

LAND COVER TYPES AND THEIR EFFECT ON THE URBAN HEAT SIGNATURE OF UNIVERSITY CAMPUSES USING REMOTE SENSING

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ABSTRACT

The campus, as an educational area, has a variety of land cover with varying surface temperatures. Knowledge of land use in a localized urban environment and its effect on the Urban Heat Signature (UHS) of a university campus is insufficient, so it is essential to assess UHS-related localized urban environments. The objective of this study is to assess land cover and its effect on the UHS of two university campuses. The research used spatial-temporal analysis employing satellite images during the period 2013-2014. The areas studied were the University Malaya (UM) and University Indonesia (UI) campuses. The results show that the land cover of both university campuses has the same localized urban environment pattern. Based on Landsat 8 TIRS (100 m ground resolution) both university campuses had UHS profiles related to vegetation cover of 25-33°C, with mean temperature 28°C is the lowest temperature, and building cover of 33-39°C, with a mean temperature 35°C, is the highest temperature, caused effect from Land cover types. Google Earth visual interpretation and digitalization provided the land cover based on 10m×10m vector square grids with their attributes validated by field survey. The research shows a trend of UHS change between 2013 and 2014, with the maximum temperature of >30°C on the UM and UI Campuses with increased of temperature 1°C. The study concludes that the UHS behavior is an effect of its temporal relation with land cover, which is new knowledge on university campuses about localized urban environments.

Keywords: Land cover; Spatial and temporal analysis; Urban heat signature profiles

1. INTRODUCTION

In Southeast Asia, for example, Malaysia, observations in the past 20 years have noted a temperature increase of 0.5°C to 1.5°C, in line with the intensity of land use change (Malaysian Meteorological Department, 2009). Urbanization has initiated alterations in the natural ecosystem become an urban landscape (Tran et al., 2006). Even though the increased temperature is a natural phenomenon in urban areas, but it could be a threat in tropical cities when the temperature is higher than 30°C (Tursilowati, 2008; Ichinose et al., 2008; Tursilowati et al., 2012). Such increased temperatures will impact on human life (Salleh & Ghaffar, 2009; Johnson et al., 2012).

Land cover type as a representation of land use (Ren et al., 2012) can absorb and reradiate sun

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Radiation and generate urban heat (Wong & Yu, 2005; Srivanit & Hokao, 2013). In general, the urban land cover associated with buildings, roads and pavements, highways, green parks and also bare soil (Ahmad & Hashim, 2007). Land cover type as climatic (temperature) characteristics of local climates. Temperature and land use/cover information, which allows monitoring of the urban environment and human activities, enhances our understanding of the urban environment (Asmat et al., 2003).

Urbanized areas have significantly higher daylight surface temperatures compared to those of surrounding rural areas with relatively more vegetation (Tran et al., 2006). Urbanized areas are associated with high temperatures, while green spaces are associated with low temperatures (de la Barrera et al., 2015) caused by urban surface temperature reflect from the solar radiation (Li et al., 2010). Urban areas, were the temperature higher in densely built cities, have different heat intensity (Su et al., 2012), the other hand the urban heat phenomenon is a natural consequence related to the land cover type and solar radiation. (Kim & Baik, 2005; Ichinose et al., 2008; Memon et al., 2009; Mirzaei & Haghighat, 2010; Stewart & Oke, 2012). Built-up surfaces in urban areas are related to high temperatures (Taha, 1997; Tran et al., 2006), while green surfaces with moist soil might reach a temperature of only 18°C (Gartland, 2008). According to Chen and Ng (2012), urban heat has become critical in zones where inadequate shading and green spaces are unable to intercept and balance the heat from direct solar gains (Srivanit & Hokao, 2013). Urban air temperatures can be on average 2°C higher than in rural areas (Taha, 1997) and the maximum surface temperatures are also associated with high-rise city core areas (Tran et al., 2006). According to Shahidan et al. (2012) and Tran et al. (2006), the highest outdoor thermal stress observed during bright sunny days with a calm wind in the summer season. However, in tropical climate zones, the most considerable thermal anxiety may occur during the yearly hot, dry periods at noon due to higher solar radiation exposure (Srivanit & Hokao, 2013). Land cover in localized urban environments has natural consequences related to sun radiation which high-low temperature urban land cover is Urban Heat Signature.

