Urban heat hazard on University of Malaya Campus

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Abstract. Urban heat is a phenomenon that caused by relationship solar heat and land cover types consequence, and the urban heat effect on the environment and impact on human activities. It is effect and impact become a hazard when upper the threshold. The study objective to examine the urban heat hazard on the University of Malaya Campus. The method uses remote sensing, gis, and perception study to examines the urban heat hazard. The result explained that the maximum temperature from land cover type was upper than 32°C during 2013-2016. The result concluded that the maximum temperature from land cover type (>32°C) was categorized as a strong heat stress UHS and AST using UTCI. The perceptions from UM student categories very hot and very uncomfortable. This condition would impact on human health with increasing stress caused by sweating and blood flow. It could be an impact on health with cardiovascular embarrassment and dangerous heat stroke. Those are urban heat hazard happened on University Malaya campus.

1. Introduction
Urban heat is a phenomenon caused by the relationship between solar heat and land cover [1]. Thus, it is a consequence of urban setting or urban growth [2,3,4,5]. The urban heat effect resulted in an observed maximum temperature difference of 4.01°C between a well-plant area and the central business district area in Singapore [6], with an air temperature minimum of 26°C and a mean temperature of 30°C [7]. Air temperatures in dense cities are higher than those in less dense cities [6,3,8]. The urban heat intensity varies between highly developed and lowly developed areas or between areas with different build-up areas [9, 10, 11]. These negative impacts could degrade the quality of the environment and cause many problems in a tropical climate [12].

The urban area is a landscape with different land cover types and human activities due to population and activities enabling better urban living. A university campus could be regarded as a small city [13,14]. A university, as an institution, has a responsibility to the community to support better urban living [15,13] and conduct research addressing better urban life on its campus. Whenever heat signatures upper, then their threshold would become heat hazard and could be a threat to the sustainable urban environmental quality and human wellbeing. Especially in the education area as part of the metropolitan regions like the University of Malaya campuses, since 2010, the university community lead by UI created the UI Green Metrics World University Ranking (greenmetric.ui.ac.id) concern with environmental quality. That is a real concern the university community around the world to the sustainability of good quality of life. The study of urban heat signature behavior of land cover...
types become heat hazards in the education area, those very limited, that is the reason it was essential to study urban heat signature in the education area. Those studies in the educational area were significant to give a new understanding of land use development management to ensure sustainable environmental quality and human wellbeing on university campuses.

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2. Methodology
In this study, potential heat hazard that has threatened populations were ascertained from the land surface and air surface temperature and also perception study based on land cover types. This research used Google Earth data archive to generated land cover types, thermal satellite by Landsat 8 TIRS from USGS to makes LST, and perception study data from an online survey. The geodatabase processes and analysis then layout a standard used ArcGIS with a cartographic standard.

The urban heat hazard identified via data-gathering methods from LST used Landsat 8 to acquire land surface data and used satellite imaging thermal bands to generate the LST/UHS. The Landsat data for the UM campus used path 127, and row 058 acquired from 2013 to 2016. The direct collection of air surface temperature used in this survey was rapid, with measurements collected every 10-15 minutes in the daylight in June 2013 and March 2015. With data collected for 10- to 12-hour. Air surface temperature data were sampled based on land use covers, e.g., building covered, paved open space, water bodies, open vegetation-covered, and dense vegetation covered. A total of 30 samples were collected. The perceptions of respondents were investigated to identify the level and type of impact of the natural hazard. The perceptions students had about their campus were assessed and evaluated using data collection collected with a questionnaire distributed to 100 students on the UM campus. The student respondents from universities using an online survey, and the respondents answered questions about their perception of heat and land cover types and the potential impact of urban heat hazard on human activity.

All data used the Universal Thermal Climate Index (UTCI) for assessing the UHS behavior in 2013-2016. The UTCI used five categories of heat stress based on the level of temperatures, such as Extreme Heat Stress (> +46°C), Very Strong Heat Stress (+38 to +46°C), Strong Heat Stress (+32 to +38°C), Moderate Heat Stress (+26 to +38°C) and No Thermal Stress (+9 to +26°C) to detect the UHS on the UM campus [16]. Moreover, the UHS associated with the urban heat hazards on the university campuses evaluated with the effective thermal index, which determines temperature sensation levels and the comfort associated with each sensation level, e.g., sensation levels ranging from hot to neutral and comfort levels within the sensations ranging from very uncomfortable to comfortable. The UHS analysis using a spatial-temporal analysis, with the spatial pattern, density, overlay between landscape features and UHS and trend analysis, was used to obtain a temporal trend for both campus universities. The rest of the results were related to landscape features and their potential heat hazard threats at urban universities.

