centre which lead to leap-frog urban sprawl toward suburb, as well as different plot ratio placed at the maximum cap by the authority in City Center lead to the saturated build-up and downsizing the high-rise development. The possible solution to curb the severity of these issues lie in identifying the growth pattern in the change of land use and expansion that create the limitation of development. The identification of land use change plays an important role in delivering an accurate feasibility study and in structuring an effective strategic plan for improvement of planning standard for the authority. This paper analyses the information through remote sensing approach by identifying the urban growth pattern for KL City Centre using satellite image (1989 to 2019) and examine the influence of different plot ratio to the built-up area in City Centre which complies with the Local Authority Standard. In detail, the focus directed towards understanding the City Centre growth by determining the built-up area expansion, in addition to analyzing the implementation of plot ratio control through land use zoning. The study has found the urban growth expansion/ limitation of development.

Keywords: Urban growth, land use, built up, plot ratio, urban development, remote sensing.

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1. Introduction

Kuala Lumpur granted as a city in 1972 and granted as Federal Territory in 1974. Since then, it has undergone rapid infrastructure development. In 2014, Land use area for Kuala Lumpur is getting bigger 2584.11 area in total compared to 2001 which is only 1824.16 area and increased on density (Boori, Netzband, Voženílek, & Choudhary, 2015a).

It shows that the growth of the city is expanding due to the land use distribution. Mixed land uses and multiple-use buildings is categories as typical urban function (Zitti, Ferrara, Perini, Carlucci, & Salvati, 2015).

The changes of development patterns influence the relationship between the market and physical environment (Paulsen, 2014). The urban expansion influence by the population and traffic conditions which reflect to the density and development trend toward Transit Oriented Development.

The built-up area from the city centre to 50 km (Boori, Netzband, Choudhary, & Voženílek, 2015b) outward the city is decreased in 2014 because of the high intensity and floor space in the city centre while in 2015 it increased to 2573.10 acres (Noor, Rosni, Hashim, & Abdullah, 2018) because of the land use change in Strategic Planning Zone (SPZ) which resulted from the increased and decreased of development were involved many main category such as residential, commercial, institution and public facilities. From 1990 to 2010 showed that changes in green spaces in Kuala Lumpur because of the land use sprawl pattern and the built-up areas increased (Noor, Abdullah, & Manzahani, 2013).

In defining the urban sprawl and urban form, there are two indicators for single or multiple cities which is degree of urban sprawl and urban expansion rate (Jiao, 2015).

Thus, in order to assess the urban expansion of Kuala Lumpur (Figure 1), comparison of the current urban boundary and the historical urban boundary before the upgrade of Kuala Lumpur as a city is reasonable. The vital factor for remote sensing data is building area followed with the building height. (Hu & Wang, 2013).

Besides, the total floor space also second important factor, demonstrated the synthesised on landed and high-rise buildings while spatial characteristics are relevant in differentiate the land uses.

However, due to data availability, Landsat data of the year 1989 is used instead of 1979 one because Landsat TM gave better radiometric resolution than Landsat MSS. Monitoring the land use pattern help the local authority and developers in projecting their build up development to ensure the smart growth of development and controlling the urban expansion.

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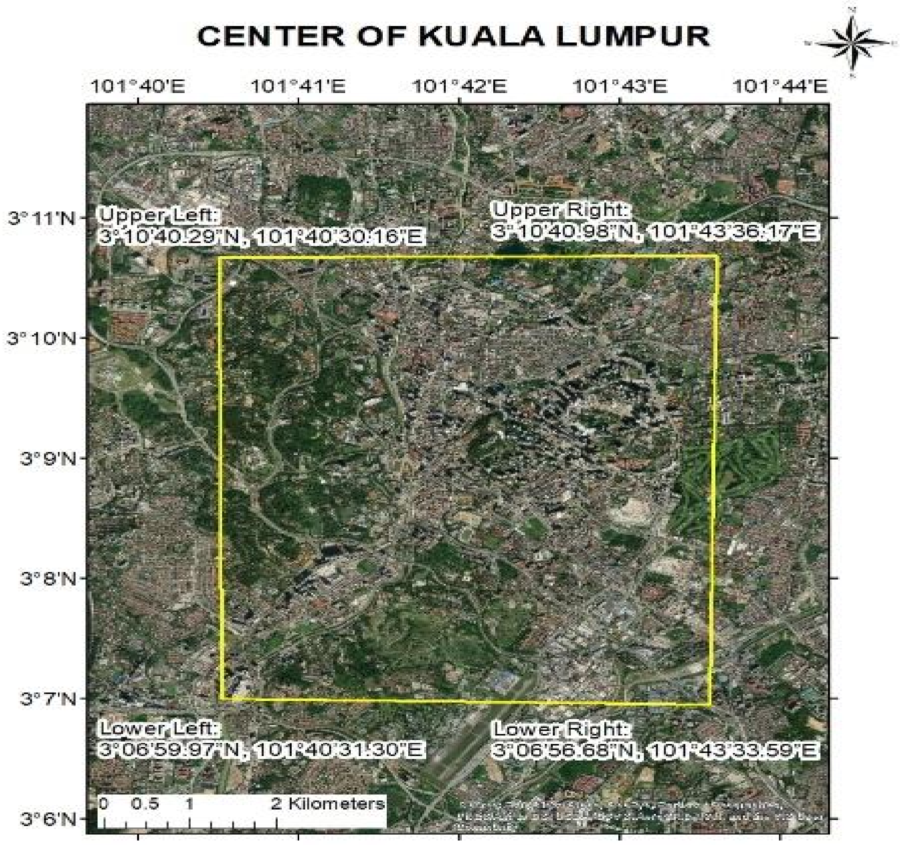