Remote sensing techniques are beneficial and efficient in analyzing the relationship between land surface temperature and land cover in tropical regions (Asmat et al., 2003; Ahmad & Hashim, 2007; Mirzaei & Haghighat, 2010; Kuşçu & Sengezer, 2011; Mallick et al., 2012; Tursilowati et al., 2012; Senayake et al., 2013; Rozentein et al., 2014; Roy et al., 2014). Thermal bands with spatial resolutions are retrieved from land satellites (Wong & Yu, 2005; Wong et al., 2007; Tursilowati, 2008; Mirzaei & Haghighat, 2010; Tursilowati et al., 2012, Wibowo, et al., 2013; Weng et al., 2014). Furthermore, LST retrieved from the thermal images can show that areas covered by vegetation and farmland have lower LST, while urban areas have much higher LST (Srivastava et al., 2009). Wong et al. (2007) concluded from thermal images that there was a reddish color of thermal distribution on and around buildings, that a greenish color appeared in high-density plantation areas, with a yellowish color between these areas. The colors in this research are also related to Mallick et al. (2012), who argue that the spatial distribution of land surface temperature is related to land cover distribution. LST is an essential factor in global change studies, heat balance, and as a control for climate change (Srivastava et al., 2009). This temperature information provides a powerful way to monitor the urban environment (Asmat et al., 2003).

University campuses are considered as cities on a smaller scale (Wong et al., 2007; Saadatian et al., 2013; Srivanit & Hokao, 2013), due to their coverage area, population size and various complex activities (Srivanit & Hokao, 2013). The accelerated rate of urban growth in tropical cities (Makaremi et al., 2012, Ren et al., 2012) and urban land cover will generate heat intensity (Srivanit & Hokao, 2013). Nowadays, climate change has become the primary issue of global concern for university leaders (Suwartha & Sari, 2013), who have realized the impact of university activities on the environment (Srivanit & Hokao, 2013). University institutions have

a responsibility to communities for creating better urban living (Srivanit & Hokao, 2013; Wang et al., 2013). Within universities there exist many types of land cover, which exhibit different heat absorption and transmission capacities in their design and materials. The knowledge of land use as a localized urban environment and its effect on the urban heat signature (UHS) of university campuses is insufficient, so it is essential to assess UHS about localized urban environments. The objective of this study is to assess land cover and its effect on the UHS of two university campuses. The focus of the research is on the UHS of the University of Malaya and University of Indonesia, and the spatial and temporal behavior of urban heat on the two campuses.

2. METHODOLOGY

According to the introduction to the paper, campuses in a tropical area were chosen as the study region to answer the objectives of the research, these areas located at the University of Malaya (Malaysia) and University of Indonesia (Indonesia). The study uses LST from Landsat 8 TIRS (satellite image) data (Mirzaei & Haghighat, 2010; Kuşcu & Şengezer, 2011; Tursilowati et al., 2012; Senayake et al., 2013; Rozenstein et al., 2014; Roy et al., 2014). Landsat 8 had two thermal bands; this research used Band 10 to process becoming LST data, as according to Wang et al. (2015), and thermal band 11 has considerable data uncertainty (Wang et al., 2016). It is the latest series of the Landsat system, carrying two sensors: an Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). This study mostly employed the TIRS sensor, which has two bands (TIR-1 and TIR-2), with 100-meter spatial resolution and 16-day temporal resolution. The limitation of using remote satellite sensing is cloud cover.

2.1. Datasets

The research started from the acquisition of data on the land cover using Google Earth data and validated survey ground truth, and the land surface temperature data obtained from (employed) a thermal band of Landsat 8 TIRS. The Landsat 8 data for the UM campus with Path 127 Row 058 in the year 2013 used data from 22/4/13, 27/7/13, 12/8/13, 31/10/13 and 16/11/13 and for the year 2014 used data from 4/2/14, 8/3/14, and 12/6/14. The Landsat 8 data for the UI campus with Path 122 Row 064 in the year 2013 used data from 22/6/13, 25/8/13, 10/9/13 and 26/9/13 and for the year 2014 used data from 9/6/14, 28/8/14, 13/9/14 and 29/9/14. The remainder of the source data obtained from <http://glovis.usgs.gov/>.

