Effect of urbanization activities towards the formation of urban heat island in Cameron Highlands, Malaysia

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Abstract. This study carried out to study the effect of urbanization activities towards the formation of Urban Heat Islands (UHI) in Cameron Highlands (CH). The aim of this study is to identify the formation of UHI in CH following the urbanization activities. This study also involved two main data that are primary through field survey and secondary data from collection data. In addition, this study was used qualitative and quantitative method. The data was taken two times a day, at a day and night between the hours of 12:00 to 14:00 and 19:00 to 21:00. Data in this study analyzed by using correlation analysis and analysis of Geographic Information Systems (GIS) which known as interpolation. Result found the formation of UHI in CH was concentrated at city centre namely in Pekan Tanah Rata. From the whole average value, city centre was recorded the highest reading of temperatures which is 30.5°C, while reading of temperature for subtown and suburban was recorded 28.6°C and 23.8°C. Average of humidity in CH during the day was recorded as highest reading in the suburban area namely Tringkap Bee Farm (station 11) which is 58.4%. Then, average of humidity in CH at night was recorded highest reading in the suburban area namely Habu Mini Market 91 (station 9) which the value is 83.2%. The reading of wind speed in CH during the day recorded the highest reading day at the suburban namely Tringkap Bee Farm (station 11) which the value is 2.3 m/s. While, following the reading of wind speed in CH at night, suburban namely Habu Mini Market 91(station 9) was recorded the highest reading which is 0.8 m/s. The Intensity of Urban Heat Island in CH during the day was recorded 2.8°C, while at night intensity of UHI was recorded 1.4°C. Overall, the urbanization activities in CH had caused the formation of UHI. Therefore, measures of legislation such as protect forest from development by control the urbanization activities need to be implemented so that the formation of UHI can be reduced and overcome.

1. Introduction

Urban Heat Island (UHI) is one of the most frequent phenomena in the city, especially in urban areas where the region experiences the fastest and most urbanization process. The formation of UHI phenomena also occurs as a result of the rapid urbanization process associated with anthropogenic factors as stated in the study of Wong [18]. Various urban microclimate parameters varied as noted by Botkin and Keller study [2] [12] according to space and time as a result of the rapid urbanization process. Changes in urban microclimate parameters due to the urbanization process are closely related to urban morphology and urban physical properties.

The morphology of the city can be linked to the surface of the city where the city on the earth surface is stretched and concretized, the ability to absorb heat energy is high enough to be filled with rock 'jungle' which able to radiate heat to the environment [2]. The formation of UHI exists in every city in the world which is considered a manifestation of urbanization and urban growth [4] [8]. The formation of UHI is also a result of human activity in urban areas. Hence, urban growth will encourage human activities in urban areas.

Urbanization activities will not only have a negative impact on the environment but will affect the health of the city's ecosystem [3] [10] [16]. Rapid urbanization will further promote the use of more modern and sophisticated technologies. The use of modern and sophisticated technologies not
only speeds up urban development but also affects the quality of the environment as the technology produces various types of pollutants that will be released into the city's atmosphere.

Therefore, steps to reduce the formation of UHI should be identified so this phenomenon will not have a negative impact on future generations. Thus, the impact assessment of urban activity on the establishment of UHI was carried out in the study area which is Cameron Highlands. This study involves the collection of daily temperature within five days from 27 January 2017 to 31 January 2017 covering the selected area of study. The data were analyzed to detect the temperature distribution in the study area and its relation to the formation of UHI.

2. Study Area
In this study, several study areas were selected by stations (table 1). The selection of the stations in Cameron Highlands is based on urban activities that include urban, suburban and rural area. The study involved 13 observation stations covering 5 urban areas, 3 suburban areas and 5 rural areas (figure 1). Station 1 is located at Cactus Point, an area that carries out cactus flower business activities. According to the Cameron Highlands District Council [5], although this station is less focused by tourists as well as locals, the location of this station is close to the city center resulting in higher temperatures recorded at this station than the station in the rural area. Next, station 2 is located at Hotel Kea Valley. This station is a tourist attraction and traders and station 3 is Water Cress Valley an area that runs agricultural activities.

