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Change Detection In Land Surface Temperature Pattern Of Covid-19 Using Satellite Image Analysis In Kuala Lumpur, Malaysia

Mohd Sahrul Syukri Yahya[1], Edie Ezwan Mohd Safian[2]

[1,2]Department of Real Estate

Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia

86400 Parit Raja, Batu Pahat, Johor, Malaysia

[1]shahrulm016@gmail.com, [2]edie@uthm.edu.my

Abstract – COVID-19 is a serious disease and global issue that affects the economy, society, the environment and health. Climate change has impacted the temperature (LST). By the end of January 2020, Malaysia had recorded its first confirmed cases of COVID-19. As a preventative measure against the rapid spread of COVID-19 in Malaysia, the government has advised the general public to stay inside and to keep their physical contact with others to a minimum at distances of at least one metre. Additionally, residents have been urged to stay away from public gatherings. COVID-19 has had a tremendous impact on Kuala Lumpur, a state that is both popular with tourists, investors and a hub for students. Due to widespread calls for people to stay home instead of traveling, several tourist hotspots, educational facilities, and commercial enterprises have been hit hard. In Malaysia, the lockdown policy known as Movement Control Order (MCO) has been implemented phase-by-phase to stop the spread of COVID-19. This study aimed to investigate whether the COVID-19 epidemic has changed the average temperature of Earth's land as a result of the epidemic. Variations detected in LST before, during, and after a pandemic have been visualised using data from the Landsat 8 satellite image. It was discovered that the LST dropped at the beginning of the COVID-19 pandemic, when people were less likely to spend time outdoors. As a result of the newly enacted norm, the LST was raised.

Keywords – COVID-19; Land Surface Temperature; Landsat 8; Pandemic; Norm

I. INTRODUCTION

There are numerous ways in which the COVID-19 pandemic may impact the economy, society, the environment, and the health of individuals. Kuala Lumpur has experienced unprecedented rates of urbanisation and development. It's no surprise that the increase in urbanisation and subsequent increase in urban growth area will result in altered land use patterns. The urban built-up area extends beyond the natural vegetation belt. Due to the absorption of radiation and the emission of heat to the surroundings, the surface temperature of urbanised regions is rising as impervious surfaces replace plant and evaporative surfaces [1, 2, 3]. Hot temperatures are generated on the roads due to the friction of tyres and the exhaust of motor vehicles. In addition to emissions and combustions from automobiles, the city's industrial sector and power plant region also contribute to the city's land surface temperature (LST) [4].

Generally, metropolitan heat islands (MHIs) are areas where there is a significant difference in temperature between urban regions and the surrounding or nearby countryside [5, 6]. The COVID-19 pandemic started a year ago, at the end of 2019. The World Health Organization (WHO) stated on March 11 that the COVID-19 outbreak had been given pandemic status, an upgrade from its previous designation as an epidemic [7]. The COVID-19 virus found for the first time in Wuhan, China [8, 9], has been picked up by a significant number of people across the world. There was a confirmed case of COVID-19 in Malaysia in January 2020, and the virus spread fast [10, 11, 12]. Policymakers in Malaysia have urged citizens to stay indoors and reduce their social interactions with others as a means of controlling the spread of the COVID-19 virus. Kuala Lumpur is a popular tourist destination and a major educational centre, and its residents have reported feeling the effects of the COVID-19 outbreak. The widespread allure of staying home and avoiding traffic by keeping busy with home-based duties has devastated popular tourist destinations, educational institutions, enterprises, and industries. Because of these restrictions, less people are willing to use public and private transportation. Reduced gas and smoke from burning are released into the streets. Therefore, the Ministry of Health urged the public to stay indoors so that the COVID-19 virus could not spread.

