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## **THE RELATIONSHIP OF LAND USE CHANGES AND LAND SURFACE TEMPERATURE FOR URBAN AREA IN KUCHING, SARAWAK**

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### **Abstract**

Land surface temperature (LST) is used as an indicator for land temperature. Previous research demonstrates a strong correlation between urban growth and land surface temperature. The rising of land temperature will lead to urban heat island if there are no preventative precautions done. Due to the area's rapid urbanisation, this study will focus on Kuching City. Matang Jaya, Tabuan Jaya, Satok, and Batu Kawa were chosen as case studies. These areas are rapidly developing, with new townships and population growth. The Landsat 7 data set was used as secondary data in this study. Spatial and thermal analysis were performed on the output using ERDAS software and ArcGIS. The analyses derived land use changes between 2005 and 2017, temperature statistics for land use types, and LST retrieval for case studies. The result indicates that the land surface temperature increased with the case studies' physical development.

**Keywords:** Land Use Changes, Land Surface Temperature (LST), urban growth, spatial analysis, thermal analysis

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## **INTRODUCTION**

Land Surface Temperature (LST) is a critical parameter for studying the thermal environment and dynamics of cities. LST affects the air temperature in the lower layer of the urban atmosphere and is a significant factor in determining surface radiation and energy exchange, building internal climate, and human comfort in cities (Voogt & Oke, 2003). Rapid changes in land use and land cover patterns resulted in significant changes in LST (Choudury et al., 2018). Urbanisation was found to have a significant effect on local temperatures (Chapman et al., 2017). According to Ibrahim (2017), it also has a significant impact on land use by displacing vegetation in favour of residential and commercial areas and associated infrastructure, thereby increasing the LST.

During the day, the temperature differential between urban and rural areas is typically between 3°C to 5°C. At night, however, due to the slow radiation of heat from urban surfaces, the differences can reach as high as 12°C (EPA, 2008).

According to Jusuf (2007), different land uses will almost certainly have a different effect on urban temperature and may contribute to the urban heat island effect if no precautionary measures are taken. Thus, it is critical to incorporate remote sensing data into the study of urban climate in order to obtain the synoptic view necessary to comprehend the interaction between natural processes and their human modification (Stefanov & Brazel, 2007).

Thus, this article discussed the patterns of temperature distribution across Kuching's urbanisation and established a relationship between urbanisation and land surface temperature in the study areas.

## **STUDY SITE**

The study will focus on the central Kuching area, which is located in Kuching North City and is administered by the municipal council, DBKU. Four (4) spatial subsets were chosen for this study due to the diversity of land use types, dense urbanisation, and growing townships in Kuching. These neighbourhoods include Matang Jaya, Satok, Tabuan Jaya, and Batu Kawa. These areas primarily consisted of land uses, such as residential/housing, commercial, and new towns. Population expansion and policy changes boosted demand for space, resulting in rapid urbanization (Wan Ibrahim & Muhamad Ludin, 2016). The effects of urbanisation on the temporal variations of land surface temperature (LST) in the Kuching city area are being evaluated using a remote sensing and geographic information system (GIS) approach between 2005 and 2017. The increased adaptability in modifying digital data has resulted in several strategies for change detection with satellite imagery (Mohd Noor et. al, 2013). Thus, Landsat satellite images were used in this study.

## METHODOLOGY

The secondary data for this study comes from Landsat images taken between 2005 and 2017. All satellite images were downloaded from the United States Geological Survey (USGS) using the Global Visualisation Viewer's navigation tools (GloVis). This study used the specific band 6 (thermal band) and band 2-4 (RGB) to identify LST and land coverage. Additional secondary data were obtained from the local government of Kuching, including a cadastral map, municipal boundaries, and master plan map.

The navigation tools used in this research study are most likely remote sensing software, such as Erdas Imagine 14.0 and ENVI 5.0 for image pre-processing and data analysis. Subsequently, ArcGIS 10.1 was used to organise the data and create the maps.