Figure 01. Study area (Kuala Lumpur City Centre) year 2019

2. Problem Statement

Major issues in this research is unbalanced land use distribution within an urban centre lead to leap-frog urban sprawl toward suburb, different plot ratio placed at the maximum cap by the authority in City Centre lead to the saturated build-up and downsizing the high rise development while lower plot ratio put in suburb lowering the densities/price for some project. The issue of urban sprawl and limitation of city borders for every city in Malaysia that create the limitation of the boundary (National Urbanization Plan 2 (NUP), 2016). Because of the high intensity of development, the sprawl of development towards the suburb cannot be defined explicitly using the tools of development control. The growth of Kuala Lumpur City Centre has classified the land use zone called City Centre Commercial (CCC) which expanding and links up to the non-urbanised suburbs (Draft Kuala Lumpur City Plan 2020, 2018). In 2015, distribution of land use in Strategic Planning Zone showed that Non-sprawl distribution in the city centre with 3% smart growth over 5.3% of land use from 2.17% segregated indices (Noor et al., 2018). There are tools use in development control to identify the issue of urban growth in Kuala Lumpur base on the determination of authority allocate the city centre as a focus built-up area. The urban economic not just focusing in the middle of the region which implemented as Central Business District but also spread by locating the market value and the importance of that area.

The development of urban Mass Rapid Transit system occurs more Transit-Oriented Development in City Centre and attracts more development with a high density of the built-up area in Kuala Lumpur City Centre (Jabatan Perdana Menteri, 2016). Linkages of transportation (Transit Oriented Development) influenced the land use activity in urban economics (Flyvbjerg, 2013). Urban transport is the factor

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contributing towards urban economics which affected the land-use patterns as the accessibility to other sites caused by the transportation modes. Issues efficiency of light-rail transit development contribute to urban economic growth with current development of MRT which occurs more alternative in transportation.

New challenges that require one planning and management of the city to be more systematic (National Urbanization Plan 2 (NUP), 2016). Therefore, the analysis of location choices of the firm in intra-city location and the households is the indicator to measure the patterns of land use. This allocation also will determine the land value and the different price for the separate area. Furthermore, it caused the expansion of land use from the City Centre to the outward city. The big scale of the project was called mega-project also referring to the location in the city (Flyvbjerg, 2013).

3. Research Questions

Focusing more on monitoring, measure and analyse the urban growth of Kuala Lumpur City Centre:

- What are the land use and trend of urban growth in Kuala Lumpur City Centre?
- How can the relation between Land Use Control (plot ratio, floor space and Gross Development Value) contribute to the expansion of the built-up area?
- How to analyse the Landsat Remote Sensing Image of City Centre in defining the allocation of the built-up area?

4. Purpose of the Study

The study on monitoring the land use and built up expansion which covers the City Centre of Kuala Lumpur as the main Growth Centre called Commercial City Centre (CCC). It analyses the intensity development which covers the built-up area, land use pattern, plot ratio and built up expansion from 1989 to 2019. These are the objective in achieving the success of this study:

- To identify the land use pattern in GIS and Remote Sensing that lead to the development limitation in Kuala Lumpur.
- To understand the expansion changes and movement of built up and non-built up area from 1989 to 2019.
- To analyse the relationship of urban growth pattern from GIS with the location decision which uses of controlling the plot ratio and floor space that will give an impact to high-density development.
- To monitor the urban development growth in a relation of land use changes and build up area to potentially be used for the feasibility study.

5. Research Methods

Qualitative study approach using some observation such as measuring the built-up and plot ratio which comply with the Local Authority Standard and Guidelines from Jabatan Pelan Induk and Jabatan Perancang Bandar, DBKL; and analyse the information through remote sensing approach.

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5.1. Observation and mapping (qualitative method)

Observation of the built-up area in the city centre to see on real plot ratio that has been given when some are given a high plot ratio and consideration of market forces. The data of the average plot ratio and floor space of the building is gathered from the site observation, which conducted to estimate and measure the built up for every single development. Then the total up for every development has come with the total of built-up area for KL City Centre. To calculate that aspect of urban growth, the value of acreage for each lot and building lot has to be defined to get the percentage of plinth area and non-built up area. All development in KL City Centre is calculated to obtain the Gross Development Value (GDV) and to know the value of the land. By using comparative analysis, trend analysis, and Analysis of Remote Sensing Data. This data needs to calculate large numbers of the built-up area from each land use to every other land uses within a given radius. Major steps of Landsat image processing are shown in Figure 2 and described as follows:

Step 1: Download Landsat data from USGS Earth Explorer (https://earthexplorer.usgs.gov/).

Step 2: Image pre-processing: subset and extract the study area from the satellite images, radiometric calibration and atmospheric correction to reduce the atmospheric and sensor errors.