In March of 2020, Malaysia introduced its first movement control order (MCO) which aimed to establish stability in the country's security situation. As the COVID-19 pandemic is in its early phases, there has been a very slow spread of the virus [13]. In order to prevent and deal with COVID-19 in a way that promotes harmony and vigilance, it is not always possible to keep people in quarantine and, instead, they must begin activities in a variety of sectors while adhering closely to health guidelines. Additionally, the mobility of the urban population was limited in order to control the spread of the disease and to prevent it from spreading [14]. Across the various phases of the MCO, the variability of the relation between mobility and COVID-19 case trends shows that other forms of preventative behaviors and perceptions, be they voluntary or imposed by the government, may also play a part in preventing COVID-19 cases [15]. It has been shown that social distance policies can have a direct influence on mobility. However, there are also indirect influences due to changes in people's lifestyle practices, such as wearing masks, washing their hands regularly, and other measures. These measures may be able to delay viral spread if they are implemented [16, 17]. As the COVID-19 vaccine has yet to be discovered, many experts fear the epidemic could continue for quite some time. In light of this, the Regional Government must adopt a revised work schedule that takes into account the nature of the coronavirus. Getting outside is more common now that the old norm has been abandoned. It's probable that this will lead to deterioration in air quality, which in turn could affect surface temperatures [18].

This article was aimed at investigating how the COVID-19 epidemic had an influence on the average land-surface temperature (LST) in Kuala Lumpur urban city, and whether the temperature was altered as a result of the epidemic. Using thermal remote sensing data from Landsat 8 satellites, we can observe how temperature changes for land surface temperatures have changed before and during the pandemic. Furthermore, we can observe how changes in air quality may alter surface temperatures after the pandemic has ended.

II. Materials And Methods

2.1 Study Area and Data

In Figure 1, Kuala Lumpur has been selected as the main location for the study area. The area in which these areas are located is the central part of Peninsular Malaysia. The total population is 1.77 million people and the total land area is 243 km^2 [19]. The area is the most populous and residential. This study was located between 3° 09’ N latitude and 101° 42’ E longitude [20]. In Kuala Lumpur, the highest average daytime temperature for the month of March is 33.7 °C [21]. During December, however, the temperature averages 32.0 degrees Celsius, making it the coldest month of the year. At night, the temperature can drop significantly depending on the country and altitude, to varying degrees. The temperature in Kuala Lumpur drops to as low as 24.1 °C in January, which is the coldest month of the year. During the month of May, the warmest nights are recorded at 25.1 degrees Celsius [21]. In addition, these districts are strategically located and are the most developed in the city. Many activities are related to the economy, building and housing, and tourism. The analysis of maps and the averaging of the variables studied for this investigation were analysed between January 1st, 2019 and February 7th, 2021. This coincidentally fell when the most stringent restrictions were enforced in the investigated cities. As a result, the time period in question will be represented by the years 2019, 2020, and 2021.

Figure 1: Map of the study area

2.2 Materials and Technique

As part of this study, Landsat 8 images with OLI and TIRS have been used, and the images have been obtained directly from the USGS Earth Explorer website (earthexplorer.usgs.gov). This study requires the use of thermal infrared bands (band 10 and band 11 of TIRS). A study has also been carried out in this study analyzing the administrative boundaries of the city of Kuala Lumpur in Malaysia. In order to conduct this study, we used the acquisition date as shown in table 1 below to determine it.

Table 1: Data of the Satellite Image

Date	Band	Spectral resolution[µm]	Spatial resolution[m]	Image ID	Path/Row	Description
01 – 01 – 2019	Band 10 and Band 11 TIRS	10.3 – 11.3 and 11.5 – 12.5	100	LC08_L1TP_127058_20190101_20200830_02_T1	127/058	Before COVID-19
09 – 04 – 2020	Band 10 and Band 11 TIRS	10.3 – 11.3 and 11.5 – 12.5	100	LC08_L1TP_127058_20190407_20200829_02_T1	127/058	During COVID-19
07 – 02 – 2021	Band 10 and Band 11 TIRS	10.3 – 11.3 and 11.5 – 12.5	100	LC08_L1TP_127058_20210207_20210302_02_T1	127/058	After COVID-19