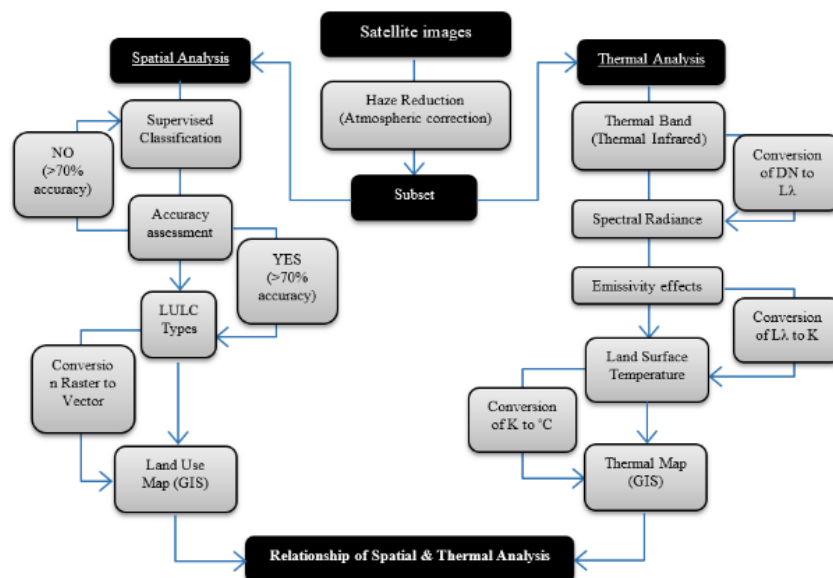


Figure 1: Steps of Data Processing and Analysis

## RESULTS AND DISCUSSION

The main output in which the results of the study are being presented include land use map for year 2005 and 2017, land use types temperatures statistics and LST retrieval for case studies.

### Kuching Land Use Cover Changes in Year 2005 and 2017

The study area's land use maps were generated in GIS and presented in Figure 2 to show the involvement of those five (5) classes of land cover types, which are urban built-up, green parks, vegetation, bare land, and water body, with different colours for each class including red, light/dark green, yellow, and light blue.

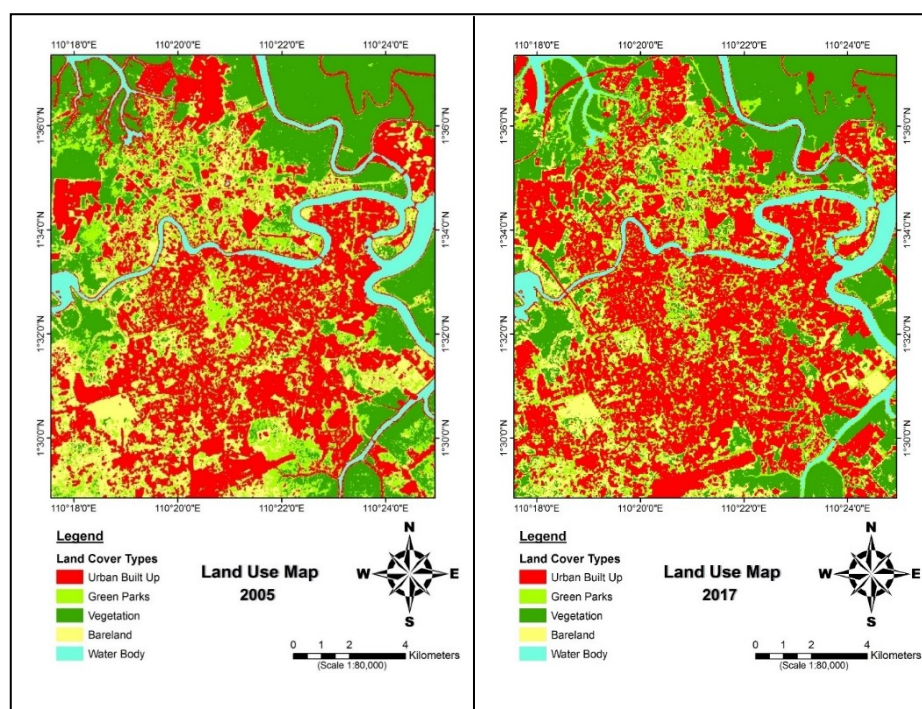


Figure 2. Land Use Map of 2005 and 2017 generated in GIS

There are two trends that can be distinguished from changes in land use/cover. To begin, the urban built-up area and green parks have gradually increased over time, while vegetation and barren land have gradually declined, the water body has remained constant. According to Table 3, urban built-up area increased by 17.1% in 2017 to 1334.4 ha, while green park area increased by 9.6% to 362.7 ha. On the other hand, as development occurs, vegetation areas will undoubtedly be impacted, as they have declined by over 5.1 percent over the last 12 years. Additionally, the results and trends revealed that vegetation was still limited and significant due to certain environmental policies implying that it should not be exploited in comparison to barren land, as the majority of it was clearly dominantly used for development purposes, to cater to the growing urban

population (urban growth). Urban growth as a whole, including gains and losses of class types, totals 73.4 percent. Therefore, for the growing city of Kuching, and as the capital of Sarawak, it is common for the city to imply a dramatic urban growth and changes in the morphology of the city size and extent.