Step 3: Selection of region of interest (ROI) and randomly generated 50 ground truth from Google Earth for image classification and accuracy assessment. Image classification was conducted using the Maximum Likelihood method.

Step 4: Image differencing to identify the expanded urban area. It involves the analysis of Landsat image from satellite imagery to analyse the built-up formation between the range of time between historical (1989) and recent (2019) years. It also needs the sharpest and persist of the digital image to get the accurate form.

The USGS Earth Explorer is an online search, discovery, and ordering tool developed by the United States Geological Survey (USGS). The characteristics of the Landsat data used in this study are described in Table 1 (Landsat Science, 2019). The reason of choosing different sensor types of Landsat sensor for both years is because the Landsat 5 operated from March 1984 to June 2013, while Landsat 8 operated from February 2013 onwards.

Table 01. Characteristics of the data used.

Year	1989	2019
Sensor Type	Landsat 5 TM	Landsat 8 OLI/TIRS
Acquisition Date	16^{th} December 1989	7^{th} April 2019
Spatial Resolution (m)	30	30
Number of Bands	7	11
Wavelengths (μm)	Band 1 – Blue: 0.45 – 0.52 Band 2 – Green: 0.52 – 0.60 Band 3 – Red: 0.63 – 0.69 Band 4 – NIR: 0.76 – 0.90 Band 5 – SWIR1: 1.55 – 1.75 Band 6 – Thermal: 10.40 – 12.50 Band 7 – SWIR2: 2.08 – 2.35	Band 1 – Ultra Blue: 0.435 – 0.451 Band 2 – Blue: 0.452 – 0.512 Band 3 – Green: 0.533 – 0.590 Band 4 – Red: 0.636 – 0.673 Band 5 – NIR: 0.851 – 0.879 Band 6 – SWIR1: 1.566 – 1.651 Band 7 – SWIR2: 2.107 – 2.294 Band 8 – Panchromatic: 0.503 – 0.676 Band 9 – Cirrus: 1.363 – 1.384 Band 10 - Thermal1: 10.60 – 11.19 Band 11 – Thermal2: 11.50 – 12.51

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Image pre-processing is a process of correcting the specific sensor and platform radiometric and geometric distortions of satellite data. Radiometric error is caused by scene illumination and viewing geometry, atmospheric conditions, and sensor noise and response during data acquisition. Atmospheric error is caused by the surface reflectance that characterizes the surface properties in the satellite images (Natural Resources Canada, 2015). Image pre-processing is important to improve the accuracy of image classification. In this study, the corrections are done with ENVI software built-in module.

Maximum likelihood classification is a supervised image classification method which is commonly practiced for multispectral data (Strahler, 1980). It is a mathematical operation derived from the Bayes theorem, that defines that according to posteriori distribution probability, a pixel with feature vector belongs to a common class (Ahmad & Quegan, 2012). In simpler words, maximum likelihood classification assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class with the highest probability (Richards, 1999). In this study, such procedure was software oriented by ENVI with the parameters set by default. The computation of ENVI implemented Maximum Likelihood classifier is scripted with the discriminant functions for each pixel in the image by:

$$g_i\ (x) = ln\ p(\omega_i) - {}^{1}/_{2}\ ln\ |\Sigma i| - {}^{1}/_{2}\ (x - m_i)\textstyle\sum_i^{-1}(x - m)$$

where i = class; x = n-dimensional data where n is the number of bands; $p(\omega_i)$ = probability that class ω_i occurs in the image and is assumed the same for all classes; $|\Sigma i|$ = determinant of the covariance matrix of the data in class ω_i; $\sum_i^{-1}(x - m)$= its inverse matrix; and m_i = the mean vector.

In this study, the features in the study area were classified into two classes, namely “Built Up Area” and “Vegetation”. “Built Up Area” is surface features with man-made features, while “Vegetation” is natural features such as forests and plantations. These two land use classes were employed with the reason that in this study area only covers urban built-up area and vegetation area.

Upon completion of image classification, accuracy assessment of the results is done to assess the quality of the classified images. Accuracy assessment is defined as determined by means of a confusion matrix that compare the classified result with ground truth on class-by-class basis (Ahmad & Quegan, 2012). A total of 50 ground truth were randomly generated from Google Earth for the accuracy assessment. An overall accuracy of the classification results can be determined by computing the total percentage of pixels that correctly classified. The overall accuracy formula is per as follows:

$$\text{Overall Accuracy} = \frac{\sum_{a=1}^{U} c_{aa}}{Q} \text{ X } 100\%$$

where Q and U is the total number of pixels and class respectively. Classification of overall accuracies more than 85% is considered the minimum acceptable results (Scepan, 1999). The Kappa coefficient, ϰ is another measurement for image classification result accuracies. It considers the off-diagonal elements and diagonal elements of the classified result in terms of image algorithms.

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$$\kappa = \frac{\sum_{a=1}^{U} \frac{c_{aa}}{Q} - \sum_{a=1}^{U} \frac{c_{a\bullet}\, c_{\bullet a}}{Q^2}}{1 - \sum_{a=1}^{U} \frac{c_{a\bullet}\, c_{\bullet a}}{Q^2}}$$

where $c_{a\bullet}$ = summation of rows. For a multispectral classification results, κ of 0.90 – 1.00 indicating a high accuracy result (Jensen, 1996).