2.2. Data Processes

The generated data of land cover of both campuses obtained from Google Earth. Data collection and extraction started from downloaded satellite imagery from Google Earth (Park, 2009, Wibowo et al., 2016). The satellite image data from Google Earth was mosaicked using ArcGIS software. The result of the mosaicked images does not have geographic references. A georeferenced tool was used for the mosaicked images to obtain a georeferenced image based on Universal Transform Mercator (UTM) projection (Wibowo et al., 2016). Land cover types were obtained from Google Image Data by visual interpretation and digitalization was based on 10m×10m vector square grids with their attributes (Shim, 2014; Wibowo et al., 2015; Wibowo et al., 2016). To validate the land use cover data from Google Earth (survey). The data was saved in geodatabase storage and processed to produce a summary of the total area of each land cover type, set within standard symbols, colors and layout using ArcGIS with a cartographic standard as a land cover map (Wibowo et al., 2016).

The data processing is generated Land Surface Temperature using Equation 1 ($L\lambda$ = spectral radiance ($\text{wm}^{-2}\text{sr}^{-1}\mu\text{m}^{-1}$); M = Multiplicative digital number value at band 10; DN of Band 10 = Digital Number of Band 10 Landsat 8 OLI; A = Additive value of spectral radiance at band 10 according to http://landsat.usgs.gov/Landsat8_Using_Product.php).

$$L\lambda = (M * DN \text{ of Band } 10) + A \quad (1)$$

Second, the spectral radiance resulting from equation 1 was converted to estimate the land surface temperature, following previous studies (Tursilowati et al., 2012; Wibowo et al., 2013; Wibowo et al., 2016). The formula represented in Equation 2.

$$Temp\text{-}KELVIN = K2 / \ln ((K1 / L\lambda) + 1) \quad (2)$$

Temp-Kelvin is the estimation of land surface temperature from the satellite sensor with the temperature unit in Kelvin; $K1$ is the calibration constant 1 for Landsat 8 OLI ($774.89 \text{ Wm}^{-2}\text{sr}^{-1}\text{m}^{-1}$); $K2$ is the calibration constant 2 for Landsat 8 OLI (1321.08 K), and $L\lambda$ is the spectral radiance of band 10.

The final processing was a conversion from Kelvin to Celsius (Tursilowati et al., 2012; Wibowo et al., 2013) using Equation 3.

$$Temp\text{-}CELSIUS = Temp\text{-}KELVIN - 272.15 = T - 272.15 \quad (3)$$

Temp-Celsius is the land surface temperature with the standard for temperature in degrees Celsius, where 1°K is equivalent to 272°C . The value of the urban heat signature uses temperatures in degrees Celsius ($^\circ\text{C}$). The land surface temperature value in degrees Celsius ($^\circ\text{C}$) based on the relationship between land-use/land-cover types and the heat emitted from their surfaces. (Kim & Baik, 2005; Ichinose et al., 2008; Memon et al., 2009; Mirzaei & Haghighat, 2010), and then defined as the Urban Heat Signature (UHS). The UHS explains the heat characteristics of certain land cover measured in different periods.

2.3. Analysis

Urban heat (Wong & Yu, 2005; Srivanit & Hokao, 2013), as the relationship between land cover types and sun radiation (Kim & Baik, 2005; Ichinose et al., 2008; Memon et al., 2009; Mirzaei & Haghighat, 2010). Remote Sensing (RS) and the Geographic Information System (GIS) were used in the research to explain the spatial-temporal variations in UHS. The analysis of the UHS was spatial-temporal; the spatial analysis used spatial pattern, density, and overlay between land cover and UHS and trend analysis to establish the temporal trends on both university campuses. The remaining results saw related to (a) land cover and its impact on the UHS of the university campuses using remote sensing.

