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Evaluating the Urban Heat Effects of High Rise Non-Green Buildings: A Case Study in Kota Bharu, Kelantan, Malaysia

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Abstract

This study provides an overview of the urban heat effect of the high rise non-green building in the urban area located in Kota Bharu, Kelantan by collecting and analyzing related data using sky view factor (SVF).The SVF is one of the essential aspects related to pollution, temperature variations, heat island and several other environmental specifications. A common method through fish-eye photographs were taken at ground level with a digital camera together with a detachable 180' fish-eye lens. The result highlighted the SVF value at six high rise non-green buildings was in a range between 0.24 and 0.67. The highest temperature recorded was 42°C on rooftop of Kelantan Trade Center building whilst the lowest was 30°C on rooftop of Ibu Pejabat Polis Kontinjen Kelantan. The surrounding and building materials were found to have a persistent influence on the formation of urban heat.

1. Introduction

Urban heat island effect is a well-established phenomenon with a clear negative health impacts (Arnfield, 2003). High levels of urban heating have been linked to poor urban air quality (Sarrat et al., 2006) as well as altered precipitation (Shepherd, 2006). Furthermore, as the areal extent of cities expands (Lang & Knox, 2009), the impact of urban landscapes and the subsequent of urban heat island effect may no longer be confined to just the urban core but spread to more suburban regions (Stone et al., 2010).

Many studies have been conducted to improve the knowledge upon environmental issues and continue to be an important part of green initiative demand in developed countries. However, such approach was a setback to developing and undeveloped countries. Urban heat island phenomenon may have happen for a while now, but in Malaysia, the number of research done upon it is very minimal. The studies were mainly executed in largest urban cities in Malaysia namely Kuala Lumpur, Penang, Johor Bahru, Ipoh, Melaka (Sham, 1981; Lim, 1980; Zainab, 1980) where the concentration of development and population (>10 000 people) were high. Most of the development, was highly concentrated in the western belt of the Peninsular. Nevertheless, new growth urban cities continued to emerge in the northern and eastern part of Peninsular namely Alor Setar, Kota Bharu and Kuala Terengganu.

A study on urban heat island effect in Kelantan, particularly in Kota Bharu, has never been done before. In the mid-nineteenth century, Kota Bharu, the capital state of Kelantan was merely a small trading post (MPKB, 2016). Today, Kota Bharu, a land area of 115.64 km² with a population exceeding 300,000 people (MPKB, 2016), is one of largest urban cities in the country. In the urban city,the effects of the complex geometry of the urban surface, the shape and orientation of high rise buildings and structures, the peculiar thermal and hydrological properties of the urban morphology have led to a profound transformation of the environment.

The main focal point of this study was to evaluate the effect of high rise non green building in the urban area of Kota Bharu, Kelantan by using sky view factor (SVF). According to Knoke (2006), a high-rise building structure is considered to be one that extends between 75 feet (23 meters) and 100 feet (30 meters) or about seven to ten stories (depending on the slab-to-slab distance between floors). Meanwhile,a non green building can be referred as a non-environmentally sustainable building, designed, constructed and operated with several environmental impacts.

2. Materials and Methods

2.1. Study Sites

The study was executed in Kota Bharu, the city center of Kelantan. Over the past decades, Kota Bharu had undergone a rapid development particularly the constructions of the high rise buildings. The area of this

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study consisted of a radius of six high rise non-green buildings namely KPJ Perdana Specialist Hospital (7 stories/height=25.6m), Hospital Raja Perempuan Zainab II (8 stories/height=26m), Perdana Hotel (10 stories/height=35.8m), Ibu Pejabat Polis Kontinjen Kelantan (11stories/37.2m), Wisma Persekutuan Kelantan (13 stories/height=40.2m) and Kelantan Trade Centre (19 stories/height=52.1m). Six points were established of each selected buildings.

2.2. Data Collection

Sky view factor (SVF) is one of the essential aspects related to pollution, temperature variations, heat island and several other environmental specifications. The SVF is represented by a value that is dimensionless set between 0 and 1 and approaches merge in perfectly flat topography, whereas region with interferences such as buildings and trees will cause the SVF to decrease proportionally (Oke, 1993).One of common technique for measuring SVF in urban environments is through photographical method (Unger, 2004).