Figure 2 is a flowchart depicting the data processing procedure. This method employs the free software QGIS. Raster calculator is the tool for calculation. For the processed Landsat 8 satellite image (pre-pandemic, during the pandemic, and after the post-pandemic normal), the thick thermal infrared band 10 (TIRS band) is the starting point, as it is one of the three separate acquisitions of the image carried out on three different dates. Next, determine the spectral radiation at the Top of the Atmosphere (TOA). The formula and equation for L, or thermal infrared radiation, is as follows by (1) [22].

$$L\lambda = M_L * Q_{cal} + A_L \tag{1}$$

Where M_L is the multiplicative rescaling factor for that particular band, Q_{cal} is the DN value for that particular band's picture, and A_L is the additive rescaling factor for that particular band. Files containing image metadata can be mined for M_L and A_L-related data (see Table 2).

After obtaining the TOA, the brightness temperature was calculated. The power of microwave radiation that travels upwards from the uppermost part of the Earth's atmosphere to the surface of the globe is what is meant to be understood by the term "brightness temperature" (BT). [23] This term was first introduced in 1987. Equation (2) [24], which calculates the reflectance of an image by utilising the thermal constants that are stored in the picture's metadata file, is used to transform reflectance to BT that is contained within a Landsat image.

$$\text{BT} = \frac{K_2}{\ln\left[\left(K_1 / L\lambda\right)+1\right]} - 273.15 \tag{2}$$

The brightness constant K_1 defines the brightness temperature (BT), while the thermal conversion constants L_1 and L_2 define the thermal conversion constant K_2. To obtain the data in Celsius, add absolute zero (about 273.15°C) to the radiant temperature [25].