3. RESULTS AND DISCUSSION

3.1. Land cover at UM and UI campuses

Land cover, as the localized urban environment on UM and UI campuses, can be seen in Table 1. About the comparative land cover of UM and UI, it found that the two urban campuses had a similar cover, but different total percentage areas. Land cover on the UM campus about building cover was 20.9% greater than on the UI campus, which had building cover of only 10.9%. The UM campus was covered by 59.1% dense vegetation, which was lower than the UI campus cover of 65.3%. The spatial distribution of land cover on the UM and UI campuses could see in Figure 1.

3.2. Spatial-Temporal UHS on UM and UI campuses

The spatial UHS pattern in 2013 and 2014 at UM could see in Figure 2, with color gradation from yellow to red (low to high temperature). Based on the spatial distribution of UHS on the UM campus, distribution of low temperatures was clustered in the middle and to the north of the campus, and high temperatures clustered to the south of the campus.

Table 1 Land cover distribution on UM and UI campuses 2013-2014

| No | Land cover | UM campus | | UI campus | |
|----|--|-----------|----------------|-----------|----------------|
| | | Area (ha) | Percentage (%) | Area (ha) | Percentage (%) |
| 1 | Building cover (faculties, colleges, administrative buildings) | 67.3 | 20.9 | 33.0 | 10.9 |
| 2 | Paved open spaces | 52.9 | 16.4 | 35.8 | 12.6 |
| 3 | Bodies of water | 3.0 | 0.9 | 22.9 | 7.5 |
| 4 | Open green surfaces (grassland, shrubs, isolated tree strains) | 23.3 | 7.2 | 19.3 | 6.4 |
| 5 | Dense vegetated surfaces | 189.0 | 59.1 | 197.4 | 65.3 |
| | | | 100.0 | | 100.0 |

