Monitoring urban heat signature and profiles of localized urban environment in the University of Malaya

A Wibowo1, M M Yusoff 2 and K O Salleh3

1Department of Geography, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia
2Department of Geography, Faculty of Arts and Social Sciences, University of Malaya, Kuala Lumpur, Malaysia

Corresponding author’s email: adi.w@sci.ui.ac.id

Abstract. Urban heat mainly caused due to the anthropogenic and due to heat stored and re-radiated from the sun. In a tropical country, activity during daylight is possible in a large part of the year and such cities rapidly contribute to influence the global climate change as Urban Heat. Education area with their activity in university is similar to an urban area with a small scale. The university campus has a localized urban environment. The land cover in an university is similar to land cover in an urban area. Every land cover has its urban heat signature. This paper aims to understand the urban heat signatures (UHS) based on the land cover on the university campus. To answer the aim of the research, we used the collected temperature data based on land cover in the education area. Data collection for the ground air surface temperature with a survey by rapid 20 min at sample location by day and night time using a handheld air temperature tool. This result concluded land cover is related to the spatial-temporal of UHS. University of Malaya campus found UHS the relation within highest vegetation covered and UHS the lowest temperature, and the other hand building covered had UHS with the highest temperature. The result saw UHS behavior in 2013 had a temperature of 1.5 °C with max temperature maximum > 30 °C for all land use cover types within UM. The vegetation-covered had UHS with the lowest temperature, and the other hand building covered had UHS with the highest temperature. The localized urban environment also gave the UHS related to vegetation covered and the building covered. The vegetation-covered relation by UHS with the lowest temp and the other hand building covered relation by UHS with the highest temp. The rest of this result gave new insight that monitoring is essential for land cover management and significant for an assessment of UHS behavior in the university campus.

Keywords: Education area, land cover, monitoring, urban heat signature

1. Introduction

The study of urban heat firstly did in Europe country with first documentation of urban heat occurs in 1818 when Luke Howard's groundbreaking study of London's climate found an artificial excess of heat in the city compared with the country [1]. The study of urban heat in the US began in the first half of the century by Mitchell in 1953 and 1961 [2]. Case studies of individual cities are an early form of descriptive studies start with Schmidt in 1929 at Vienna, Sundborg in 1950 at Uppsala-Sweden, Niewolt in 1966 in Singapore, and Sani in1973 at Kuala Lumpur, Malaysia. In more recent time, descriptive studies took the form of surveys of urban climate in many cities or a region, for example, Switzerland
by Wanner and Hertig in 1984, Tama River Basin, Japan by Yamashita et al., in 1986, South West US by Balling and Idso, 1989 and several tropical cities by Tso in 1960 [3]. Although the urban climate in the temperate country has received some research attention, the tropical country also more important now due to the region's rapid urbanization [4]. The rapid urban transition in Asia involving a large volume of the population with increased energy consumption and dense urban infrastructure reported to affect the quality of life of urban inhabitants significantly as well as to worsen the urban environment and urban climate [5].

Study Day-time urban heat mapped in dry seasons in tropical cities, shows that the locations of the maximum urban heat intensity roughly coincides with densely built-up areas found in the centers of cities. Bangkok had the highest daytime Urban heat intensity of 8°C, followed by Manila 7 °C and Ho Chi Minh City 5 °C in the dry season. The mean rural temperatures were 29.5 °C for Bangkok in February, 26.5 °C for Manila in November and 30 °C for Ho Chi Minh City in February [5]. In common with other cities, Kuala Lumpur-Petaling Jaya built-up area is relatively warmer than its environments. Moreover, the warmth of the commercial center or the heat is evident with temperatures over 28.8 °C compared to the cool outskirt of 24.4 °C [6]. Urban heat intensity in Jakarta found centralized in the downtown areas and spreading to the surrounding area in 1989 and 2002, moreover, distribution of Urban heat that indicate by a high surface temperature (upper than 30 °C) seen in the central area of the city where buildings, roads, parking areas, and other non-vegetation surface types are dominant [7]. Tursilowati in this research also shows the comparison of the temperature distributions between 1989 and 2002. The result shows that the urban development during 13 years has caused a significant increase in the surface temperature, and the increase is not limited to the central (flat) part of the city, but spreading to the southern hill part as well [7].

The significance of climate "variation" or "change" depends not only on the behavior of the change itself but also on the characteristics of society and systems exposed to the changes [8]. Urban heat mainly caused by the anthropogenic and heat stored and re-radiated from the sun. Urban heat signature (UHS) is heat information based on air surface temperature generated by land cover and sun heat during daylight. In a tropical country, activity during daylight is possible in a large part of the year, and such cities rapidly contribute to influence the global climate change as Urban Heat. Education area and activity in university is the same as urban activity on a small scale. It means it will influence a different urban heat in a different area in university. This paper aims to understand the urban heat signatures on the education area base on the land cover in a university campus.

2. Materials and method

The research in university is essential to identify the behavior of urban heat signatures as a land-use type and significant to mitigate and adaptive urban heat threat on campus as part of urban areas within sustainable campus environment quality and management. This research will contribute new knowledge about UHS threats depend on the on-campus environmental management, especially in tropical cities (figure 1).