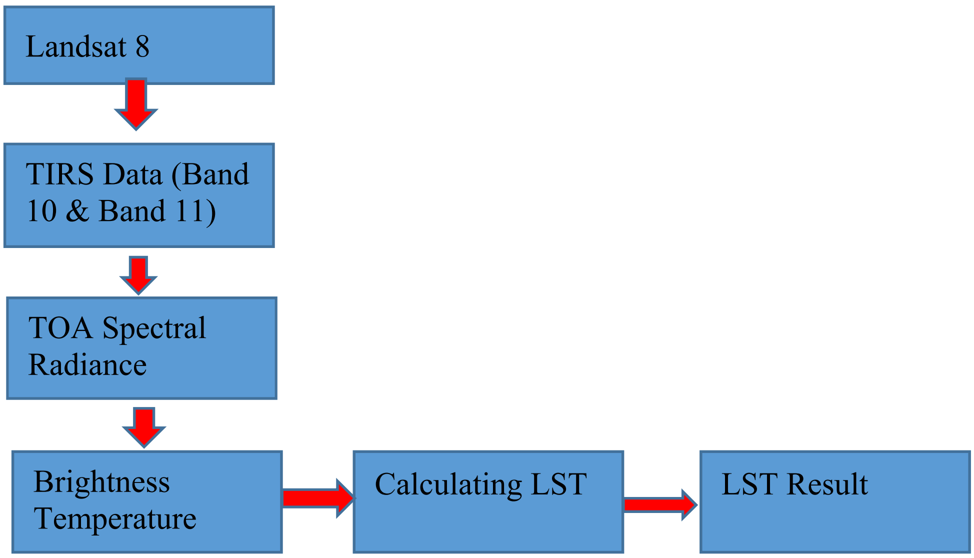

Figure 2: LST Processing Flow

III. Results And Discussion

The current study used Landsat 8 OLI/TIRS sensors to acquire urban surface temperature maps of Kuala Lumpur. These maps have been analyzed using the LST method to estimate the surface temperature. These figures illustrate the output of the LST map that can be seen in Figures 3, 4, and 5. Three-time periods with different years are used to assess the LST detection. To identify the variations, LST detection was classified into six categories and given different colours. A blue area represents the low cold spot area, whereas a red area represents the high hot spot area. Kuala Lumpur urban city surface temperatures before (January, 2019), during (April 2020), and after (after returning to normal) the global influenza pandemic is depicted in the following set of temperature map figures (February 2021). The numbers suggest that temperatures dropped during the COVID-19 epidemic and then rose once the post-COVID normal was established. In figure 3, we see the distribution of temperatures before the outbreak of the epidemic (January, 2019) and during the outbreak of the pandemic (April, 2020). In Figure 4, it can be seen how the temperature distribution has changed after the return to normal (February 2021). Figures 6, 7, and 8 demonstrate how the surface temperature distribution is explained when a bar chart diagram is used to illustrate the results. A vertical line on the graph represents the number of pixels, while a horizontal line represents the temperature.

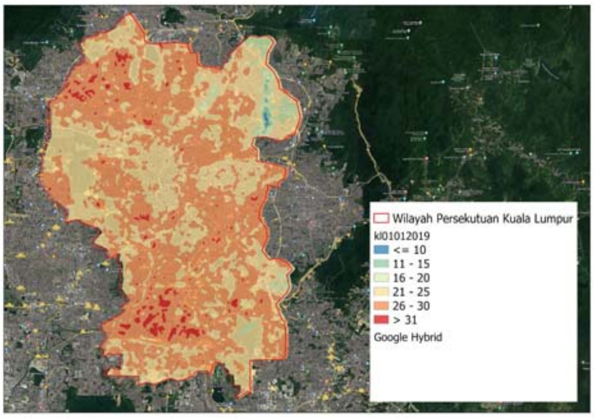

Figure 3: LST map before Lockdown (January 2019)

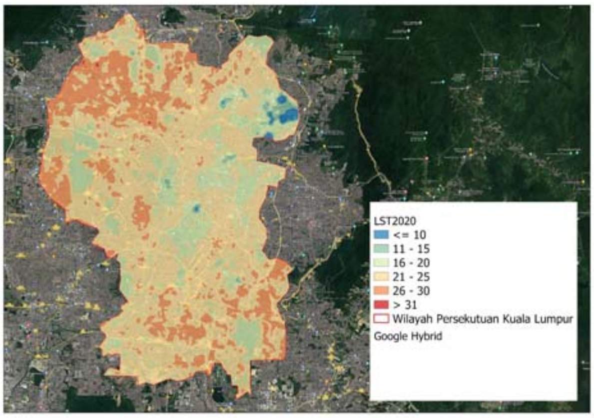

Figure 4: LST map during Lockdown (April 2020)

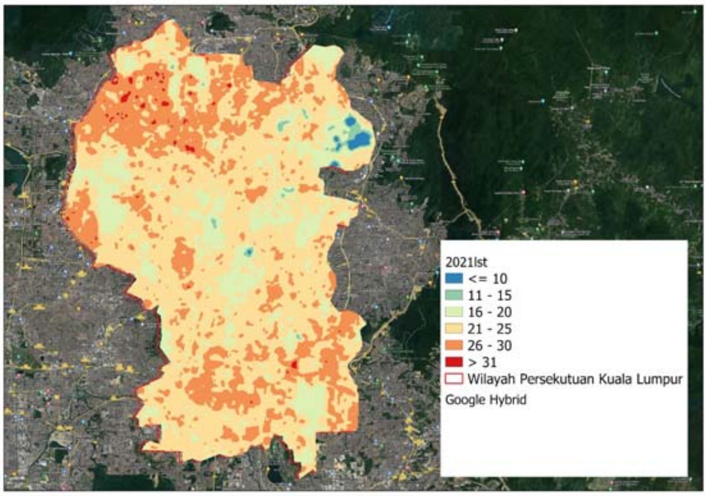

Figure 5: LST map after Lockdown (February 2021)