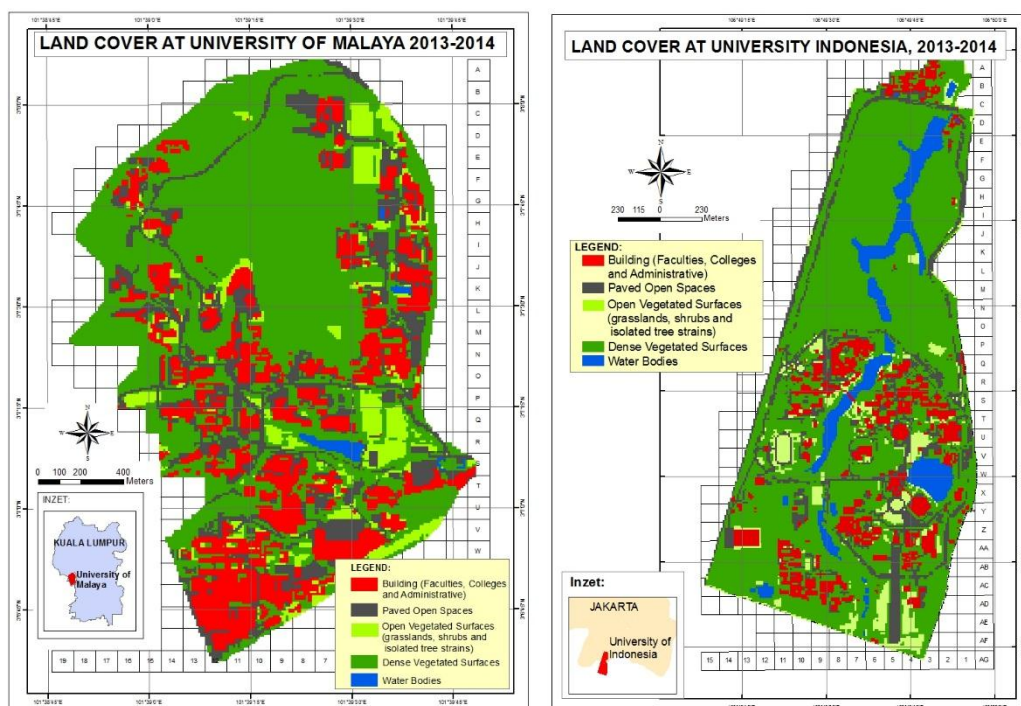


Figure 1 Spatial pattern land cover on UM and UI campuses

UHS in 2013 with low temperatures was very limited, while on the other hand red and yellow-red colors were more dominant and distributed around the UM campus. Spatial distribution of UHS in 2014 was similar to that of 2013, but with very clear yellow in June 2014, with an area distribution covering more than 40% of the UM campus. The spatial density of UHS at UM is explained by the percentage of covered areas with high, moderate and low temperatures, as seen in Table 2. The spatial densities varied every month, depending on cloud cover. In general, the UM campus had moderate UHS cover most months.

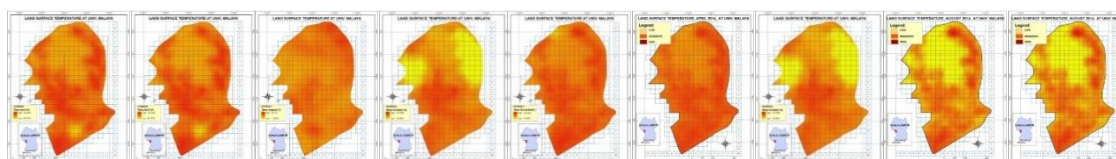


Figure 2 UHS spatial pattern 2013-2014 on the UM campus

Table 2 Spatial density with percentage cover of UHS on the UM Campus

| No | Urban Heat Signature | Apr 2013 | Jul 2013 | Aug 2013 | Oct 2013 | Nov 2013 | Mar 2014 | Apr 2014 | Jun 2014 | Oct 2014 |
|-------|----------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 1 | Low | 23.5 | 32.6 | 44.4 | 20.5 | 5.5 | 37.5 | 23.6 | 53.6 | 43.0 |
| 2 | Moderate | 49.9 | 60.0 | 48.0 | 38.7 | 47.7 | 56.1 | 35.6 | 43.1 | 32.5 |
| 3 | High | 26.6 | 7.3 | 7.7 | 40.8 | 46.8 | 6.4 | 40.7 | 3.3 | 24.5 |
| Total | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

To understand the monthly land cover effect on the temporal UHS behavior on the UM campus could see in Figure 3. The behavior on the UM Campus in 2013 started on 22/4/2013 at 25-31°C; followed by 27/7/2013 at 20-24°C; 12/08/2013 at 17-23°C, 31/10/2013 at 20-31°C; and 16/11/2013 at 17-24°C. The corresponding behavior on the UM campus in 2014 started on 4/2/14 at 28-38°C, 8/3/14 at 30-39°C, 12/6/14 at 10-17°C; and 15/10/14 at 25-33°C. These results show that UHS between 2013 and 2014 on the UM campus had a positive trend, with an average trend temperature 1°C. The temporal trend for temperature maximum had a positive trend line ($y = 4.2745x$).

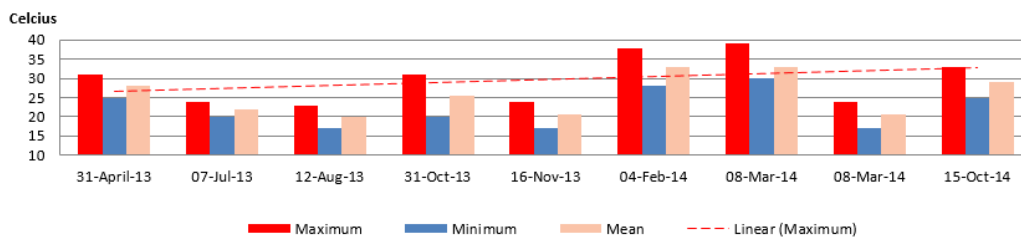


Figure 3 UHS behavior 2013-2014 on UM campus

The spatial UHS patterns in 2013 and 2014 on the UI campus could see in Figure 4. That figure shows a distribution of low temperatures clustered within the center of the north part of campus, and high temperatures clustered in the center and to the south. The spatial pattern of UHS in June 2013-2014 shows a small area with red and yellow color distribution around the campus; in August 2013-2014 there is a spatial distribution of red color clustered to the south of the campus in 2013, but in 2014 there is a distribution of yellow color around the campus. UHS with low temperatures dominated the spatial distribution in Sept/Oct 2013 and Sept 2014, with moderate temperature cover in June, August and Sept 2013, and Sept/Oct 2014. Furthermore, the red color had a dominating spatial distribution pattern in June 2014. The spatial density of UHS on the UI Campus could see in Table 3. In general, the UI campus had moderate UHS cover most months.