In GIS operations, image differencing is a technique to detect and analyse the changes between two images. It is performed by subtracting the digital number (DN) value of a pixel in the desired band in the first image with the same pixel of the same band in the second image (Afify, 2011). In this study, this operation is done to detect the expanded urban area between 1989 and 2019.

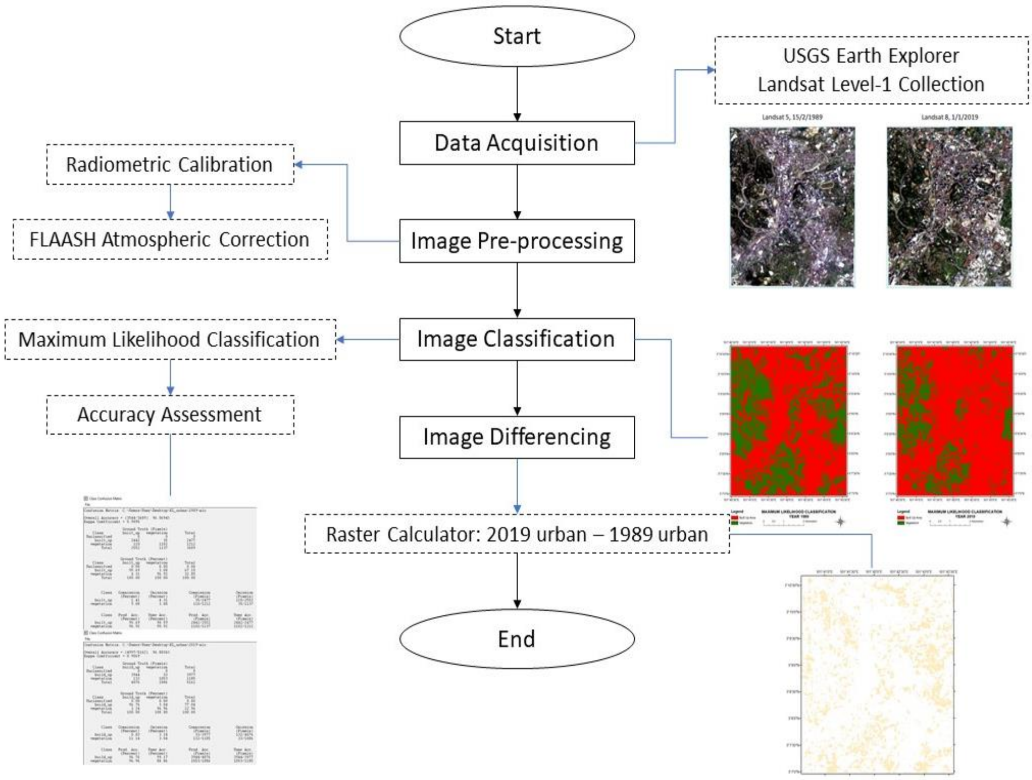

Figure 02. Image processing of Landsat data

6. Findings

City Centre Commercial (CCC) in blue colour (Figure 3), which commercial areas that provide for an extensive range of distribution (35.4%) reflect on height and plot ratio as the centre for activity, floor space and the built-up area in City Centre. Land use distribution in the City Centre majorly focused in the golden triangle of Kuala Lumpur and distributed towards the east area of Kuala Lumpur resulted by the transit line and linear development from Jalan Ampang and Jalan Tun Razak. While others area is more distributed with local commercial and mixed development. The CCC area is a primary built-up commercial zone which allowing higher intensity development with the rapid growth of commercial building and mega project. The distribution of Main Commercial (MC) and Local Commercial (LC) leads

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to the intensive growth of development. Redevelopment and development of infill area create more economic development especially for heritage core and buffer zone in Kuala Lumpur.