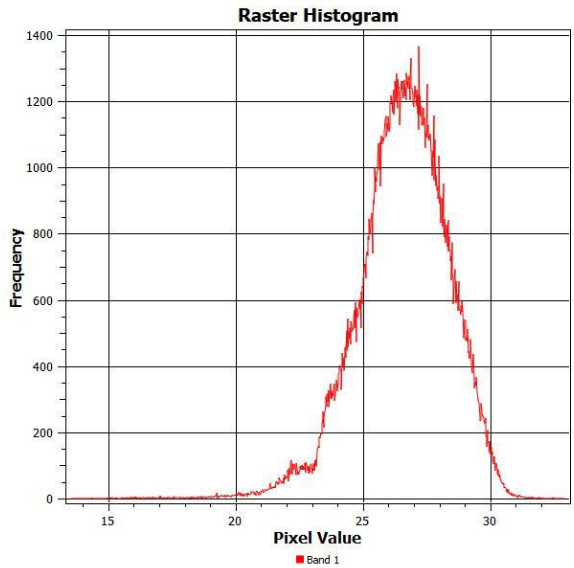

Figure 6: Pre-COVID-19 LST distribution data

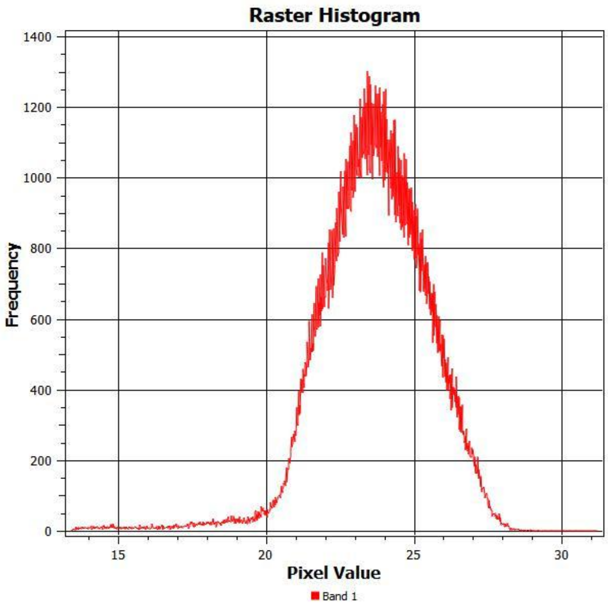

Figure 7: Distribution of LST during COVID-19

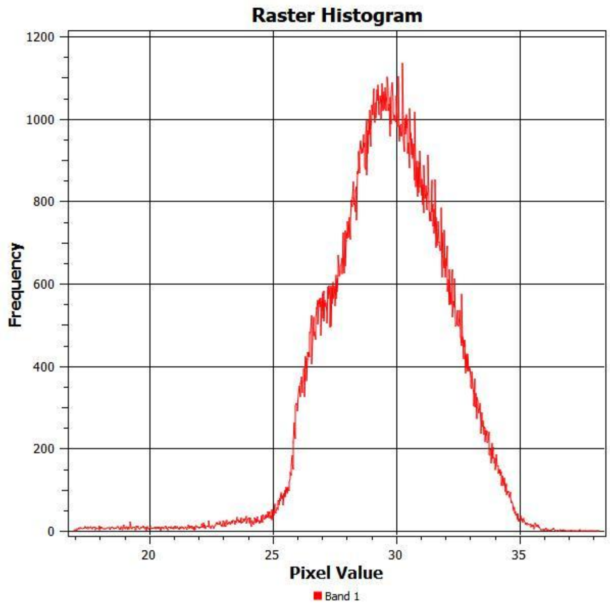

Figure 8: Post COVID-19 LST distribution data

Table 2 shows the information regarding the decrease in the Level of Standard of Living due to the COVID-19 pandemic in Kuala Lumpur urban city due to the pandemic. The level of temperature is low about 31.2^{o}C in 2020 because the COVID-19 are the highest cases in Malaysia especially in Kuala Lumpur. The maximum LST value found in 2021 after MCO. The government does the MCO to fight the diseases. The range temperature during MCO is 17.8^{o}C compared to before and after MCO. The difference of LST for 2019, 2020 and 2021 are 20.4, 17.8 and 21.3. During MCO, all people must stay at home, work from home and do not allow outside activity. The results of the study indicate that the phase of the MCO process had a positive impact on the results of the study. Foot traffic is relatively low due to the low density of population and a wide variety of vehicles on the roads. As a result of the reduction of transport and industrial pollutant emissions during the period of MCO in Kuala Lumpur, the mean LST has been reduced significantly.

Table 2: Comparison of land surface temperature in Kuala Lumpur

Date	Minimum	Maximum	Mean	Difference	Range
2019 (Before)	12.5	32.9	26.5	20.4	19.4
2020(During)	13.3	31.2	23.6	17.9	17.8
2021(After)	16.9	38.2	29.6	21.3	21.3

As a result of the short duration of the MCO period and the controlled economic activity, the temperature of the land surface may have slightly decreased during the MCO period in 2020. Numerous anthropogenic and natural activities impact the global surface temperature. As a result of their implementation, long-term sustainable environmental management techniques can also partially alter spatiotemporal weather patterns. Air pollution has been found to be comparatively lower in those stations which are located close to greeneries, compared to those which are situated away from greeneries. The decision to extend the COVID-19 pandemic MCO period impacts much more than just the global economy. Additionally, it affects the social and cultural rhythms of nations as well as humanity's sanity. When human activity is temporarily halted in the form of industry, commerce, and transportation, the natural environment can restore homeostasis through various processes. This is in order to regain equilibrium. The MCO system has been found to be extremely healthy from an environmental perspective. The air pollution level in Kuala Lumpur developed a tendency to decline during MCO for a brief period of time. There is no guarantee that enforcement of the MCO system will reduce pollution in the long run. The lockdown system is a temporary measure. Therefore, in order to preserve the purity of the environment, a sustainable alternative management technique needs to be implemented.

