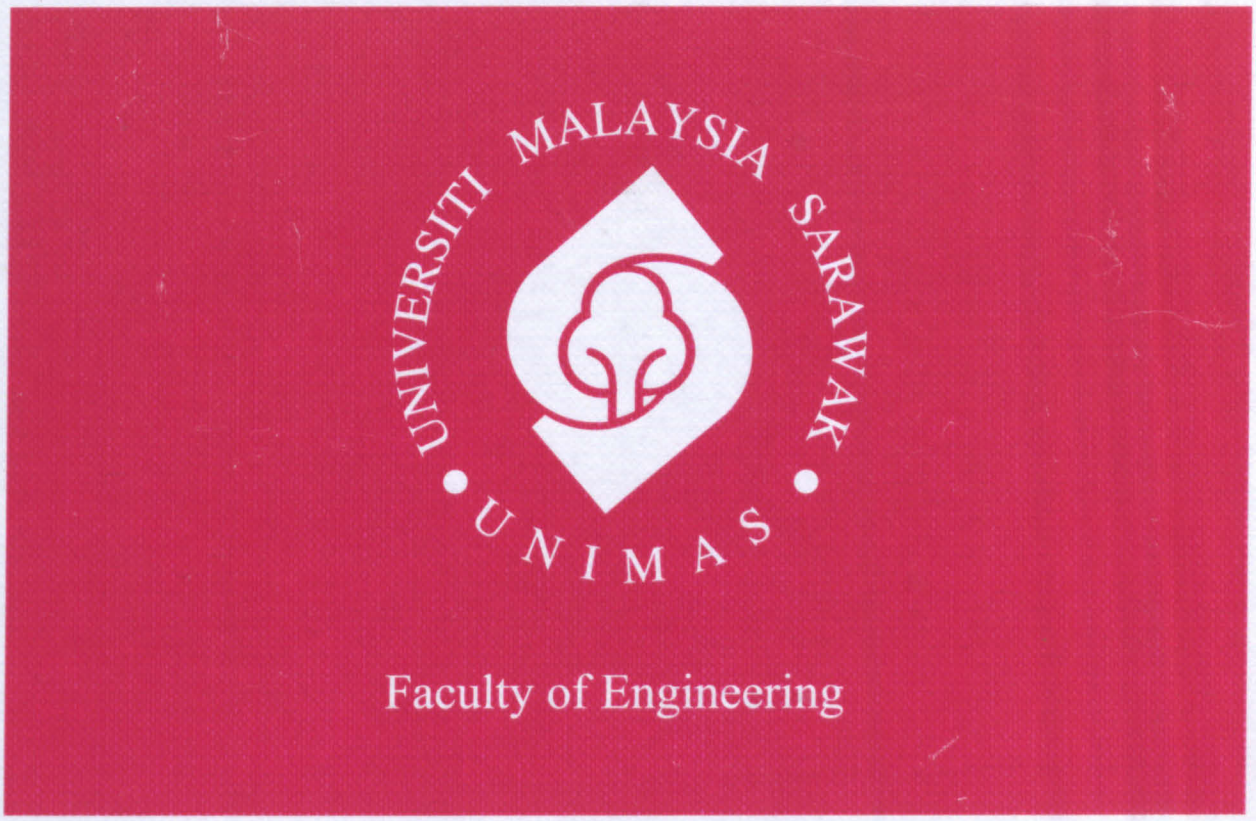

THERMAL COMFORT ASSESSMENT FOR UNIVERSITI MALAYSIA SARAWAK (UNIMAS) COMMUNITY BASED ON DIFFERENT BUILDING LAYOUTS

Fazlin Binti Abdul Azidi

Bachelor of Engineering with Honours
(Civil Engineering)
2019

Pusat Khidmat Maklumat Akademik
UNIVERSITI MALAYSIA SARAWAK

THERMAL COMFORT ASSESSMENT FOR UNIVERSITI MALAYSIA SARAWAK (UNIMAS) COMMUNITY BASED ON DIFFERENT BUILDING LAYOUTS

FAZLIN BINTI ABDUL AZIDI

A final year project report submitted in partial fulfilment of
the requirement for the degree of
Bachelor of Engineering (Hons) Civil Engineering