| Station | Observation Area | Latitude (N) | Longitude (E) | Area |
|---------|------------------|--------------|---------------|------|
| 1.      | Cactus Point     | 4°30’5.1264  | 101°24’12.4164| Suburban |
| 2.      | Hotel Kea Valley | 4°30’14.5548 | 101°24’25.74  | Suburban |
| 3.      | Water Cress Valley | 4°30’28.6308 | 101°24’59.4036| Suburban |
| 4.      | Pasar Malam      | 4°29’34.8864 | 101°23’21.3288| Urban |
| 5.      | Kok Lim Strawberry Farm (Brinchang) | 4°29’49.92 | 101°23’42.7236| Urban |
| 6.      | Bharat Group Tea (Tanah Rata) | 4°27’14.4504 | 101°22’8.346 | Urban |
| 7.      | Terminal Freesia, Pekan Tanah Rata (Tanah Rata) | 4°28’14.2834 | 101°22’42.0528 | Urban |
| 8.      | Hotel Casa Adela Rosa (Tanah Rata) | 4°29’7.0224 | 101°22’40.1376 | Urban |
| 9.      | Habu Mini Market 91 (Habu) | 4°26’0.6216 | 101°23’20.2596 | Rural |
| 10.     | Habu Bee Farm (Habu) | 4°44’6.666 | 101°38.9509 | Rural |
| 11.     | Tringkap Bee Farm (Tringkap) | 4°30’39.8052 | 101°25’40.9728 | Rural |
| 12.     | Cameron Lavender (Tringkap) | 4°31’36.7284 | 101°25’38.154 | Rural |
| 13.     | Kedai Emas Fong Sheng (Tringkap) | 4°30’56.0196 | 101°25’41.1924 | Rural |
3. Research Methodology

To carry out this study, the observation process has been conducted to create findings in this study. Subsequently, to ensure that the observation process can be performed well some of the equipment has been used. The selection of equipment to be used for this observation should also be well designed so that the selected equipment is appropriate to the aspect of the study which will be measured [1] [14]. There are two main tools that have been used in the study of UHI formation in CH which is 'Weather Skymaster' and Global Positioning Systems (GPS). The Weather Skymaster is used to record temperature readings, relative humidity and wind velocity. This tool has a reading accuracy of +/- 3 percent for wind speed, +/- 2 ° F for temperature and +/- 3 percent for relative humidity.

To complete the survey, data has been recorded for five days from 27 January 2017 to 31 January 2017. The data has been taken twice daily at 12: 00-14: 00 and 19: 00-21: 00. Weather data readings for each station are taken three times and been totaled to represent the station readings. During the observation, environmental aspects such as human activities, urban activities, number of vehicles and others are also recorded. The data in this study analyzed using correlation analysis to make the relationship between temperature and relative humidity. Then, the average temperature distribution at CH was also analyzed using the Geographical Information Systems (GIS) software which is interpolation in the form of map illustrations via Contouring Inverse Distance Weighted (IDW) method.

The production of the map will involve some of the key processes to produce output that can explain the phenomena of the formation of UHI in CH. Then, this study has also used an average temperature analysis by urban-rural temperature profile to identify the value of IUHI in CH [6] [7] [9] [17]. This temperature-stripping method involves field studies that have involved 13 observation stations which cover urban areas down to rural areas to measure temperature
parameters, relative humidity and wind velocity. Hence, IUHI will be evaluated and analyzed by the following equation is derived from equation (1).

\[ \Delta T_{u-r} \]  

Given that, \( \Delta T \) : Average Temperature Change  
\( U \) : Average Temperature in Urban Area  
\( r \) : Average Temperature in Rural Area

4. Research Findings
In this study, the formation of UHI in CH was identified by the average temperature distribution in the area (According Table 2). Previously discussed, Station 4, 5, 6, 7, and 8 are the urban area, stations 1, 2, and 3 are suburban areas while stations 9, 10, 11, 12, and station 13 are rural areas.

In the study on the formation of UHI in CH, the formation of UHI in urban area of CH was identified by the average temperature distribution in the area. As shown in previous chapters, Station 1, 2 and 3 are suburban areas, stations 4, 5, 6, 7, and 8 are central downtown which categorized as urban areas, while for stations 9, 10, 11, 12, and 13 is rural area. Through the analysis, the results showed that the formation of UHI was valid in CH. The formation of UHI at CH during the day was formed in the downtown area compared to suburban and rural areas (see figure 2a).

Table 2. Average temperature, relative humidity and wind velocity in 13 observation area in Cameron Highlands.