Fish-eye photographs were taken at ground level with a digital camera together with a detachable 180' fish-eye lens. The camera was attached to a tripod and the picture was taken from its height above the surface at each of the selected points. As reference points, edges of the surrounding buildings were used. Since no elevation standard for capturing SVF imagery had been established (Svensson, 2004), the pictures were taken vertically at the same tripod height in an attempt to ensure consistency. The photographs were collected between 11 a.m. till 2 p.m. under clear blue skies.

All the taken photographs using the fish-eye lens were analyzed and scanned to create digital images. The scanned images were then converted from color to black and white. The black color represented ground, buildings and vegetation whilst white represented the sky. This conversion was done by altering the brightness and contrast of each image. It relied on the sky conditions and the existence of cloud, direct sun, obstructions and the amount of vegetation and buildings in the image.

Images taken under constant sky conditions which was clear with no direct sun were usually the simplest method to analyze consistently and accurately using fish eye lens. When scattered clouds appear in an image, particularly near the horizon, the clouds often appeared as dark as buildings or vegetation in the image, which makes it difficult to set appropriate brightness values to discriminate terrain and sky. When the sun appeared in an image it causes particular problems for the analysis of vegetation, as it tends to wash out branches and tree trunks in the image.

In these fish-eyed photos, the hemispheric environment was projected onto a circular plane. After photo procession and skyline identification, SVF was estimated by calculating the share of the visible sky in RayMan 1.2 application. RayMan model, simulates the short- and long-wave radiation flux densities from the three-dimensional surroundings in simple and complex environments. The aim of the RayMan model is to calculate radiation flux densities, sunshine duration, shadow spaces and thermo-physiologically relevant assessment indices using only a limited number of meteorological and other input data

The temperature on the rooftop of each buildings were also recorded using a termometer throughout the 7 consecutive days of study.

3. Results and Discussion

3.1. Daily Temperature

The daily temperature was recorded on each rooftop of these buildings from the time of 11 a.m. to 2 p.m. The data was recorded persistently for seven consecutive days. Figure 1 indicates the recorded temperature.

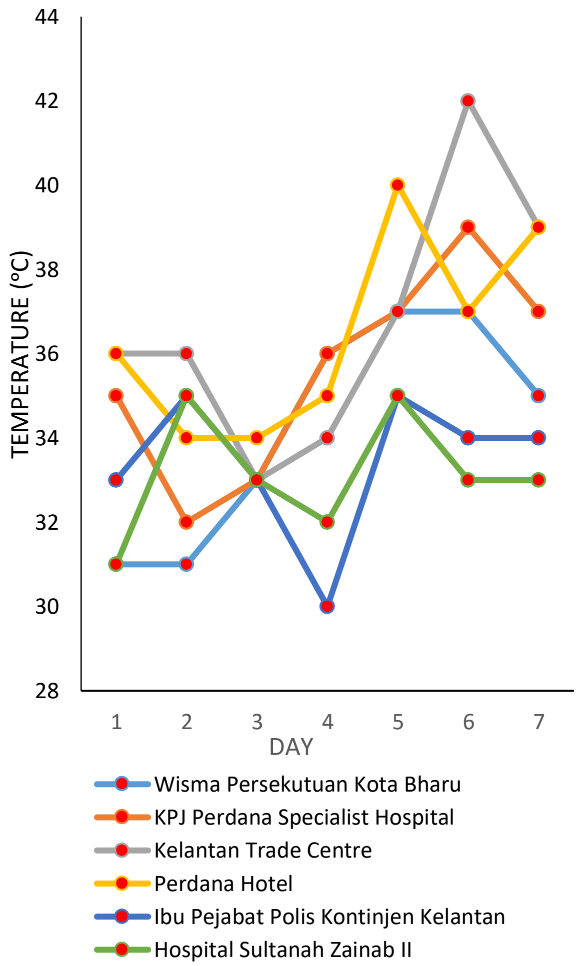

Figure 1: Daily temperature recorded for each building

All the selected six buildings were not recognized as green building because the materials used were not equipped to adapt buildings to the Malaysia climate, culture and environment. The buildings were built in between year 1979 and 2013. The thermal

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properties of materials can increase storage of sensible heat in the fabric of the city that triggered the formation of urban heat island effect (Oke et al., 1991). Tall and packed buildings contribute to the complex exchange between buildings and the screening of the skyline which causes urban heat (Oke et al., 1991). This was proven when the highest temperature recorded was 42°C at Kelantan Trade Center with the height of 52.1m tall located in between KPJ Perdana Specialist Hospital and Hotel Perdana.