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2019

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ABSTRACT

The rapid urbanisation especially in Sarawak has transformed current environment from natural vegetation to engineer structured. This built up environment give significant impact on the outdoor thermal environment due to the rises temperature in urban areas. Building arrangement and its building layout patterns is also a parameter in influencing the radiation of air flow in and outside of the buildings. This building characteristics that lead to UHI not only found in city areas but also can be found in university campus area such as UNIMAS where there is also existence of various type of building layout patterns, high rise building and compacted building area. Furthermore, the study of thermal comfort in university area have not fully explored. Therefore, this study aims for outdoor thermal comfort assessment that conducted in Universiti Malaysia Sarawak (UNIMAS) where the different building layout patterns have been found which might contributes to higher heat impacts. This thermal comfort assessment was conducted by using subjective measurement through questionnaire survey and the data obtained was analysed using SPSS software. The results indicated that the Sakura College building have contribute to higher heat impact where 42% of the respondents feel hot. While, for Cempaka College and Reservoir Park, the result showed that only 30% and 17% of the respondents feel hot respectively. The thermal environment at Sakura College was founded to be the most critical place due to the building arrangement which is directly exposed to the sunlight and causes 61% of the respondents to feel uncomfortable while doing their activities. The shading effect due to the building arrangement of Cempaka College helps to protect the respondents from exposed to direct sunlight and makes 55% of them feel comfortable. Meanwhile, the presence of vegetation area such as tall trees and water body helps in regulating the air movement in Reservoir park where 87% of the respondents feel comfortable during carry out their activities. Based on the overall results, it can be seen that the respondents at three different locations are able to accept and adapt with the current thermal environment. However, most of them are preferring the locations especially Sakura and Cempaka College to be cooler in the future. Lastly, throughout this study, it hope to be useful and able to propose proper building arrangement by considering the effect of different building layout patterns on thermal environment especially for university community.

ABSTRAK

Pembangunan pesat terutamanya di Sarawak mengubah keadaan sekeliling daripada vegetasi asli (sumber asli) kepada struktur bangunan. Pembinaan struktur yang pesat ini telah memberi impak kepada termal persekitaran luaran akibat daripada peningkatan suhu di kawasan bandar. Reka bentuk dan pola susun atur bangunan merupakan salah satu parameter yang mempengaruhi radiasi pergerakan udara dalam dan luar bangunan. Ciri bangunan yang membawa kepada fenomena UHI bukan sahaja terdapat di kawasan bandar bahkan juga di kawasan kampus universiti seperti UNIMAS dimana terdapat kewujudan beberapa jenis pola susun atur bangunan, bangunan tinggi dan kawasan padat dengan pembinaan. Tambahan pula, kajian terhadap keselesaan termal di kawasan universiti belum dikaji secara menyeluruh. Oleh itu, kajian keselesaan haba luaran telah dijalankan di Universiti Malaysia Sarawak (UNIMAS) di mana pola susun atur bangunan yang berbeza telah dikenalpasti di kawasan kampus yang boleh menyumbang ke arah kesan haba yang tinggi. Kajian keselesaan haba ini dilakukan dengan menggunakan kaedah penilaian secara subjektif iaitu melalui pengagihan borang kaji selidik dan data dianalisis mengunakan perisian SPSS. Hasil kajian mendapati bahawa bangunan Kolej Sakura menyumbang kepada kesan haba yang tinggi dimana 42% responden berasa panas. Sementara di Kolej Cempaka dan Taman Rekreasi, hasil kajian menunjukkan hanya 30% dan 17% responden masing-masing merasa panas. Termal persekitaran di Kolej Sakura dikenalpasti sebagai tempat yang kritikal kerana susun atur bangunan yang terdedah kepada cahaya matahari dan telah menyebabkan 61% responden berasa tidak selesa ketika menjalankan aktiviti. Kesan teduhan hasil daripada susun atur bangunan Kolej Cempaka yang melindungi responden daripada terdedah kepada cahaya matahari telah membuat 55% responden berasa selesa manakala kewujudan kawasan vegetasi seperti pokok yang tinggi dan tasik membantu mengawal pergerakan udara di Taman Rekreasi dimana 87% responden berasa selesa semasa menjalankan aktiviti. Berdasarkan hasil kajian secara menyeluruh, semua responden di tiga kawasan kajian boleh menerima dan menyesuaikan diri dengan thermal persekitaran semasa. Namun demikian, kebanyakkan responden mencadangkan agar kawasan Kolej Sakura dan Cempaka lebih sejuk pada masa hadapan. Akhir sekali, melalui kajian ini,ia diharapkan bermanfaat dan mampu menghasilkan susun atur bangunan yang terbaik dengan mengambil kira kesan perbezaan pola susun atur bangunan terhadap termal persekitaran terutamanya untuk kepada warga universiti.