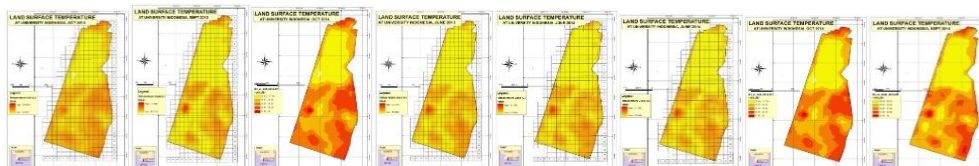


Figure 4 UHS spatial pattern 2013 and 2014 on UI campus

The temporal temperature of UHS on the UI campus in 2013 can be seen in Figure 5, which shows UHS behavior on 22/6/2013 of 22-28°C; on 25/8/2013 of 26-32°C; 10/9/13 of 27-34°C; and on 26/9/13 of 27-34°C. The corresponding behavior in 2014 was a UHS on 9/06/14 of 20-28°C; on 28/08/14 of 25-32°C; on 13/09/14 of 25-33°C, and on 29/9/14 of 21-33°C. These results show that the UHS between 2013 and 2014 on the UM campus had a negative trend,

with an average trend temperature of 1°C. However, the maximum temporal trend was positive ($y = 4.973x$).

Table 3 Spatial density with percentage UHS cover on UI Campus

| No | Urban Heat Signature | Jun 2013 (%) | Aug 2013 (%) | Sep 2013 (%) | Oct 2013 (%) | Jun 2014 (%) | Sep 2014 (%) | Oct 2014 (%) | Oct 2014 (%) |
|------------|----------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 1 | Low | 12.9 | 28.4 | 34.6 | 57.6 | 16.4 | 51.0 | 26.4 | 26.4 |
| 2 | Moderate | 46.4 | 43.0 | 47.9 | 37.3 | 33.8 | 46.5 | 56.0 | 56.0 |
| 3 | High | 40.7 | 28.6 | 17.5 | 5.1 | 49.7 | 2.5 | 17.6 | 17.6 |
| Percentage | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

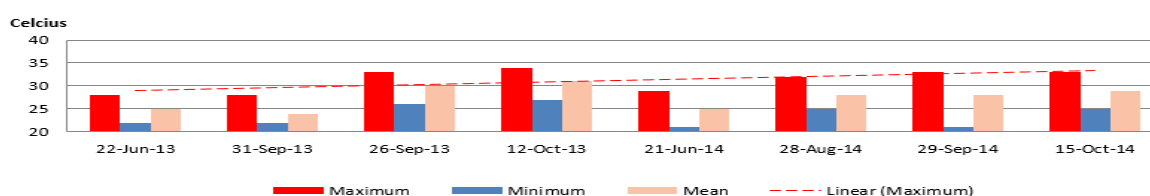


Figure 5 UHS behavior 2013-2014 on UI campus

3.3. Land Cover and its Impact on UHS on the UM and UI Campuses

The localized urban environment represented by land cover types had different heat signatures within the urban areas. The UHS in UM campus is corresponding to paved open spaces with a mean of 21.6-35.1°C, building cover with a mean of 27.0-35.3°C, waterbody cover with a mean of 26.5-33.7°C, open vegetation cover with a mean of 25.6-34.7°C and dense vegetation cover with a mean of 25.9-32.8°C (Table 4).