3. Discussion
The Urban Heat Signature was the relationship between Land Cover Types (LCT) and Land Surface Temperature (Figure 1). The UHS in UM discussion related to five land cover types: Building Covered, Paved Open Space, Water Bodies, Open Vegetated Covered, and Dense Vegetated Covered, explained in Table 1. Based on Table 1 UHS April 2013, max temp for all land cover types is 31.0°C except water bodies with min temp 30.0°C. Based on LST March 2014, max temp on Paved Open Space and Building Covered are 39.0°C, the rest of the lowest than temp 37.0°C and Dense vegetated had temp. 34.0°C. Based on UHS March 2015 max temp on Paved Open Space, Building Covered and Dense Vegetated Covered with temp 33.0°C, the Open Vegetated Cover and Waterbodies had max
temp lowest than 33.0°C. Based on UHS March 2016, max temp on Paved Open Space and Building Covered with temp 36.0°C, and Dense Vegetated Cover had max temp 34.0°C.

**Figure 1.** Urban Heat Signature in 2013, 2014,2105 and 2016 on UM Campus

| Land Covers Types          | 2013 (°C) | 2014 (°C) | 2015 (°C) | 2016 (°C) |
|---------------------------|-----------|-----------|-----------|-----------|
| Paved Open Space          | 31.0      | 39.0      | 33.0      | 36.0      |
| Building Covered          | 31.0      | 39.0      | 33.0      | 36.0      |
| Open Vegetated Covered    | 31.0      | 37.0      | 32.0      | 35.0      |
| Dense Vegetated Covered   | 31.0      | 34.0      | 33.0      | 34.0      |
| Water Bodies              | 30.0      | 36.0      | 31.0      | 35.0      |

Sources: Data Processing from Landsat 8 TIRS

The UHS will effect Air Surface Temperature (AST). To detect the effect UHS on AST using the survey data, then collect the temperature of land cover types during daylight. Based data survey in Figure 2, all sample locations at the UM campus had a temperature of 26-28°C at 8 am, which increased to >30°C from 11 am until 5 pm, with a temperature of >32°C occurring between 2 pm and 4 pm. Areas with a building cover landscape feature reached a maximum temperature of 35°C at 3 pm, paved open space areas reached a maximum temperature of >34°C at 4 pm, water bodies reached a maximum temperature of 33°C at 2 pm. Open vegetation areas reached a maximum temperature of >34°C at 3 pm.

**Figure 2.** Air Surface Temperature in June 2013
The research also found that the air surface temperature showed a temporal UHS behavior in March 2015 related to Figure 3. The six locations at the UM campus had the same temperature of approximately 27°C at 7 am, which increased until 10 am. In the time, all areas experienced a temperature of more than 30°C, and the afternoon, the air surface temperature was >32°C. The maximum temperature for each location occurred at a different time. At location 1, the maximum temperature of more than 34°C occurred at 2 pm, at locations 2, 3, 5 and 6, the maximum temperatures occurred at 3 pm, and only at location 4, the maximum temperature occurred at 4 pm. Thus, the results found temperatures >32°C from 12 pm to 6 pm at the UM campus in March 2015.

To examine the Effect between UHS in June 2013 and March 2015, due to Figure 2 and Figure 3, the data put on the UTCI (Universal Thermal Climate Index) threshold at UM Campus (Table 2).