**Table 2:** Class Growth Statistics in Hectares

Class Types	Year 2005 – 2017	
	Changes (ha)	Class Growth (%)
<b>Urban Built Up</b>	1334.3 (+)	17.14 (+)
<b>Green Parks</b>	362.7 (+)	9.60 (+)
<b>Vegetation</b>	260.6 (-)	5.09 (-)
<b>Barren land</b>	1436.4 (-)	41.58 (-)
<b>Water Body</b>	0.00	0.00
<b>Total (Gain and Losses)</b>		<b>73.41%</b>

### Relationship of Urban Growth and Land Surface Temperature

The investigation of each land use type's thermal signature is critical for understanding the relationship between land use and LST. A comparison of land use and LST retrieval was conducted by selecting sampling points for each land use category and spatial subset to compare all LST retrieval. The minimum and maximum temperatures were recorded, and the average of the LST was calculated over two time periods. As a result, Table 3 summarises the overall findings and then delves into the findings for each spatial subset graph and map.

**Table 3:** Spatial Subsets LST Retrieval

Spatial Subset	2005			2017		
	Min (°C)	Max (°C)	Mean (Σ)	Min (°C)	Max (°C)	Mean (Σ)
<b>Matang Jaya</b>	21.8	26.9	24.3	26.9	30.3	28.6
<b>Satok</b>	21.3	25.9	23.6	24.4	29.8	27.1
<b>Tabuan Jaya</b>	21.3	26.9	24.1	25.4	29.8	27.6
<b>Batu Kawa</b>	19.2	23.8	21.5	24.9	29.8	27.4

### Case Study 1: Matang Jaya

The Matang Jaya areas were envisioned as a new township in Kuching, complete with housing (Taman Matang Jaya, Yen Yen), commercial (Emart, Metro City), and educational facilities (SMK Matang Jaya, SK Petra Jaya, SMKA Sheikh Hj Othman Abd Wahab).

Table 3 showing that, between 2005 and 2017, the LST value gradually increased. The LST has undergone significant changes as a result of the growth of Matang Jaya township and the corresponding increase in built-up areas of these areas (refer to Figure 3). From 2005 to 2017, the minimum LST increased from 21.8°C to 26.9°C and the maximum LST increased from 26.9°C to 30.3°C, respectively.

#### ***Case Study 2: Satok***

Satok areas are those where commercial (Kubah Ria, Wisma Satok) and residential (Star Garden, Happy Garden) land uses predominate, with some provision for Malay settlement (Star Garden, Happy Garden) (Kpg Kudei, Kpg Ajibah Abol).

The results in Table 3 indicate that the LST in Satok areas increased from 21.3°C to 24.4°C (min.) and 25.9°C to 29.8°C (max.) between 2005 and 2017. Satok areas were one of the earliest commercial areas in Kuching and has seen significant changes in land use with the construction of numerous new commercial areas in the surrounding areas (refer to Figure 4).

#### ***Case Study 3: Tabuan Jaya***

Tabuan Jaya, like Matang Jaya, is a growing new township in Kuching with amenities, such as housing (Tabuan Park, Tabuan Desa, Tabuan Laru), commercial (Viva City, Giant), and education (I-System, Kolej AITC, SK Tabuan), among others.

Based on Table 3, Tabuan Jaya areas obtaining an increase in LST over two-time periods of 21.3°C to 25.4°C (min.) and 26.9°C to 29.8°C (min). (max). Between 2005 and 2017, the mean LST was 24.1°C and 27.6°C, respectively. Meanwhile, similar to Matang Jaya, the LST obtained clearly demonstrates the areas surrounding Kuching, a growing township with changes in land uses in certain areas, particularly in the red color zone areas (refer to Figure 5).