| Station | Location               | Average Temperature (°C) | Average Relative Humidity (%) | Average Wind Velocity (m/s) |
|---------|------------------------|---------------------------|-------------------------------|-----------------------------|
|         |                        | Day | Night | Day | Night | Day | Night |
| 1       | Cactus Point           | 24.5| 19.8  | 51.7| 75.0  | 0.7 | 0.2   |
| 2       | Hotel Kea Valley       | 26.9| 20.5  | 47.3| 65.8  | 1.1 | 0.3   |
| 3       | Water Cress Valley    | 25.2| 18.8  | 52.3| 68.0  | 0.9 | 0.4   |
| 4       | Pasar Malam Brinchang | 28.7| 22.3  | 53.3| 64.4  | 1.3 | 0.2   |
| 5       | Kok Lim Strawbwrry Farm | 27.2| 19.8  | 57.8| 70.2  | 1.9 | 0.5   |
| 6       | Bharat Group Tea      | 28.9| 19.5  | 56.0| 65.8  | 0.6 | 0.3   |
| 7       | Pekan Tanah Rata      | 30.0| 22.9  | 48.6| 63.0  | 0.8 | 0.1   |
| 8       | Hotel Casa Adela Rosa | 28.6| 18.7  | 57.3| 67.8  | 0.6 | 0.4   |
| 9       | Habu Mini Market 91   | 24.3| 16.6  | 56.4| 83.2  | 1.7 | 0.8   |
| 10      | Habu Bee Farm         | 25.7| 17.2  | 55.0| 75.9  | 2.3 | 0.7   |
| 11      | Tringkap Bee Farm     | 25.0| 17.6  | 58.4| 78.8  | 1.3 | 0.5   |
| 12      | Cameron Lavender      | 24.8| 18.3  | 55.4| 82.3  | 1.2 | 0.4   |
| 13      | Kedai Emas Fong Sheng | 27.2| 21.5  | 52.7| 65.3  | 0.5 | 0.2   |
Figure 2. Average temperature distribution in Cameron Highlands using IDW contouring techniques (a) Day time, (b) Night time.

However, the station that shows the highest average temperature distribution in the downtown area is station 7. Station 7 is Tanah Rata Town, Freesia Terminal. This station is the highest area of potential for temperature increase and formation of UHI. The situation clearly demonstrates that UHI phenomena are concentrated in the downtown area at night [13] [15]. Station 7 is also an area that carries out various urban activities and transportation activities. This station is also tourist attraction area until evening. Hence, tourist density and vehicle congestion in the area led to the formation of UHI at night. Next, the average temperature distribution at CH at night shows that the highest reading area in the city center is shown with a ton of dark colors which presented in the temperature distribution map (see figure 2b).

The average temperature distribution analysis in CH shows that the influence of urbanization due to human activity during day and night plays a huge role in establishing a high average temperature distribution especially in downtown areas [6] [27]. Such a situation can be demonstrated through the analysis of the temperature distribution that has been produced and field observations on the dominant
 urban activity in the downtown area. The downtown area has the highest average temperature compared to suburban and rural areas.

4.1 Cross profile of temperature in Cameron Highlands
The cross profile of the temperature has been developed to determine the formation of UHI in CH. Hence, this temperature cross profile is constructed to make the comparison of the temperature difference between urban, suburban and rural areas (see figure 3). Among the three focused areas, the temperature difference has been detected between the downtown area and its surroundings. This situation was supported by a study conducted by Tan where the temperature difference is about 1-2 °C between the industrial area and the village area [13]. Hence, the difference in temperature between the surrounding areas proves the existence of UHI formation during the day and night in CH.

The anthropogenic factors primarily from urban activity have led to the formation of UHI in CH [11]. This is due to the rapid urbanization process especially in human activities such as trading, business, transportation and activity which involves the production of large quantities of heat that have caused a high temperature distribution over the surrounding area. For the suburban areas, it is usually free from the influence of human activity and this condition is also characterized by a green area that indicates the 'normal' temperature.

![Figure 3. Cross profile of temperature between urban, suburban and rural areas in Cameron Highlands.](image)

Table 3. Station between urban, suburban and rural areas in Cameron Highlands.

| S* | Rural         | S* | Suburban     | S* | Urban                |
|----|---------------|----|--------------|----|----------------------|
| 9  | Habu Mini Market 91 | 1  | Cactus Point | 4  | Pasar Malam Brinchang |
| 10 | Habu Bee Farm   | 2  | Hotel Kea Valley | 5  | Kok Lim Strawberry Farm |
| 11 | Tringkap Bee Farm | 3  | Water Cress Valley | 6  | Bharat Group Tea |
| 12 | Cameron Lavender | 7  |               |    | Pekan Tanah Rata |
| 13 | Kedai Emas Fong Sheng | 8  | Hotel Casa Adela Rosa |    |                      |

*S* = Station
5. Conclusion

In conclusion, the analysis of the findings shows a significant temperature increase in CH and caused the formation of UHI in CH. This increase in temperature is the result of rapid urbanization activity in CH especially in human activities. The rapidly-evolving urbanization process in CH has led to the production of heat resulting in the formation of UHI. IUHI value for urban and rural area during daytime is 2.8 °C while at night is 1.4 °C. IUHI during the day has shown that high temperature increases will affect the comfort of residents and tourists in CH.

For rural areas in CH such as the Habu Bee Farm is relatively less urbanized as it does in the city center of CH. The area is also less saturated with buildings that are capable of blocking the wind. The rural area also has more green areas compared to the downtown area. The area also more spacious and airy and less crowded with residents or tourists. Hence, temperatures in the rural areas are low and do not experience dry climate like in downtown. However, CH's urbanization activities should be controlled and mitigated in order to reduce the impact of climate change on the comfort of residents and tourists in CH.

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