### Table 2. Air Surface Temperature on UTCI threshold in UM Campus

| UTCI (°C)     | Stress Category       | 2013       | 2015       |
|---------------|-----------------------|------------|------------|
| Above +46     | Extreme heat stress   | --         | --         |
| +38 to +46    | Very strong heat stress| --         | --         |
| +32 to +38    | Strong heat stress    | 11 am – 04 pm | 12 pm – 03 pm |
| +26 to +32    | Moderate heat stress  | 07 am – 11 am; 07 am – 12 pm; 05 pm – 06 pm. | 03 pm – 06 pm. |
| +9 to +26     | No thermal stress     | --         | --         |

Sources: Data Analysis

The Effect on Environment and the relation between LCT and AST explained in June 2013 and March 2015, explained in Table 3. The minimum temperature for June 2013 is 27.4 for open and dense vegetated covered. The building covered as an area with the highest temperature. Furthermore, in March 2015 explained that the water body as an area with the highest temperature. On the other hand, open vegetation-covered at the lowest temperature.

The human internal temperature range is much narrower than the range of external temperatures, so when external temperatures are high, humans may overheat or feel warm [17]. Urban heating causes many problems for the inhabitants of cities in tropical environments, including the deterioration of living environments [12]. Additionally, Chen [18] addressed how the typical use of dark materials and pavement collects and traps high levels of solar energy, leading to increases in ambient air temperatures and reducing human comfort [15].
High temperatures damage the natural ecosystems in cities [3]. Furthermore, high temperatures may increase the potential risk of ill health in urban populations caused by thermal extremes [19,20]. Temperature is the most significant component of the experience of comfort in space [16]. Furthermore, many urban residents who exposed to higher temperatures for extended periods will feel uncomfortable, and the temperatures may affect the health of these people [3]. The Impact of UHS Profiles on Human Quality of life explains with UHS influencing the campus system both an environment and human dwelling preferences also given to Urban Heat Hazards awareness in the campus area.

The relationship between temporal urban heat signature and threat on human quality of life using a survey on intensity perception study. The research used more than 130 respondents from UM students. The respondent minimum one year studied in university. The respondent answer questions about the heat intensity profile from low temperature (<30°C) until high temperature (>30°C) within a relationship with temperature sensation (level hot intensity and comfort). The survey used an online method survey by email to the had response from the student as a community campus. Students perceived that heat intensity impacted their health in a particular quality of life is a comfort, health and doing activities in universities

The demographic of respondents on perception relationship within UHS and Threat on Human Quality of Live in UM Campus total with 134 responses. The ages of responses between 21-30 years old (108 response), 31-40 years old (19 response) and 41-50 years old (7 response) with a female (81 response) response highest than male (51 response) and the majority respondent is Malaysian Nationality (124 response) compare other countries (10 response).

Based on the respondent on perception intensity study in UM Campus, answer that the Paved Open Space as an area with hot perception and dense vegetation as a neutral perception (Table 4).

### Table 3. Land Cover Types and Air Surface Temperature in UM Campus

| Land Covers Types              | June 2013  | March 15   |
|-------------------------------|------------|------------|
| Min (°C) | Max (°C) | Average (°C) | Min (°C) | Max (°C) | Average (°C) |
| Paved Open Space              | 28.3       | 34.4       | 32.1     | 27.3     | 34.3       | 30.8       |
| Building Covered              | 27.8       | 34.5       | 31.3     | 27.0     | 34.8       | 30.9       |
| Open Vegetated                | 27.4       | 34.4       | 31.5     | 27.7     | 33.3       | 30.5       |
| Dense Vegetated Covered       | 27.8       | 34.1       | 31.2     | 27.4     | 34.1       | 30.7       |
| Water Bodies                  | 27.8       | 33.9       | 31.4     | 27.7     | 35.2       | 31.5       |

Sources: Data Processing form Survey

| Land Use Cover Type                                      | Neutral | Slightly Warm | Warm | Hot | Very Hot | Total (%) |
|----------------------------------------------------------|---------|---------------|------|-----|----------|-----------|
| 1. Faculties, Colleges, and Administrative Buildings    | 22      | 16.4          | 17   | 12.7| 24.6     | 42.6      | 5         | 3.7 | 100 |
| 2. Paved Open Spaces                                    | 9       | 6.7           | 29   | 21.6| 65       | 48.5      | 5         | 3.7 | 100 |
| 3. Water Bodies                                         | 26      | 19.4          | 23   | 17.2| 38.1     | 51        | 31        | 23.1| 3   | 2.2 | 100 |
| 4. Open Vegetated Surfaces (Grasslands, shrubs, and isolated tree strand) | 16 | 11.9          | 25   | 18.7| 40.3     | 31        | 40.3      | 31   | 23.1| 8   | 6.0  | 100 |
| 5. Dense Vegetated Surfaces                             | 30      | 22.4          | 36   | 26.9| 40       | 29.9      | 23        | 17.2| 5   | 3.7 | 100 |

Sources: data processing from the survey
Perception intensity study in UM Campus on the comfort level of land use cover, respondent, answering that Paved Open Space as an area with uncomforted perception, and dense vegetation as a comfort perception on comfort levels showed in Table 5.