3.2. Sky View Factors

The findings of SVF for each station established at six high rise non green buildings in Kota Bharu city centre is shown in Table 1. Meanwhile, from the photographic analysis, the white represent sky visibility. Thus, the higher the white area, the higher the SVF percentage (Figure 2).

The highest SVF value was on point 2 of Kelantan Trade Center with 0.729 and the lowest with 0.072 on point 5 at Hospital Sultanah Zainab II. The Wisma Persekutuan Kota Bharu was found to have an average SVF value of 0.616. The lowest SVF value was 0.524 at point 4 while the highest was 0.694 at point 1. The surrounding area of Wisma Persekutuan Kota Bharu had a less number of trees. There was a massive open parking lot with less vegetation.

The second building, KPJ Specialist Hospital has the average SVF value of 0.476 was considered low as compared to the other buildings. The sky visible were interfered with trees, the neighboring buildings and the building itself. The lowest SVF value was 0.242 at point 1 while the highest was 0.620 at point 2. Kelantan Trade Center had the average SVF value of 0.533. Its highest SVF was 0.729 at point 2 while the lowest was at 0.305 at point 1. This building was the highest among the other buildings and located closely next to KPJ Perdana Specialist Hospital. There was hardly any vegetation in the nearby.

Perdana Hotel is a facility providing accommodations, meals, and other services for travelers and tourists. Thus, the surrounding was beautify with big trees and a lot of decorative vegetation. The highest SVF value was 0.611 at point 3 and the lowest was 0.335 at point 4. There was an open parking lots adjacent to the hotel which allow sky to be detectable.Ibu Pejabat Polis Kontinjen Kelantan had the average Sky View Factor value with 0.378. The lowest SVF value was 0.316 at point 6 and the highest value was 0.533 at point 5. This building area was surrounded with several huge trees in its compound and at the same time there was also a large open space for assembly purpose.

Hospital Sultanah Zainab II had the lowest average SVF value of 0.244. The highest SVF value was 0.483 at point 3 and the lowest SVF value was 0.072 at point 5. Hospital Sultanah Zainab II has a lot of vegetation surrounding it. There were also a lot of less higher buildings surrounding the designated building.

The analysis showed that existing average SVF value is between 0.24 and 0.62 (Table 1). The highest SVF value was on point 2 of Kelantan Trade Center (height=52.1 m) with 0.729 and the lowest with 0.072 on point 5 at Hospital Sultanah Zainab II (height=26 m). Lack of interferences such as buildings and trees in the nearby had contributed higher SVF value to Kelantan Trade Center as compared to Hospital Sultanah Zainab II where its area was moderately surrounded with dense vegetation and a few of lower buildings. Apart from that, Kelantan Trade Center was recorded with the highest temperature of 42°C whilst Ibu Pejabat Polis Kontijen Kelantan with the height of 37.2 m was recorded with the lowest temperature of 30°C.

The SVF measures the openness of the sky to radiate transport in relation to a specific location, where a value of 0 which is equivalent to complete obstruction means that all outgoing radiation will be intercepted by obstacles and a value of 1 which is equivalent to no obstruction means that all radiation will propagated freely to the sky (Brown et al., 2001). High SVF value indicates the ratio of the radiation received by a planar surface from the sky to the radiation emitted from the entire hemispheric radiating environment were also high. (Watson & Johnson, 1987). Thus, contributing to urban heat island effect. The findings in this study clearly indicate that increasing in building height may increase in the fluctuations of SFV values.

Table 1: Sky View Factor calculated at 6 selected buildings with 6 different points

Building/Point	Sky View Factor						Mean
	1	2	3	4	5	6	
Wisma Persekutuan Kota Bharu	0.694	0.556	0.676	0.524	0.563	0.680	0.616
KPJ Specialist Hospital	0.242	0.620	0.455	0.570	0.482	0.489	0.476
Kelantan Trade Center	0.305	0.729	0.494	0.516	0.723	0.000	0.553
Perdana Hotel	0.345	0.349	0.611	0.335	0.425	0.575	0.44
Ibu Pejabat Polis Kontinjen Kelantan	0.324	0.382	0.501	0.530	0.533	0.316	0.378
Hospital Sultanah Zainab II	0.172	0.318	0.483	0.167	0.072	0.249	0.244