#### ***Case Study 4: Batu Kawa***

Batu Kawa areas, along with Tabuan Jaya and Matang Jaya, are developing into a new township in Kuching, with the provision of amenities, such as residential or housing (Taman Desa Wira, SkyVilla Residence), commercial (MJC City, Emart Batu Kawa), and educational (SJKC Tapang Hilir, SK RPR Batu Kawa), among others.

Referring to Table 3, Batu Kawa areas retrieved an increment of LST between 19.2°C and 24.9°C (min) and 23.8°C to 29.8°C (max). Batu Kawa was formerly known as MJC City Development's growing township, which offers commercial and residential space. Thus, the LST trends demonstrated significant changes in land use from 2005 to 2017, particularly in the red spot areas (refer to Figure 6).

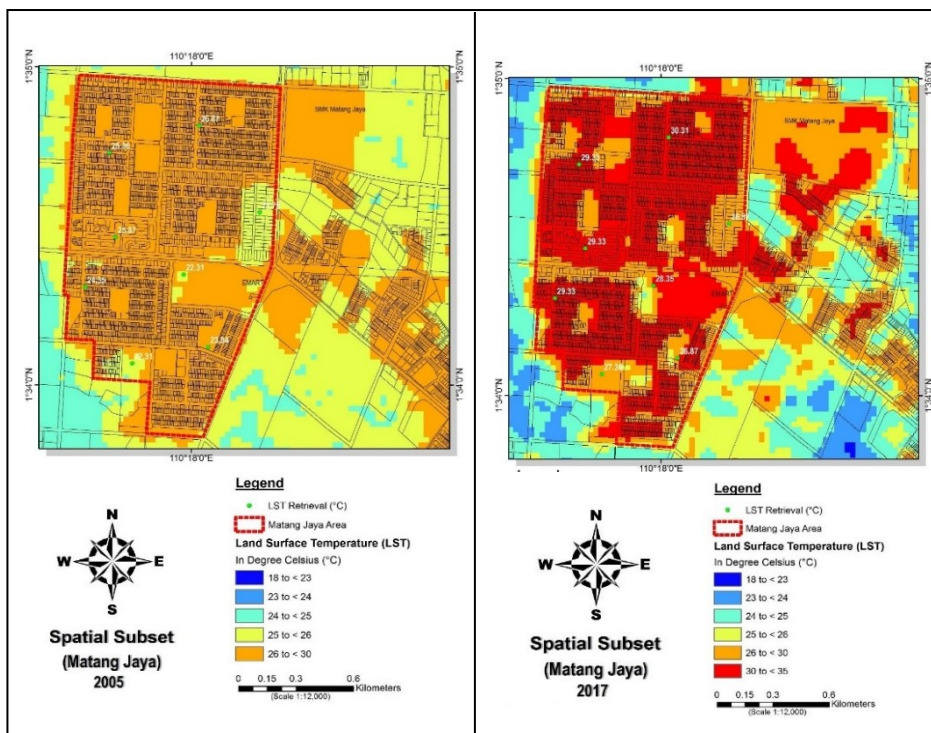


Figure 3: Comparison of LST in Matang Jaya for Year of 2005 and 2017

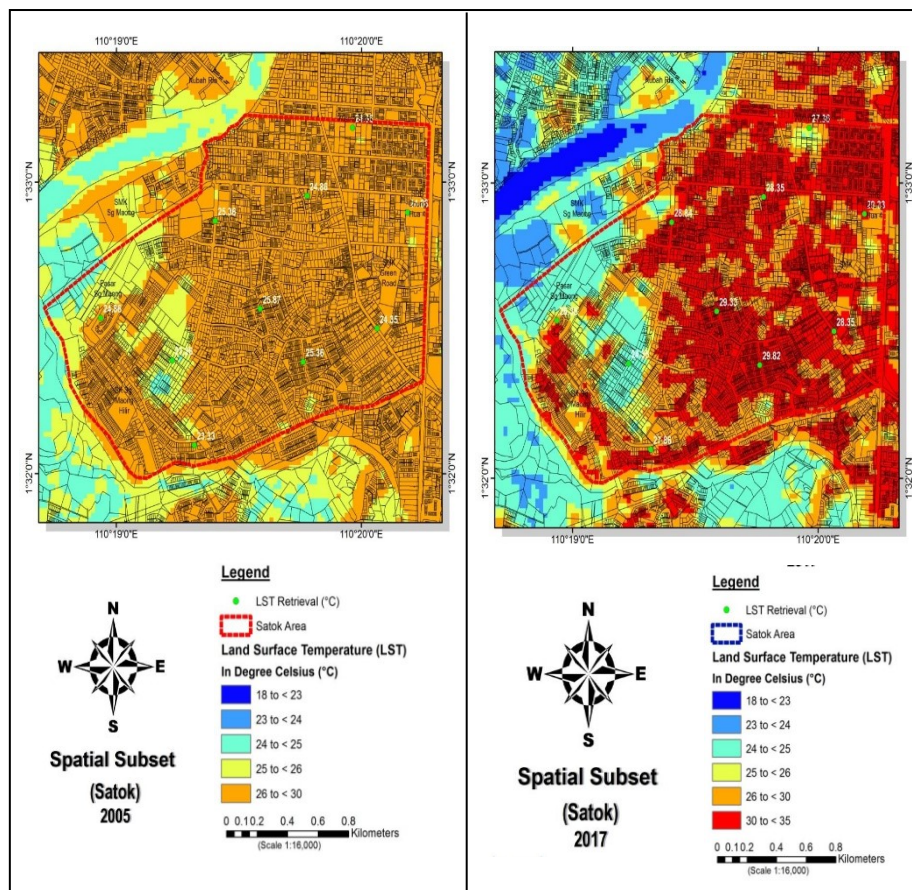


Figure 4: Comparison of LST in Satok for Year of 2005 and 2017



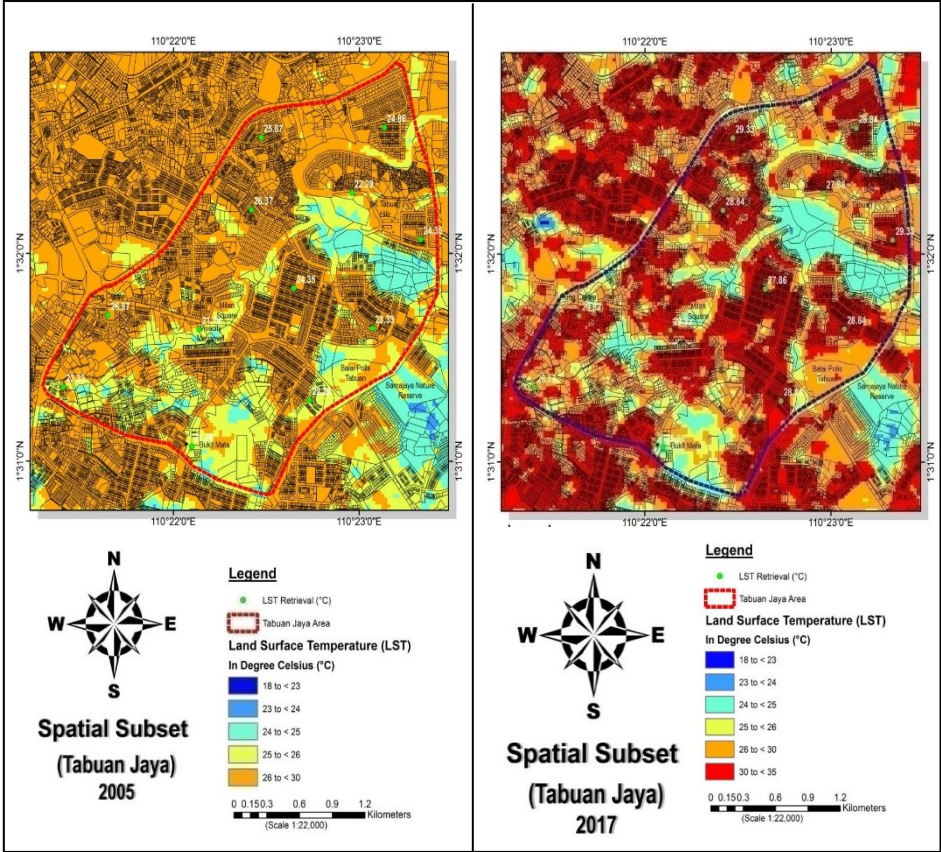


Figure 5: Comparison of LST in Tabuan Jaya for Year of 2005 and 2017

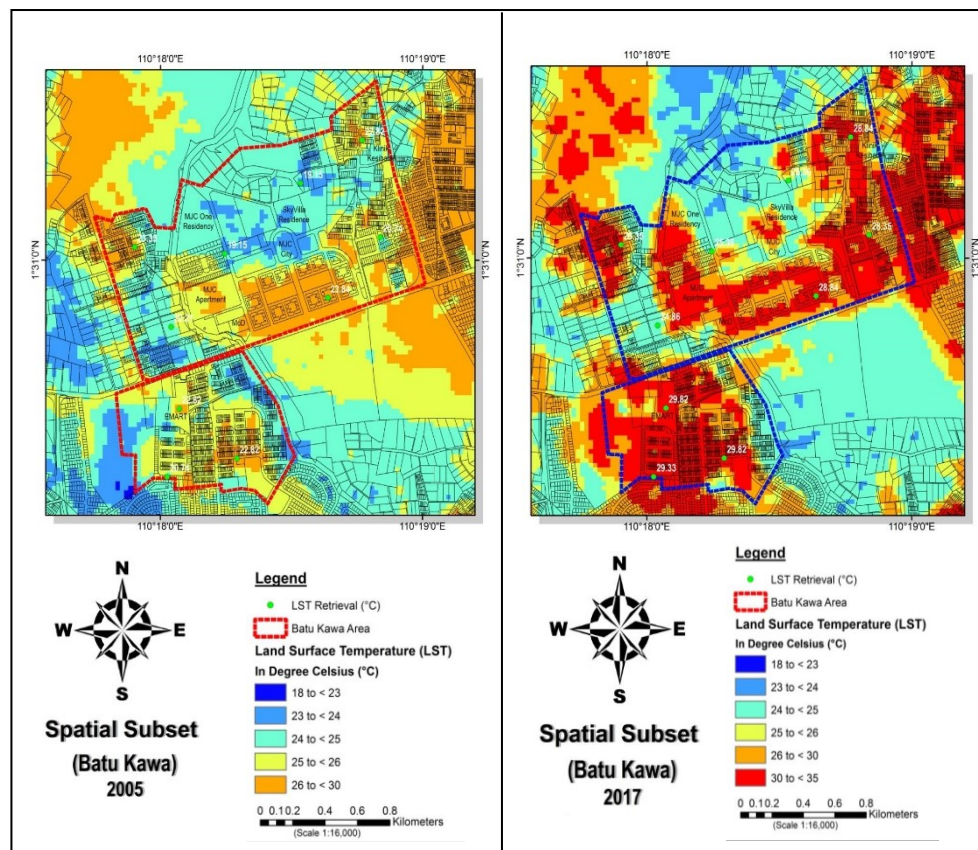


Figure 6: Comparison of LST in Batu Kawa for Year of 2005 and 2017

