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# Spatiotemporal analysis of land-use changes in a metropolitan city in Malaysia

**Abdulwaheed Tella*[1], Abdul-Lateef Balogun [1], Asmau Balogun[2]**

[1]*Geospatial Analysis and Modelling (GAM) Research Laboratory, Department of Civil and Environmental Engineering, Universiti Teknologi PETRONAS (UTP), 32610 Seri Iskandar, Perak, Malaysia*
[2]*Department of Petroleum Geoscience, Universiti Teknologi PETRONAS (UTP), 32610 Seri Iskandar, Perak, Malaysia*

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**ABSTRACT**

Land-use/cover change is an essential element for global environmental development. Rapid changes in the types of land cover can impact the ecosystem and urban sustainability. Thus, this study investigated the land-use changes in a Kuala Lumpur, the most urbanised and populated city in Malaysia. Landsat 8 OLI imageries were used to examine the five (5) years transformation in the land use/cover from 2015 to 2020. The classification of the land use was done in ArcGIS environment, while the error matrix approach was used to validate the classification. From the result, there was an observable built-up expansion from 2015 to 2020 with an estimated 2% increase since 2015. In the land use/cover area mass, there were 0.26% and 4.3% decrease in the water bodies and thick vegetation respectively recorded in 2020. These findings may be attributed to the transformation of the lands for building and construction purposes. Also, the 2.26% increase in the light vegetation in 2020 may be due to the growth of green foliage for enhancing good air quality and breeze. Due to the expected expansion and an increase in urban development, strategical urban planning is necessary to sustain the environment and reduce the impacts of hazards.

## 1. INTRODUCTION

Rapid urbanisation, coupled with some anthropogenic activities, has led to some changes in the land use and cover. Due to some development and growth, land use has influenced the landscape patterns in many cities (Dadashpoor, Azizi, & Moghadasi, 2019). The changes which do not only impact the green ınfrastructure but social, economic and technological forces (Hersperger et al., 2018). Thus, the study of land-use change is critically essential in global environmental change (Lawler et al., 2014; Verburg et al., 2015). Moreover, land-use change is a critical factor for understanding and forecasting climate change and natural hazards (Ning et al., 2018; Tella & Balogun, 2020). Therefore, it becomes essential to understand the series of changes that has transcended to predict some future events and ensures urban sustainability.

Considering the expected increase in urban sizes by 2050 (United UN, 2014), the effects on land use patterns are inevitable. The impact of changes in the land such as deforestation which is common in Southeast Asia (Guo, Lenoir, & Bonebrake, 2018) due to necessity or expansion of conurbations has led to the adverse effect of climate change (Guo et al., 2018; Halim et al., 2020). The changes in the green vegetation, water bodies, and bare surface to build-up due to urban expansion have led to the declination and degradation of the land surface (Halim et al., 2020; Xu et al., 2016). This study, therefore, aims to study the land change pattern in Kuala Lumpur, a megacity in Malaysia. Kuala Lumpur is a metropolitan city, which is the federal capital of Malaysia with an approximate land area of 243 sq. km (Althuwaynee, Balogun, & Al Madhoun, 2020). Due to rapid urban expansion, industrialisation, and commercialisation in this region, it has led to the transformation of landscapes and contamination of the surrounding (Sanusi et al., 2017).

In order to understand the land-use changes and patterns in this city, it is necessary to investigate and examine the alteration in the land use/cover over the previous years. The outcome of this study will assist urban planners and stakeholders in spatial planning on land-use change for urban and environmental

* **Corresponding Author**

*(Tellaabdulwaheed01@gmail.com) ORCID ID 0000 – 0002 – 4380 – 3343
(geospatial63@gmail.com) ORCID ID 0000 – 0002 – 0418 – 3487
(asmaumusa060@gmail.com) ORCID ID 0000 – 0003 – 2306 – 2039

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sustainability. For this purpose, remote sensing and geographical information system (GIS) is used to examine the land-use and cover change. Thus, this research investigates the changes in land use and cover in the last five years in Kuala Lumpur.

## 2. METHOD

Kuala Lumpur is a metropolitan city in Malaysia, with an estimated land area of 243 km$^2$ (Althuwaynee & Pradhan, 2017). It has a relatively flat terrain with an elevation range of 0 to 420m above the sea level (Althuwaynee et al., 2020). The study area is also referred to as Kuala Lumpur Extended Mega Urban Region being the centroid for socio-economic development, coupled with being a national capital of Malaysia (Halim et al., 2020). Over 33% of the total population in Malaysia are residing in Kuala Lumpur, with an expectance of increase in the population density in the future (Abdul Samad & Shaharudin, 2017). Fig.1 shows the location of the study area.