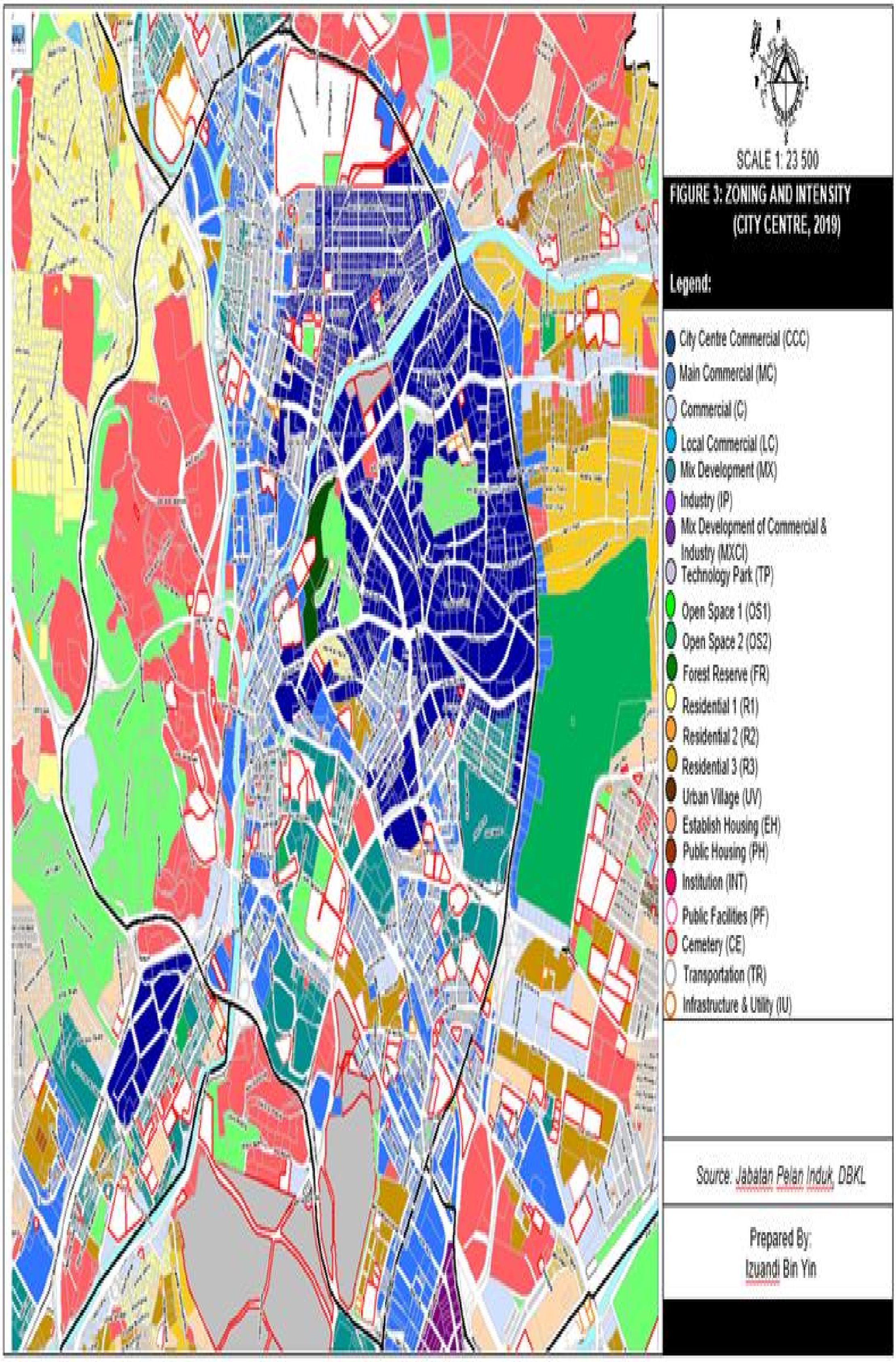

Figure 03. Zoning and intensity (KL City Centre, 2019)

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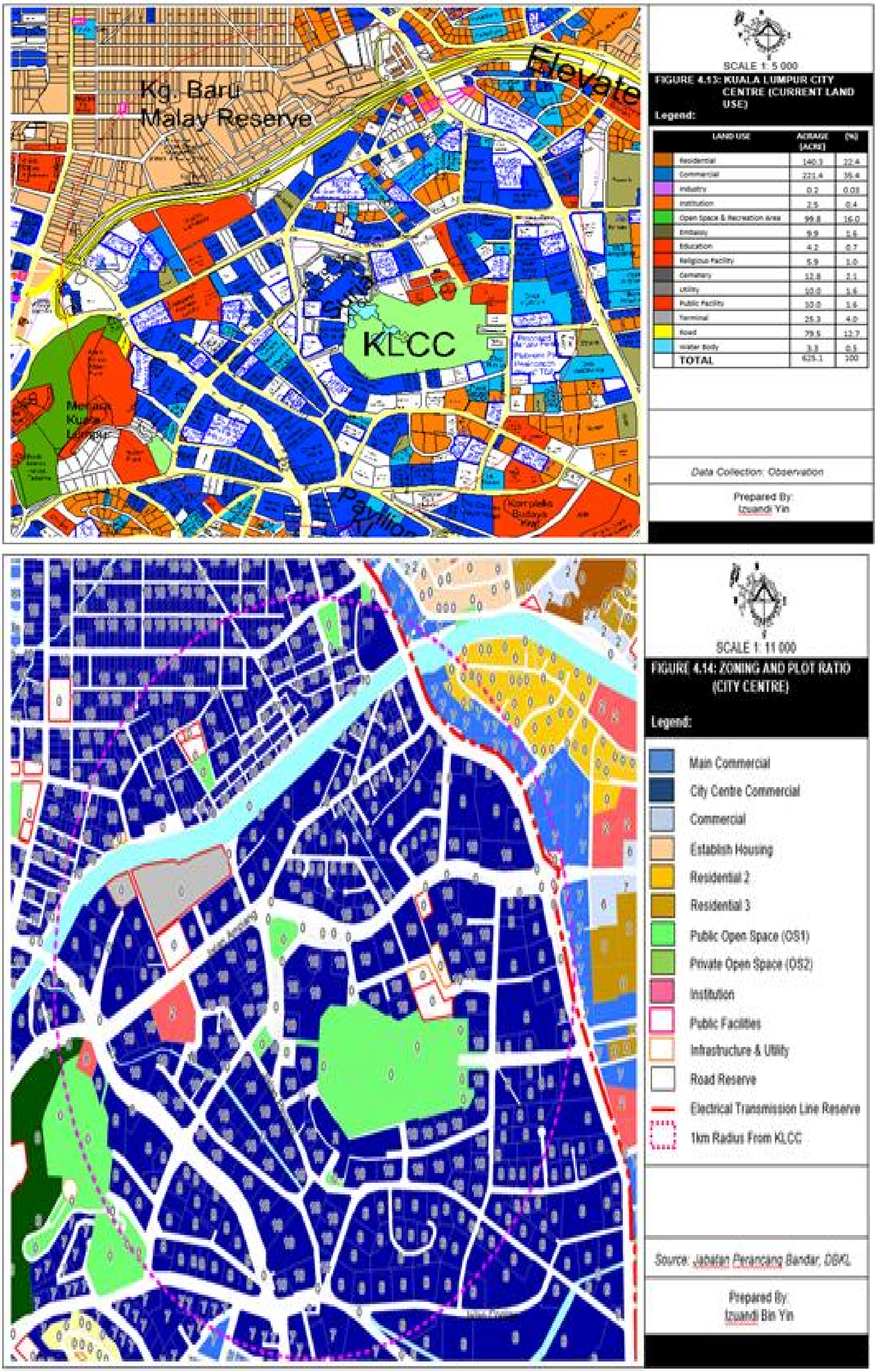