Table 4 Land cover and its impact on UHS on the UM campus 2013-2014

| Land Cover Type | UHS April 2013 (°C) | | | UHS Oct 2013(°C) | | | UHS Feb 2014 (°C) | | | UHS March 2014 (°C) | | |
|---------------------|---------------------|------|------|------------------|------|------|-------------------|------|------|---------------------|------|------|
| | Min | Max | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max | Mean |
| Paved Open Space | 25.0 | 31.0 | 29.2 | 21.6 | 31.0 | 26.3 | 29.0 | 38.0 | 34.8 | 30.0 | 39.0 | 35.1 |
| Building Cover | 25.0 | 31.0 | 29.4 | 22.0 | 32.0 | 27.0 | 30.0 | 38.0 | 35.1 | 31.0 | 39.0 | 35.3 |
| Open Veg. Surfaces | 25.0 | 31.0 | 28.7 | 20.0 | 31.0 | 25.6 | 29.0 | 37.0 | 34.6 | 31.0 | 37.0 | 34.6 |
| Bodies of Water | 28.0 | 30.0 | 28.6 | 21.0 | 32.0 | 26.5 | 33.0 | 36.0 | 33.7 | 33.0 | 36.0 | 33.7 |
| Dense Veg. Surfaces | 25.0 | 31.0 | 28.1 | 20.9 | 31.0 | 25.9 | 28.0 | 38.0 | 32.8 | 30.0 | 39.0 | 32.8 |

The UI campus had different results to the UM campus. The UHS on the UI campus corresponding to paved open spaces had a mean of 27.0-34.8°C; building cover a mean of 29.4-35.1°C; waterbody cover one of 28.1-33.7°C; open vegetation cover a mean of 28.7-34.6°C, and dense vegetation cover had a mean of 27.6-32.8°C (Table 5).

Comparative land cover by buildings on the UM campus was 20.9%, higher than on the UI campus, which was only 10.9%. The UM campus was covered by 59.1%, of dense vegetation, while the UI campus had coverage of 65.3%. Both universities had urban areas (building cover and paved open spaces) with a total area of more than 20%. This result relates to previous studies, in that urban areas can generate urban heat (Wong & Yu, 2005; Ahmad & Hashim,

2007; Tursilowati et al., 2012; Wibowo et al., 2013). Furthermore, the land cover type is a representation of land use (Asmat et al., 2003; Ren et al., 2012, Lenzholzer & Brown, 2013; Steeneveld et al., 2014).

Table 5 Land cover and its impact on UHS on the UI campus 2013-2014

| Land Cover Type | UHS Jun 2013(°C) | | | UHS Sep 2013(°C) | | | UHS May 2014(°C) | | | UHS Sep 2014(°C) | | |
|---------------------|------------------|------|------|------------------|------|------|------------------|------|------|------------------|------|------|
| | Min | Max | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max | Mean |
| Paved Open Space | 25.0 | 31.0 | 29.2 | 28.0 | 35.0 | 31.1 | 29.0 | 38.0 | 34.8 | 20.0 | 34.0 | 27.0 |
| Building Cover | 25.0 | 31.0 | 29.4 | 28.0 | 33.0 | 31.4 | 30.0 | 38.0 | 35.1 | 27.0 | 33.0 | 30.4 |
| Open Veg. Surfaces | 25.0 | 31.0 | 28.7 | 28.0 | 35.0 | 31.1 | 29.0 | 37.0 | 34.6 | 22.0 | 35.0 | 28.8 |
| Bodies of Water | 28.0 | 30.0 | 28.6 | 28.0 | 32.0 | 29.1 | 33.0 | 36.0 | 33.7 | 27.0 | 31.0 | 28.1 |
| Dense Veg. Surfaces | 25.0 | 31.0 | 28.1 | 28.0 | 34.0 | 29.9 | 28.0 | 38.0 | 32.8 | 22.0 | 33.0 | 27.6 |