The research used air surface temperature and land surface temperature to answer the objective. The air surface temperature was collected by using a mobile device to measure air surface temperature and stored in the memory than were manually acquired from the mobile temperature and humidity tool related to Suzuki [9]. The air surface temperature rapid survey, a technique uses a mobile temperature and humidity tools [9-11]. Sampling data for temperature related to Suzuki [9] measured the Urban Heat in Japan as a grid with the size is 100-meter square. The grid sizes determined by the spatial representation of land cover. The land cover digitizing based on the data from google earth and survey at the University of Malaya (UM) Campus, then the data used to create a land cover map detail.
3. Results and discussion
Detail land cover map in UM campus was created using data from google earth and survey at UM Campus (figure 2a). Thus, the general land cover map generated from a detail land cover map in UM campus (figure 2b). Those are five detailed land covers: building, impervious, open area, vegetation, and two general land cover: building area and vegetation. Based on General Land Cover map, this map used to identify the vegetation coverage at each grid around the UM campus (table 1). The highest vegetation covered almost 50% area at UM campus (166 m²), lowest and moderate vegetation covered 48% area at UM campus. Based on the vegetation covered used to get sample locations, this research had sampled in the highest vegetation and lowest vegetation. The air surface temperature took from 11.00 in the morning until 21.00 in the night time. The result saw the urban heat signature (UHS) in UM campus. The UHS at Highest Vegetation Cover at UM with the highest temperature during 15.01–16.00 is 35.00°C (see table 2 and figure 3).

![Figure 1: Theoretical framework](image1.png)

![Figure 2: (a) The detail and (b) general land cover.](image2.png)
Figure 3 explains the lowest temperature (30.30 °C) after 20.00-night time, and the highest temperature (35.00 °C) during 15.01-16.00. The temperature is starting from 12.00 until 18.00 with temperature > 32.0 °C. It meant that temperature > 32.0 °C exist for more than 6 h.

Based on the vegetation covered the lowest vegetation, the result shows the urban heat signature (UHS) in UM campus, it can be seen in table 3 and figure 4. The UHS at Lowest Vegetation Cover at UM with the highest temperature during 15.01–16.00 is 35.14 °C. Figure 4 explains the temperature starting at 12.00 daytime with temperature > 32.0 °C until 21.00 in the nighttime, it means that temperature more than 32.0 °C exists for more than 9 h.

The research findings, firstly is the information about the land cover based on vegetation-covered to an understanding of UHS at the UM campus. Second, the different time was collecting start from 11.00 until 21.00 to identify a differentiation UHS between time collecting in UM campus. The result shows that temperature in an area with the highest vegetation cover had a low temperature related time

| Table 1. Vegetation covered based on general land cover |
|---------------------------------|---------|-----------|
| Vegetation covered | Areas (m²) | Percentage (%) |
| Lowest vegetation | 84 | 25.61 |
| Moderate vegetation | 78 | 23.78 |
| Highest vegetation | 166 | 50.61 |
| Total area | 320 | 100.00 |

| Table 2. Urban Heat Signature (UHS) at highest vegetation covered |
|---------------------------------|---------|-----------|---------------------------------|---------|-----------|
| No | Time | Temp (°C) | No | Time | Temp (°C) |
| 1 | 11.00–12.00 | 31.94 | 6 | 16.01-17.00 | 33.87 |
| 2 | 12.01-13.00 | 32.27 | 7 | 17.01-18.00 | 32.74 |
| 3 | 13.01-14.00 | 33.12 | 8 | 18.01-19.00 | 31.60 |
| 4 | 14.01-15.00 | 34.06 | 9 | 19.01-20.00 | 30.95 |
| 5 | 15.01-16.00 | 35.00 | 10 | 20.01-21.00 | 30.30 |

Figure 3. The urban heat signature on highest vegetation covered
exposure (6 h), while, the other area with the lowest vegetation had a high temperature related time exposure (9 h). Moreover, the highest temperature in an area with the lowest vegetation had the highest temperature until night time. This result explains that comparison UHS between the lowest vegetation cover and the highest vegetation cover had different UHS (< 0.5 °C) at the same time (see figure 5).

Table 3. Urban Heat Signature (UHS) at lowest vegetation covered

| No | Time          | Temp (°C) | No | Time          | Temp (°C) |
|----|---------------|-----------|----|---------------|-----------|
| 1  | 11.00-12.00   | 31.74     | 6  | 16.01-17.00   | 33.44     |
| 2  | 12.01-13.00   | 32.82     | 7  | 17.01-18.00   | 33.69     |
| 3  | 13.01-14.00   | 33.16     | 8  | 18.01-19.00   | 33.22     |
| 4  | 14.01-15.00   | 33.51     | 9  | 19.01-20.00   | 33.22     |
| 5  | 15.01-16.00   | 35.14     | 10 | 20.01-21.00   | 32.67     |

Figure 4. The urban heat signature in lowest vegetation covered

Figure 5. The comparison of urban heat signature at University of Malaya in June 2013.
4. Conclusion
This result concluded that land cover related to the spatial-temporal of UHS. University of Malaya campus found that the UHS had a relation within the highest vegetation covered with lowest temperature (exist during 6 h) and the lowest vegetation covered with the highest temperature (exist during 9 h). The result shows that UHS behavior in 2013 had temperature 0.5 °C with temperature maximum > 35.00 °C for all land cover based on vegetation covered in UM campus. The localized urban environment also gave the UHS related to vegetation covered and building covered. The rest of this result gives a new knowledge that monitoring is significant for land cover management and also be an assessment of UHS behavior in the campus area.

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