Figure 04. Current land use and plot ratio in 1km radius (KL City Centre, 2019)

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Those commercial floor space show the high-rise development along the main road and highways in the city were located many business and offices and other uses of commercial activity. Different plot ratio is given by the authority for every center base on the importance direct the growth focusing on the CCC area only.

KL City Hall put different plot ratio for each lot which the highest plot ratio recorded in 1km from KLCC average is 1:10 (around KLCC and along Jalan Tun Razak) while the lowest is 1:6 in the south-east area (along Jalan Conlay and Jalan Raja Chulan).

KL Structure Plan 2020 has specified the total of 41 million-meter square feet of floor space for commercial and projected the need up to a total of 65 million-meter square feet by the year 2020 base on KL City Plan 2020 while in City Centre allocated 46.6% from overall floor space. Meanwhile from the data collection and observation shows that City Centre has been allocated with highest plot ratio with the average of 1:8 and 625.1 acre/km of land use (Figure 4) while the built-up area is 1.8 Million square foot (Table 1) which cover 19.4% from overall built-up area and 43% of floor space in Kuala Lumpur Territory (Draft Kuala Lumpur Structure Plan 2020, 2018).

Table 02. Plot ratio and built up area observation

Strategic Zone	**Commercial GFA**		**KL Commercial GFA (sq.m.) 2019**			
	KLSP 2020	**Draft KL City Plan 2020**	**Average Plot Ratio**	**GDV (RM Mil.)**	**Floor Space**	**Built up Area (Sqft)**
City Centre	14,383,332	30,665,958	1:8	11,726.4	17,668,700	1,888,711
KUALA LUMPUR	41,275,508	65,800,206	1:4	46,964.7	40,929,191	9,712,524

6.1. Results of image classification

Figure 5 shows the classified images of year 2019 and 1989. In general, urban expansion occurred in the eastern central of the Kuala Lumpur city with vegetated area turning into built up area. The overall accuracy of the 2019 classified image is slighter higher than the 1989 classified image, as listed in Table 3. Based on the literature, the image classification done in this study yielded high accuracies.

Table 03. Accuracy assessment of the classified images.

Year	**1989**	**2019**
Overall Accuracy (%)	94.16	97.07
Kappa coefficient, κ	0.87	0.93

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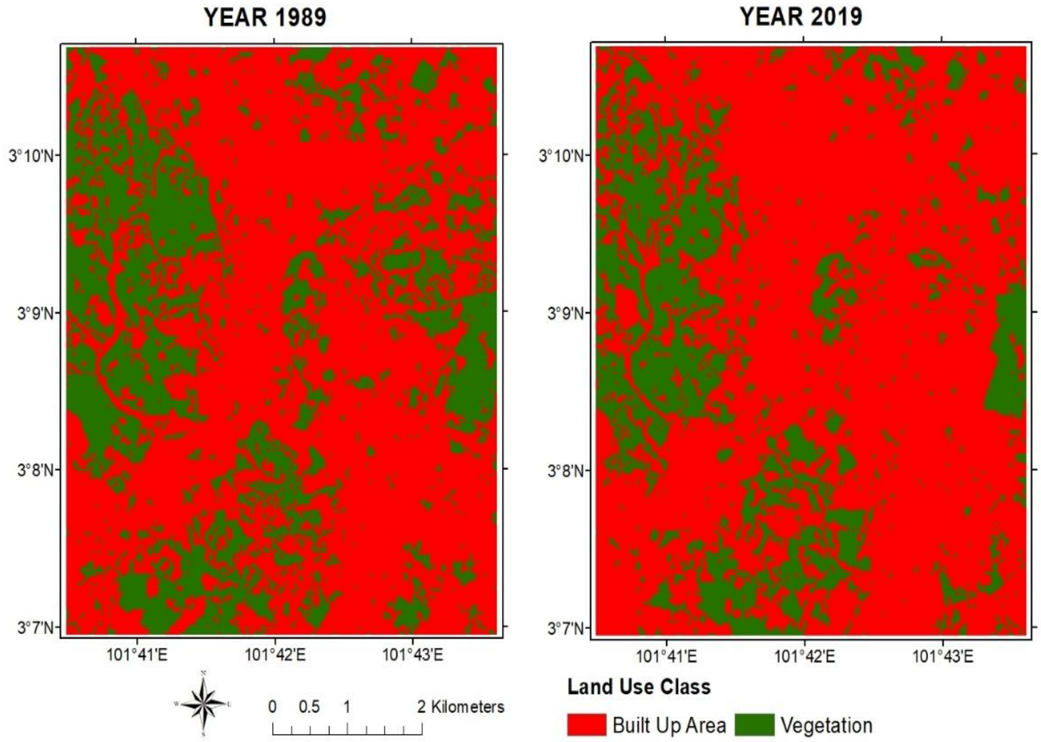