Spatial UHS distribution in 2014 was similar to that of 2013, except that in June 2014 the highest temperature area distribution covered more than 40% of the UM campus. In general, moderate UHS temperatures occurred most months on the UM campus. In the study area of the UI campus, the UHS included more than 40% of low temperatures in the spatial distribution in September 2013 and September 2014. In general, moderate temperatures were recorded in 2013 (June, August, & September) and September 2014, apart from June 2014, highest temperature distributed as a spatial pattern related to land cover. The temporal UHS behavior on the UM campus between April and November 2013 showed temperatures between 17°C and 31°C, with an average of 24°C, and UHS behavior between Feb and October 2014 with temperatures between 10°C and 39°C and an average of 25°C. For the UI campus, temporal UHS behavior between June and September 2013 showed temperatures between 22°C and 34°C, with an average of 28°C, and UHS behavior between June and September 2014 with temperatures between 20°C and 33°C, with an average of 27°C. The UHS behavior in 2013-2014 was different, and this phenomenon relationship between land cover types and solar radiation. (Taha, 1997; Asmat et al., 2003; Wong & Yu, 2005; Mirzaei & Haghighat, 2010; Ren et al., 2012; Srivanit & Hokao, 2013; Lenzholzer & Brown, 2013). The variation in spatial density every month depended on cloud cover in the area of study, is a limitation of the work with satellite data. The results showed that the UHS between 2013 and 2014 on the UM and UI campuses had a positive trend, with an average temperature of 10°C; the maximum temporal trend was positive, at $y = 4.2745x$, on the UM campus, and also positive, at $y = 4.973x$, on the UI campus. The increasing trend UHS 1°C on both campuses, which is related to previous studies, which have noted temperature increases of 0.5°C to 1.5°C, in line with the intensity of land use change (Malaysian Meteorological Department, 2009).

Urban heat studies conclude that areas with high surface temperatures (>30°C) are mostly seen in central parts of cities (less vegetated), with lower temperatures found in vegetated (suburban) and areas with bodies of water (Tursilowati et al., 2012). Other research has obtained results that show that higher vegetation cover as the land cover type (Skelhorn et al. 2014) is related to low temperatures (Sham 1979; Taha 1997; Tran et al., 2006; Wong et al., 2007; Wong & Jusuf 2008; Srivanit & Hokao 2013). The final result shows the UHS behavior in 2013-2014 on both campuses as the impact from land cover and solar radiation with a mean temperature for building a cover on the UM campus of 27.0-35.3°C. Th another hand a mean temperature on the UI campus of 29.4-35.1°C, paved open spaces on the UM campus of 26.3-35.1°C and the UI campus of 27.0-34.8°C. Both land cover types had an impact on UHS behavior with the highest temperatures. These results relate to previous studies, which have shown that land cover causes urban heat (Taha, 1997; Asmat et al., 2003; Wong & Yu, 2005; Mirzaei & Haghighat, 2010; Ren et al., 2012; Srivanit & Hokao, 2013; Lenzholzer & Brown, 2013). The new finding that

land cover affects UHS for every land cover type on the university campuses of small cities had differentiated temperature as a localized urban environment.

Despite the relation between UHS and land cover type, further research into land cover and its effect on localized urban areas could conduct. In particular, different influences on land cover types, including cloud cover and temporal data (longitudinal), need to be studied further. Unfortunately, the LST reason behind this finding remains unsolved and is open to further study. Finally, this research does not examine climate change and sustainability. In the 2013-2014 period, when the warmest month with the highest UHS as impact land cover in the study area, and thus a less cooling or warming effect on the air temperature during the day is open for further study of UHS.

4. CONCLUSION

Based on Landsat 8 TIRS (100 m ground resolution) the result on both university campuses had UHS related to vegetation cover of 25-33°C with a mean of 28°C as the lowest temperature. The building covered 33-39°C with a mean of 35°C as the highest temperature, its effect on land cover types likes build-up area. Google Earth provided the land cover for visual interpretation, and digitalization based on a 10m×10m vector square grid with their attribute and land cover attribute validated with field survey.

Our research has shown the critical trend of UHS change in the period 2013-2014, with a maximum temperature of >30°C on the UM and UI campuses increased in temperature with 1°C. Finally, this study has concluded that UHS behavior is an effect of the temporal relation between land cover and solar radiation. The new knowledge for university campuses UHS is relation land cover with solar energy in the localized urban environment.

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