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LIST OF ABBREVIATIONS

UHI	Urban Heat Island
SPSS	Statistical Package for Social Sciences
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
H/W	Height to Width
SVF	Sky View Factor

CHAPTER 1

INTRODUCTION

1.1 Background of study

Thermal comfort is a term that is generally regarded as a desirable or positive state of a person. It is used in describing how warm or cold a person feels and is clearly related to the environment of a person occupies (Matthew, 2010). The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) defined it as condition of mind which expresses satisfaction with the thermal environment (ASHRAE, 2004). Based on above definitions, comfort is actually a state of mind but not a state of condition which mostly define by the people. The meaning of thermal comfort leaves open as to what is meant by condition of mind and satisfaction, but it effectively underlines that the judgement of comfort is a cognitive process involving numerous inputs affected by physical, physiological, psychological and other factors (Noppanuch Puangmalee et al., 2015). In addition, comfort also will be influenced by personal different perception which is involving mood, culture and social factors.

Architects and engineers need to understand very well about thermal comfort in order to ensure comfort and health of occupant in and outside of the building. The arrangement of buildings has been thought to be the fundamental countermeasures to enhanced outdoor microclimate by changing the design of the buildings such as building shape, height, planning patterns and furthermore also consider the presence of vegetation areas (B. Hong et al., 2015). Appropriate building layout patterns plays important role in easing the outdoor thermal environment (Chen et al., 2008) by considering the building geometries such as height to width (H/W) ratio, albedo effect and sky view factor (SVF) of the buildings.

H/W ratio is relating to the average height of buildings with the width of urban canyon and it determines the effect of street design on the urban microclimate by discussing the solar access and orientation on airflow in an urban canyon. The air temperature in the shallow canyons usually warmer than those in the deep. This is due to high exposure of the shallow canyons to the solar radiation. One of the suitable terms to apply when studying solar radiation and reflection is albedo. Albedo can be defined as the ratio of the reflected solar radiation to the incident solar radiation at the surface. Radiation that was absorbed by the earth's surface will be transformed into heat energy. This heat energy plays an important role in regulating the temperature of the environment since it will effect thermal comfort at that area. Besides that, sky view factor (SVF) of buildings also have significant impact on heat accumulation between built up areas and their surrounding environment. SVF is the ratio of the received radiation by a planar surface to the emitted radiation by the entire hemispheric environment. A development with higher SVF will decreasing outdoor thermal comfort through influencing ambient temperature and mean radiant temperature (Lee et al., 2017).

There are six basic parameters of outdoor thermal comfort. These are air temperature, radiant temperature, humidity, air velocity which are under environmental factors while clothing insulation and metabolic heat are under personal factors. An important point is that any and all of the six factors can influence thermal comfort and that it is the integrated influence of all of the six factors that determines thermal comfort respond (Matthew, 2010). There are many methods used to assess outdoor thermal comfort and subjective thermal perception. However, according to the thermal comfort parameter, outdoor thermal comfort is mainly assessed using micro-metrological measurement and guide using questionnaire (Abdul Halid et al., 2017). In this study, thermal comfort assessment will be conducted by using subjective measurement method. Subjective measurement is referred to questionnaire survey. It consists of the questions addressing the subjects thermal comfort condition and also records of subject's demographic background such as gender and age during the survey. Individuals and behavioural characteristics could also take into account during the survey or interview (Matthew, 2010).