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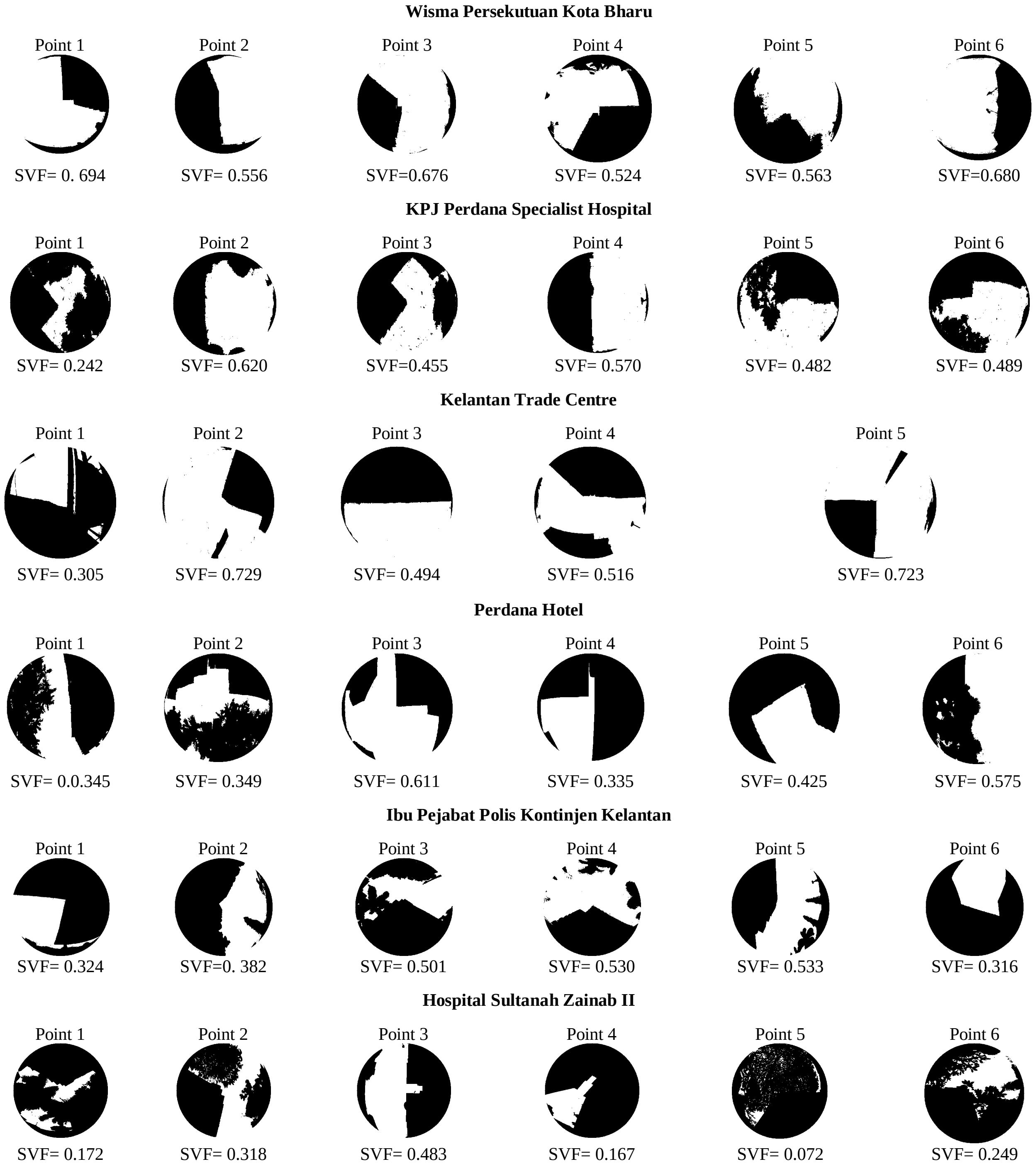

Figure 3: The value of Sky View Factor for each high rise non green buildings through photographical analysis

4. Conclusion

In this study, there is a relatively strong relationship between the height of a building and SVF value. Changes in SVF value will highly affected the changes of certain attributes such as temperature or wind velocity. The analysis in this study showed that existing average SVF value is between 0.24 and 0.62. Lack of interferences such as buildings and trees in the nearby had contributed higher SVF value as compared to the area that was moderately surrounded with dense vegetation and a few of lower buildings Hence, the urban heat island mitigation are fervently vital in urban planning and decision making process.

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