Figure 05. Image Classification on Built Up Area Between Year of 1989 and 2019

Urban expansion showed a rapid growth move towards the east and southeast regions of the city and. The expansion is mainly due to the Tun Razak Exchange in a nearby area of Cheras and Bandar Tun Razak (Figure 5). The main project in Greater KL, with one of it is Tun Razak Exchange which comply with the Greater KL strategies to create iconic places such as iconic buildings to attract and promote more high-density development around it. The development of iconic building Tun Razak Exchange in 70-acre site forecasting the Gross Development Value (GDV) up to RM40 billion. The strategic location in the golden triangle and inside the CCC. This national project supposedly supports the Economic Transformation Programme's goal in contributing the Malaysia's Gross National Income per capita with the target up to USD15,000. It will allow 3.3 million job opportunity and projecting up to USD444 billion in investments by next year. The built-up area from the city centre to 50 km outward the city is decreased because of the high intensity and floor space in the city centre (Boori et al., 2015b). The influence of planning permission in the conversion of land and change of building use allowed most of the developers and owner to change their land or building into a profitable asset.

6.2. Results of Image Differencing

Figure 6 shows the expansion of urban area in Kuala Lumpur city. By observing the expansion in terms of spatial characteristics, it is observed that the expansion is scattered around the boundary. By overlapping the expanded urban region with satellite image, it can be seen that some urban green area was being changed into built up areas, where this will gain urban sustainability issues. The change of non-urban to the urban category is found expanding to the Northeast of Kuala Lumpur while there are no changes in the City Centre which the area was saturated build and more focusing on redevelopment project (Figure 6). On the left image in Figure 6 shows the yellow spot which represents the conversion

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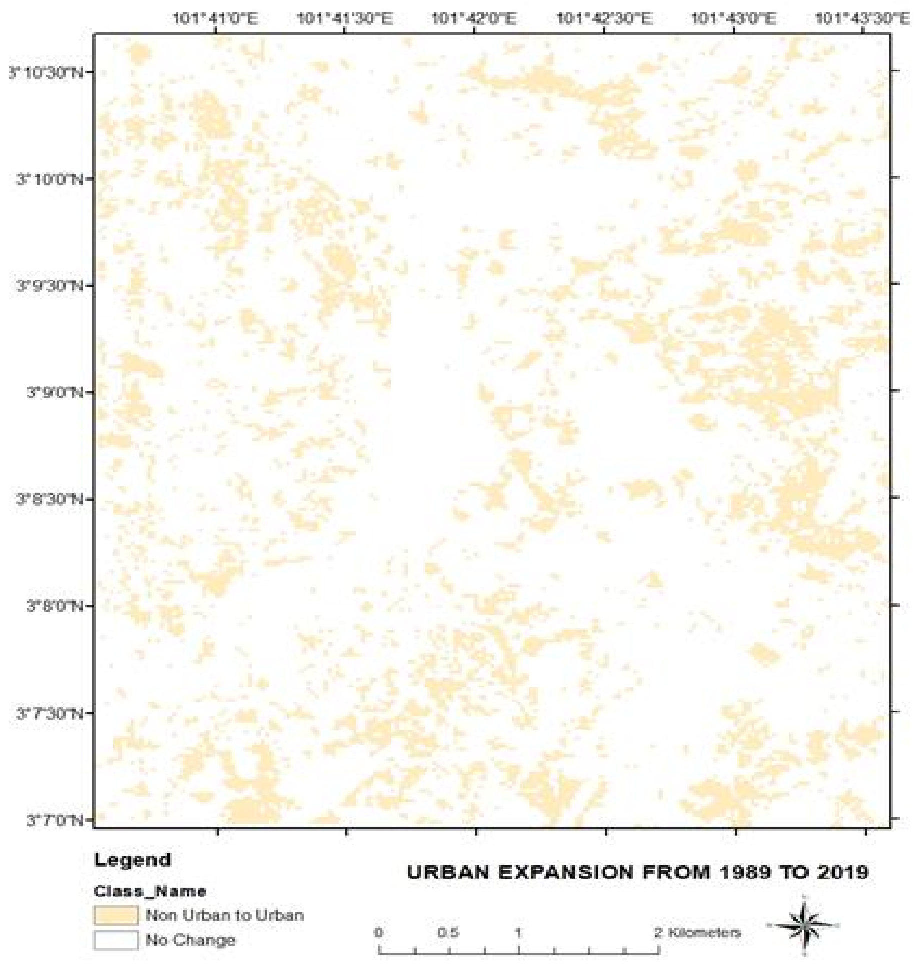
from non-urban to urban category while the white spot shows no changes which mean there are no additional densities proposed from 1989 to 2019 which the existing development is monitored by the local authority to be heritage area and redevelopment purposes. While on the right showed some vegetation area with no conversion is allowed.