The findings of this study, which highlight the critical role that industrial activities and transportation play in changing LSTs [26] are in agreement with those previously reported in the relevant academic literature. Lastly, the area with the high temperature is located in an area where there is a large density of buildings and a highly developed industrial area. This is in addition to the high temperature. The MCO also shows that the growth of urban and residential areas has indirectly affected the LST.

IV. CONCLUSION

In the present work, we analysed the average LST changes before, during, and after COVID-19 produced MCO using Landsat 8 OLI data for these three periods. We also calculated the average of the past and after years for the three time periods. The average LST in recent years has followed a different trajectory than in previous years. The incident occurred before COVID-19 was introduced into Malaysia, which is what led to the outbreak. Upon implementation of the MCO policy on 18th March 2020, the temperature decreased significantly. This is the result of a mean difference of 23.66°C being recorded as a result of the implementation of the policy. It was actually significant to note that the LST for 2020 was lower than that for the past and following years during the MCO period. In 2020, after the restrictions associated with COVID-19 were loosened, there was a significant increase in LST. As a result of this study, those findings may have been enhanced further. A better spatial resolution application of the same technology to additional Kuala Lumpur industrial cities would have allowed this. This would enable a more accurate representation of the results. It will be easier to prohibit deceptive data in light of our previous results, and this study will be able to show a direct association between COVID-19 MCO and LST.

A study conducted by this author suggests that economic activities, tourism, a healthy lifestyle, and transportation, as well as direct and indirect effects on LST and the environment have an extremely negative impact on it [28, 29]. As a result, when land use planning, the LST factor should be considered when considering whether or not anthropogenic activities will have any negative impact on the environment [30, 31]. This will contribute to the creation of favorable living conditions for residents and better quality of the environment [32]. The efficiency of city management is likely to improve due to adopting this strategy [26].

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