## Discussion

Apart from the LST retrievals from all four (4) spatial subsets, it can be concluded that from 2005 to 2017, the land surface temperature (LST) increased as land use or land cover patterns changed fundamentally as a result of accelerated development and the growing township in Kuching. The growing townships of Matang Jaya, Satok, Tabuan Jaya, and Batu Kawa can be seen as the primary contributor to the noticeable changes in the urban climate in Kuching between 2005 and 2017, as measured by the dominant changes in LST. According to Weng et al. (2007), urbanisation is defined as the conversion of non-agricultural land to uses associated with population and economic growth, which has a significant impact on the urban climate.

By enclosing land with buildings, roads, and other impervious surfaces, urban areas absorb more solar radiation and have a higher thermal capacity and conductivity. As a result, urban areas are likely to have a slightly higher temperature than rural areas due to heat generated by houses, commercial

buildings, transportation, and industry. These have accelerated urbanisation and placed extreme strain on the environment, whether on a local or global scale.

## CONCLUSION

This study discovered that the significant reason for the increase in land surface temperature (LST) in Kuching between 2005 and 2017 is due to land use changes. Urbanisation appears to have an effect on land use by displacing vegetation with residential, commercial, industrial, and related infrastructures, thereby increasing the land surface temperature (LST). Apart from that, a more extensive and thorough study is recommended in the future. With regards to environmental concerns, it is recommended that a broader scope of study be conducted in which primary source data from satellite images can be used to create certain indices such as the Normalized Difference Vegetation Index (NDVI), the Normalized Difference Built-up Index (NDBI), the Normalized Difference Bareness Index (NDBAI), and the Normalized Difference Water Index (NDWI). By determining all of the indices, the thermal study becomes more detailed, focusing on specific indices such as vegetation, built-up areas, bareness, and water, and the relationship between all of these variables and land surface temperature.

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