In light of this, this study is conducted mainly to assess human discomfort level in Universiti Malaysia Sarawak (UNIMAS) at Kota Samarahan City where some of the building elements such as high rise building, area with compacted building and different building layout patterns and environment conditions have been detected in the campus area. This is done by evaluating the thermal comfort assessment at various locations in UNIMAS to

investigate the perception on thermal sensation of the occupants in the university campus through ASHRAE thermal sensation scale and also based on different building layout. The findings are expected to produce more sustainable and comfortable environment especially for university building so that it could contribute to a sense of community and encourage more outdoor activities (M.F. Md Din et al., 2014).

1.2 Problem statement

The rapid urbanisation especially in Sarawak has transformed current environment from natural vegetation to engineer structured. This built up environment give significant impact on the outdoor thermal environment due to the rises temperature in urban areas. The heating of the atmosphere and surfaces in urban areas will then contribute to urban heat island (UHI), which is a phenomenon that the air and surface temperature of the urban area are higher than the surrounding. Building arrangement can be recognized as one of the important parameters in contributing this phenomenon (Lee et al., 2017). Building arrangement also known as building layout patterns which is very related on how radiation and air flow in and outside of the buildings. In addition, the presence of high rise building and compacted building areas will also contribute to the UHI phenomenon and hence increases the thermal discomfort for the human around that area. This building characteristics that lead to UHI not only found in city areas but also can be found in other places such as university campus area. It can be found that there is various type of building layout patterns, high rise building and also compacted building area in UNIMAS that could have higher possibility on UHI occurrence. Hence, this study will conduct in university campus in order to express the heat impact causes by different building layouts that contribute toward the thermal comfort of the UNIMAS community.

Since the outdoor thermal comfort is often linked with UHI phenomenon due to building arrangement, thermal comfort assessment was carried out to assess the thermal sensation of the people in that particular area of study. There are many study was conducted by previous researchers to investigate the outdoor thermal environment due to the effect of different building layout patterns in Malaysia. Some research can be found from M.F Md Din et al. (2014) that reviewed thermal comfort of various building layouts with proposed

discomfort index at Putrajaya and Universiti Teknologi Malaysia (UTM), Johor Bahru. However, there are very limited research regarding thermal comfort assessment found in Sarawak especially in the university for this moment. Hence, this study will concentrate on the thermal comfort assessment based on different building layout patterns in university campus area.

Height to width (H/W) ratio, sky view factor (SVF), albedo and shading effect are the parameters that relates to building arrangement and orientation. There are many study that relates thermal comfort with the building parameters and one of the study was from University Putra Malaysia (UPM) which is about thermal comfort conditions of shaded outdoor spaces for local and international students at UPM, Serdang. However, there are still have knowledge gap in studying the impact of building layouts in Sarawak university campus area toward thermal comfort. In conjunction with this matter, this study will conduct in UNIMAS to find out the relationship between thermal comfort with respect to different building layout patterns.

1.3 Objectives of study

The aim of this study is to investigate the thermal sensation of respondents in university campus which might been affected by arrangement of the buildings. Therefore, several objectives have been established to achieve this goal which are :

i. To determine the different building layout patterns that contribute to the higher heat impact in the outdoor thermal environment in university campus area.
ii. To conduct an outdoor thermal comfort assessment through questionnaire survey in university campus area.
iii. To analyse the relationship between the thermal comfort perception with different building layout patterns.

1.4 Scope of study

The scope of this study involves the elements of different building layout patterns and its effect on outdoor thermal environment within university campus. This study is focusing on thermal comfort assessment which will be conducted to evaluate the thermal perception among the university community. Different building layout patterns with different thermal environment such as at lake view, vegetation areas and compacted area surrounded by buildings in Universiti Malaysia Sarawak (UNIMAS) has been chosen as the study area.

Thermal comfort assessment is conducted by using subjective measurement and this is done through questionnaire survey. The questionnaire survey was carried out to identify the thermal response of the UNIMAS community especially students and staffs in a real thermal environment. Based on population size in UNIMAS which is around 20,000 of the community, the number of respondents that is targeted for this assessment is around 100 people. This number of respondents is based on 10% margin of error with 95% confidence level which is refer to the standard. The respondents will be random chosen and this assessment will be carried out during day time.