Table 5. Perception of Land Use Cover and Comfort Level in UM Campus

| Land Use Cover Type                        | Perception of Comfort level |
|-------------------------------------------|----------------------------|
|                                           | Very Comfort | % | Comfort | % | Slightly Comfort | % | Un comfort | % | Very Un comfort | % | Total |
| 1. Faculties, Colleges, and Administrative Buildings | 33 | 24.6 | 33 | 24.6 | 36 | 26.9 | 29 | 21.6 | 3 | 2.3 | 100 |
| 2. Paved Open Spaces                      | 11 | 8.2  | 34 | 25.4 | 36 | 26.9 | 37 | 27.6 | 16 | 11.9 | 100 |
| 3. Water Bodies                           | 23 | 17.2 | 40 | 29.9 | 52 | 38.8 | 16 | 11.9 | 3 | 2.2 | 100 |
| 4. Open Vegetated Surfaces (Grasslands, shrubs, and isolated tree strand) | 21 | 15.7 | 47 | 35.1 | 46 | 34.3 | 16 | 11.9 | 4 | 3.0 | 100 |
| 5. Dense Vegetated Surfaces               | 31 | 23.1 | 45 | 33.6 | 42 | 31.3 | 14 | 10.4 | 2 | 1.5 | 100 |

Sources: Data from survey intensity perception study

The result of LCT based on perception showed in Table 6. That is, the table is answering that Paved open space at the highest temperature compares with another land use cover. They are based on response heat intensity as a threat when the time occurs 1-3 pm at UM Campus. Response heat Intensity as Threat when temp >32°C majority with hot/very hot and uncomforted sensation. The result was answering of perception relation between temperature humidity with comfort condition for human activity on UM Campus.

Table 6. Perception of Heat Intensity and Comfort in UM Campus

| Hot Level | Neutral | Slightly Warm | Warm | Hot | Very Hot |
|-----------|---------|--------------|------|-----|---------|
| 28 – 30°C | 31      | 28           | 44   | 26  | 5       |
| 30 – 32°C | 7       | 24           | 40   | 53  | 10      |
| 32 – 34°C | 2       | 11           | 32   | 47  | 42      |
| > 34°C    | 1       | 7            | 24   | 29  | 73      |

| Comfort Level | Very Comfort | Comfort | Slightly Comfort | Uncomforted | Very Uncomforted |
|---------------|--------------|---------|------------------|-------------|------------------|
| 28 – 30°C     | 31           | 45      | 36               | 17          | 5                |
| 30 – 32°C     | 12           | 42      | 30               | 37          | 13               |
| 32 – 34°C     | 4            | 28      | 40               | 30          | 32               |
| > 34°C        | 3            | 17      | 42               | 21          | 51               |

Sources: Data from survey intensity perception study

To address the urban hazard in education area based on UHS and AST, this research result since 2014 the UHS upper than 32°C and AST started from 11 am–04 pm include strong heat stress categories of UTCI. The problem happened at the UM campus. This problem was reinforced by the results of the UM student intensity perception study. The perception from UM students answering that the temperature more 32°C included in the category very hot and very uncomforted. The highest temperature is very uncomforted (>32°C), when very uncomfortable level input into psychologies and health, this level categories impact on Increasing Stress Caused by Sweating and Blood Flow and Health level had Cardiovascular Embarrassment level and Heat Attack [21]. Related to the previous studies on the UI campus, that is condition impact on UM Campus will become the urban heat hazard for living in the education area.

4. Conclusion
The result concluded that the maximum temperature from land cover type (>32°C) was categorized as a strong heat stress UHS and AST using UTCI. The perceptions from UM student categories very hot and very uncomfortable. This condition would impact on human health with increasing stress caused...
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