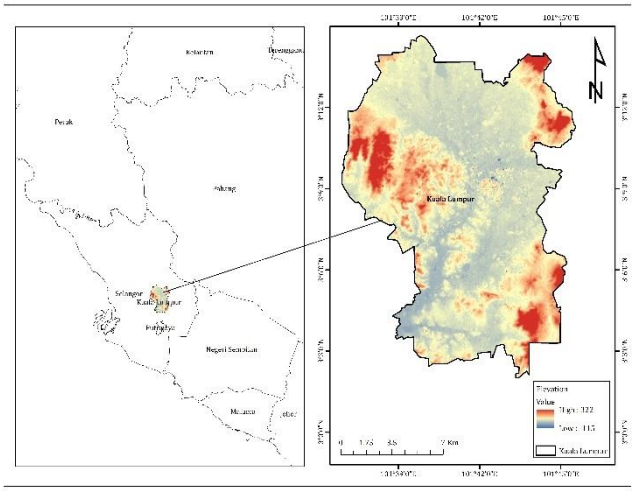


**Figure 1.** Study area

The land use and land cover (LULC) map of the study area was generated from the Landsat 8 OLI (Table 1).

**Table 1.** Landsat 8 OLI data source

| Satellite | Format | Grid Cell | Year | Source |
|---|---|---|---|---|
| Landsat OLI/TIRS | Raster | 30m | 2015 | USGS: https://espa.cr.usgs.gov/ |
| Landsat OLI/TIRS | Raster | 30m | 2020 | USGS: https://espa.cr.usgs.gov/ |

The five years transformation in the land-use and cover of the study area was investigated from the Landsat imageries of the years 2015 and 2020. Supervised classification (Maximum likelihood), one of the most frequently adopted methods used for quantitative analysis of remote sensing data (Rwanga & Ndambuki, 2017) was used in this study while detecting the significant changes. Finally, the error matrix was used to assess the accuracy of the classification.

Fig. 1 shows the flow chart of the methodology employed in this study.

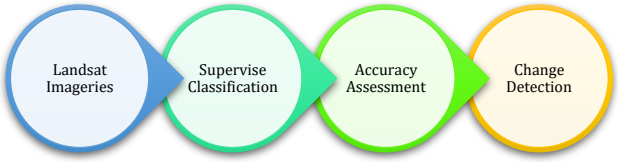


**Figure 1.** Methodology flowchart

## 3. RESULTS

The Supervised classification map for this study was carried out in ArcGIS 10.5 software. There are four land cover classes in the maps produced. The classes include water bodies, thick vegetation, light vegetation, and built up. The description of the land use and cover adopted from (Rwanga & Ndambuki, 2017) was shown in Table 2.

**Table 2.** Land use and land cover structure

| Land use/cover | Description |
|---|---|
| Water bodies | Streams, rivers, lakes, swamps, and reservoirs |
| Thick vegetation | Evergreen and deciduous forest land, |
| Light vegetation | Crop fields, shrubs, and less than 15% vegetated cover |
| Built-up | Residential area, buildings, commercial hub, industrial area, urban area and structures |

The four classes of the land use/cover maps are shown in Fig. 3 and 4. The land use/cover classification was validated using the error matrix approach in order to assess the confidence level of the selected pixel (Bai, Feng, Jiang, Wang, & Liu, 2015). In order to evaluate the accuracy, the pixel of the classified LULC was compared with the actual value pixel of the high-resolution World Imagery in the ArcGIS environment. The overall accuracy of the LULC classification was gotten using equation (1) below. The overall accuracies for classified LULC maps for 2015 and 2020 are 95% and 92.5% respectively.

$$\text{Overall accuracy (\%)} = \frac{\text{total true point}}{\text{total sample point}} \times 100\% \qquad (1)$$