In order to make this questionnaire more reliable, a pilot test will be conducted for 10 respondents for the pre screening process on the questionnaire and also to make sure the respondents understood the questions about certain critical aspects such as temperature and humidity sense, perception and their opinions about selected heat areas. Other than that, ASHRAE thermal sensation scale was used to evaluate the thermal response of the community within the selected thermal environments (ASHRAE Standard 55P, 2004). Based on the data collected, the analysis of this study will be carried out to correlate the relationship between perception of the UNIMAS community on the thermal comfort sensation with different building layout patterns that has been investigated.

1.5 Significances of study

This study will be significant endeavour in providing or producing a good building arrangement in the future. By considering the higher demands for construction developments in the future due to increasing amount of population, this study can be serve as a future references for researcher on the subject related to building planning and environmental engineering. It will also make this thermal comfort study upgraded into a larger scale of research.

Moreover, this study will also be beneficial to the urban planner, consultant, architect and engineer who is involved directly into any development or built environment design in the first place. This study can help to propose proper building arrangement by considering the effect of different building layout patterns on thermal environment especially for university community. This study also can act as a medium awareness for UNIMAS community to aware on the thermal condition in the campus so that all the community in UNIMAS can serve with better comfort environment.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this ongoing years, the proportion of provincial and urban populace wind up unequal because of progress of statistic, financial structure and globalization. As indicated by statistic insights from United Nation (UN), the country populace of the world has developed gradually since 1950 and is relied upon to achieve its crest around 2020. The worldwide provincial populace is presently near 3.4 billion and is relied upon to decline to 3.1 billion by 2050. Then, the worldwide urbanization rate has achieved 54% and this rate will achieve 66% by 2020. In view of this measurements, it demonstrated that the world urbanization has moved from created nations to build up the world. By review this measurement to littler degree, the fast urbanization likewise occur in Malaysia. As per the report titled East Asia's Changing Urban Landscape : Measuring a Decade of Spatial Growth, Malaysia is the most urbanized nations of East Asia with urban populace expanded from 10.2 million (43% of aggregate populace) to 15 million (53% of aggregate populace) and making Malaysia among the more urbanized in the locale in statistic terms after Japan, the Republic of Korea and Singapore.

In view of past research from Nor Hanisah et al. (2016) in investigation of thermal comfort for social effect have referenced that the populace augment on the planet clearly makes additionally rising innovations adapt to human expectation for everyday comforts. Urban is where the human has immense occupations openings adding to high efficiency, rich way of life and huge system of transportation and shockingly joined by urban heat island (UHI) marvel. This wonders incredibly influencing urban such that the heat caught in

building squares of the city will prompt hotter temperature contrasted with rustic regions outside the city. Reduced human settlement in the city permits more space for advancement of lodging to take care of the demand that thusly affected measure of green territories accessible.

This was supported by Lee et al. (2017) in research of outdoor thermal comfort evaluation for building arrangement parameters by reviewing that the rapid progress of urbanization give significant impact toward thermal environment. Urbanization are very related to the development or construction of larger scale buildings and higher number of human population. The consequences of urban areas have become serious issues where its lead in increasing air and surfaces temperature. Hence, it will influences human thermal comfort as each of these environments perform differently by the different amount of heat from direct solar gains and reflected long wave radiation that obtained from adjacent buildings.

Managing urban areas has become one of the most important development challenges of the 21st century (John Wilmoth, 2014). This is because of successful outdoor environment are very much depends on an understanding of environmental factors, including building arrangement and design. This issues have received extensive attention from researcher to conduct studies regarding both indoor and outdoor thermal environment. Therefore, in this study, the effect of building arrangement toward outdoor thermal comfort considered as the novelty of the research.

2.2 Thermal comfort

Thermal comfort assumes critical job in the human life since it go about as a marker to decide dimension of condition with nearness of urban zones. There are many dimension of discourse with respect to the significance and nature of thermal comfort and there was much action and discussion during the 1970s on this point (Matthew, 2010). Thermal comfort can be characterized as the physiological interim where the human can endure with nature. It is where the human body communicates fulfilment with the warm condition (Lee et al., 2017). ISO 7730 (2005) characterizes thermal comfort as a psychological condition that express fulfilment with the warm condition. Nikolopoulou (2004) thus characterizes thermal comfort

as the psycho-physiological fulfilment of people, with respect to the terms of their thermal condition. Nonetheless, fundamental meaning of thermal comfort from ASHRAE (1996) which characterizes thermal comfort as the state of mind which communicates fulfilment with the warm condition and now was received globally.