The vegetation has limited the development in respecting on the natural environment to have proper green or open space area in the urban centre. Table 2 shows that there is additional built-up area (13.32%) which come from the change of vegetation to the urban built-up area from 1989 to 2019. Some major factor on conversion from non-urban to urban land use because of the Transit-Oriented Development which recently ongoing development in Bandar Malaysia nearby Tun Razak Exchange. The expansion of development toward south area because of the Mass Rapid Transit and Light Rail Transit from City Centre towards the sub-urban area that creates automobile-oriented settlement pattern and commercial centre around it which also grab the intention for the development of PR1MA project along the LRT Station including Cempaka, Pandan Indah, Pandan Jaya and Jelatek.



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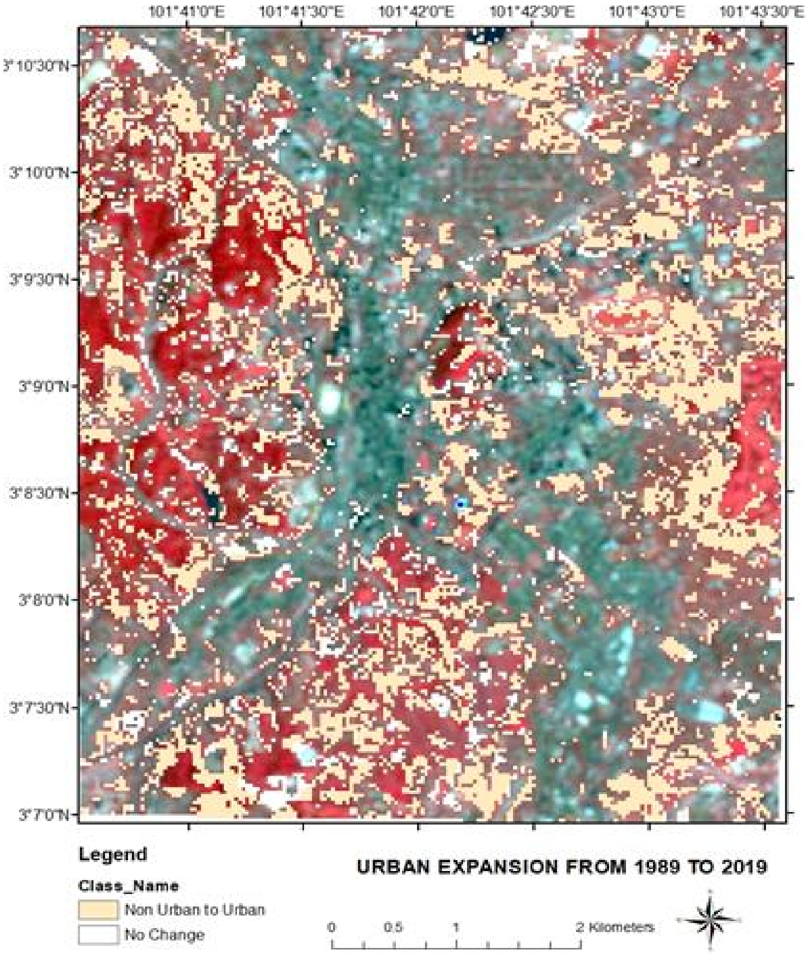

Figure 06. Image differencing centre on urban expansion from 1989 and 2019

Table 04. Kuala Lumpur City Centre expansion from 1989 to 2019

Class	1989	2019	Difference
Built Up	63.51%	76.83%	+13.32
Vegetation	36.49%	23.17%	-13.32

7. Conclusion

The result of this study has identified the growth's expansion of the built-up area in Kuala Lumpur from 1989 to 2019, and it causes of the land-use changes from vegetation to building, especially for commercial purposes. In Kuala Lumpur Golden Triangle, itself clearly shows that major activity and land use distribution come from commercial activity (35.4%). The land use activity is more focus on commercial and services activity attract more high-rise development and located around the transit station, which creates Transit Oriented Development. The influence of Planning Permission and density control for every development, especially for commercial purposes, has to lead to the expansion of the built-up area in the city centre. The allowable plot ratio and density in city centre lead to the provision of building height and floor space including the provision for other facilities especially for parking space which results in an addition of podium parking up to 6 levels. From the finding clearly, show that controlling the development in a certain area will also controlling the built-up area to avoid saturated

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development. In order to have a clear expansion and boundary, the Landsat image is helpful for authority and developers in projecting future development. With the analysis of urban built-up expansion, urban sprawl issue in Malaysia can be monitor using this approach. This result will help a total of 314 cities in Malaysia which expecting to have a clear urban boundary with solving the problem of urban sprawl and public facilities provisions to achieve the mission of National Urbanization Plan.

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