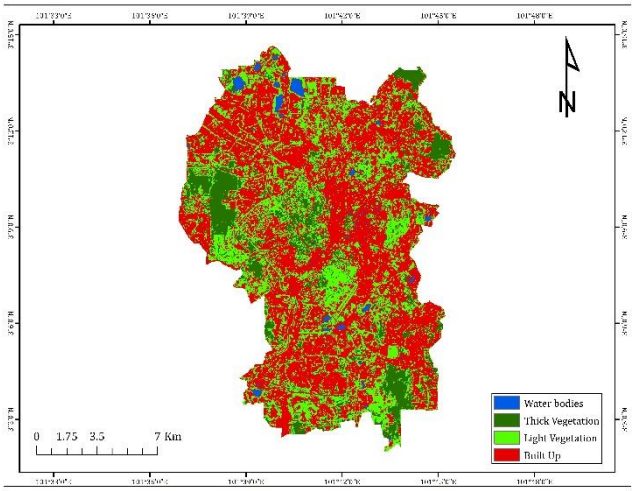


**Figure 3.** Land use and land cover map for the year 2015

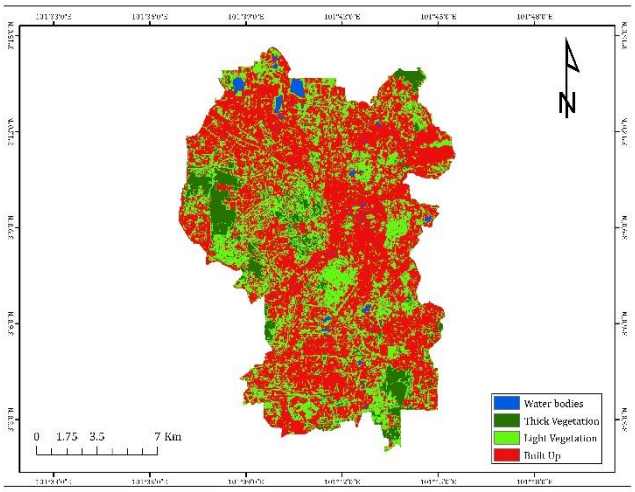


**Figure 4.** Land use and land cover map for the year 2020

The area covered of each class was calculated in square kilometre (km²) and percentage area (%) covered. Table 3 represents the area cover of the LULC. It was observed that there is a 0.26% reduction in the water bodies within the five years interval. This may be due to the transformation of water bodies into built-up or the erection of buildings above the water bodies.

**Table 3.** Area of the land use and land cover map

| | 2015 | | 2020 | |
|---|---|---|---|---|
| | km² | % | km² | % |
| **Water bodies** | 3.17 | 1.31 | 2.54 | 1.05 |
| **Thick vegetation** | 27.81 | 11.5 | 17.43 | 7.2 |
| **Light vegetation** | 74.1 | 30.63 | 79.57 | 32.89 |
| **Built-up** | 136.84 | 56.56 | 142.4 | 58.86 |

Also, clearing of the thick vegetation such as forest might have led to 10.38 km² decrease within the five years interval. Contrarily, light vegetation. Shows a considerable 2.26%. The increase in light vegetation might be due to the planting of some green vegetation in the country to balance the atmospheric elements and sustain the environment.

As hypothesised, the area covered by the built-up increase by approximately 2% affirming the hypothesis that urbanisation influence the changes in land use and cover. According to Halim et al. (2020), rapid urbanisation could affect the land-use patterns resulting in the transformation of an area to another. For instance, the transformation of the vegetated regions to built-up areas. Therefore, it is evident that there is an increasing trend in land-use change. Also, there is an expected increase in alteration of landscape forms in the future (Dadashpoor et al., 2019).

## 4. DISCUSSION

The changes in land use and land cover (LULC) have significant impacts on the sustainability of an environment. Over time, urbanisation and population density have been regarded as the two common factors that influence the changes in the LULC. This study examines the spatiotemporal variations in the LULC by considering two Landsat 8 imageries with a difference of five (5) years. Therefore, this paper reveals the transformation and changes in the LULC in Kuala Lumpur, Malaysia, using geospatial techniques. In order to validate the classification of LULC for accuracy assessment, error matrix method was used. The classification outcome exhibit acceptable accuracy. The government can leverage on the outcome of this study in controlling, monitoring and managing the urban settlement and population growth.

In the last five years, there has been some reduction in some land cover such as the water bodies, and thick vegetation. This might be due to the necessity to expand and transform some landscape for anthropogenic activities. This study aligned with the findings of Shahbaz, Loganathan, Muzaffar, Ahmed, and Ali Jabran (2016), which claimed that surge in the urbanisation and population has led to the transformation of agricultural land to industrial areas in Malaysia.

Increase in urban population demands for more housings, infrastructures and amenities leading to rise in the built-ups. According to Hussain and Byrd (2016), urban population influences the changes in the land cover due to the high demands of housings, and technology to sustain the inhabitants. An over 2% increase of the built-ups is therefore expected given the inevitable need of it.

Although further studies are required to investigate and understand the nexus between urbanisation and LULC, however, this study has shown the behavioural trend of LULC. This proofs that LULC is an important factor to be considered while studying environmental disasters such as flooding, landslide, air pollution, and drought. Also to facilitate sustainable development in the environment, LULC is an essential factor.

## 5. CONCLUSION

This paper examined the land-use changes in Kuala Lumpur, an industrialised and highly populated city in Malaysia. The study used satellite remote sensing imageries of two years 2015 and 2020. The study reveals the five years of transformation in land use. Thus, this research analysed the patterns and changes in the land use for five years interval. Compared to the year 2015, there has been a reduction in water bodies and thick vegetation in the year 2020. However, a significant increase in the built-up and light vegetation was observed in the year 2020. These findings expostulates an urban expansion and the planting of light vegetation around the vicinity for a balanced atmosphere. Considering the dynamic behaviour of the land use/cover, policies and regulations should be enforced to sustain the urban population and environment.

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