It is commonly concurred that any detail of thermal comfort conditions must consider the six basic parameters which have been categorized under environmental and personal factors. Thermal comfort is influenced by metabolic rate, clothing insulation, air temperature, mean radiant temperature, air speed and relative humidity and this can be achieved by maintaining human thermal neutrality. When dealing with uncomfortable environments which is hot or cold, people are most likely to behave unsafely due to deterioration in their ability to make decisions or perform manual tasks. When the temperature deviates from optimum comfortability, people may experience discomfort that are of a subjective nature and later physical problems that impact their health are incurred.

There are two conditions of thermal comfort that can be experienced by the human which are indoor and outdoor thermal comfort. Generally, indoor thermal comfort is involving the thermal perception faces by the occupant due to the effect of building orientation and ventilation inside of the building while outdoor thermal comfort is involving the thermal perception of the occupant due to the effect of building orientation and geometry toward thermal environment. Both of these thermal comfort are very related to the building design. A suitable design process is achieved only when the designed site for both indoor and outdoor provides comfort conditions for the occupants. These conditions enable human activities to be performed in the most ideal way and provide a healthy development of individuals. Nonetheless, in terms of thermal comfort there is a contrast between the responses which is physiological and psychological of people as indicated by whether they are indoor or outdoor spaces.

In order to determine the best comfort conditions inside the buildings, numerous standard have been developed such as ISO7730, ISO 7726, ISO 10551, ANSI/ASHRAE 55 and BE-EN 14501. From this standard, it can found that the study of indoor thermal comfort has received a great deal of attention while the outdoor thermal comfort has been less studied. Only particular studies were conducted at events such as the World Expo 1992 at Seville, the Olympic Games at Atlanta 1996, Sydney 2000 and Athens 2004 (Gabriel et al, 2011). This is due to difficulty in understanding the external thermal comfort lies in the

multiplicity of factors involved and the different existing interactions. However, the study on outdoor thermal comfort become increases in this recent year due to the rapid urbanization around the world. Therefore, this study was conducted mainly to assess the outdoor thermal comfort with focusing on the effect of building layout or arrangement.

2.3 Outdoor thermal comfort

A comfortable outdoor spaces provide a pleasure thermal comfort experience for individuals and enhance the nature of urban living (L. Chen 2012). Sadly, solar oriented radiation from the outdoor environment unmistakably gives an impact on thermal comfort of a subject (Nor Hanisah et al, 2016). Likewise, outdoor thermal environment is not only affected by meteorological parameters, such as solar radiation, temperature, air humidity, wind and precipitation (Thorsson et al., 2004) yet in addition generally influenced by the design constructed environment (Ratti and Richens, 2014), anthropogenic heat (Inchinose et al, 1999), ground surface covering (Johansson, 2006) and shading by tress and man-made objects (Lin et al, 2009).

By and large, when talking about outdoor thermal comfort, vast of the study were concentrating on city zones. For instance, past research by Xiaodong He et al. (2014) in investigation of impact of sky view factor (SVF) on outdoor thermal environment and physiological equivalent temperature at Beijing cities. This study concentrated on 20 perception cities in the Beijing central business district (CBD) and talked about the impacts of SVF on outdoor thermal environments and thermal perceptions of people in outdoor spaces to build up a local-scale comfortable microclimate for pedestrians. This study explicitly addresses current knowledge gaps for cities with typical continental climates especially a monsoon which influenced humid continental climate. The outcome from this study show that the urban street canyons play divergent jobs on outdoor thermal environments at various time periods in different climate conditions.

Other study was done by Kakon et al. (2010) that explored the impact of building height on outdoor thermal comfort during the daytime in summer in at Dhaka, Bangladesh which is a high density city situated in tropical atmosphere zone. This study underscored on pedestrian comfort condition in a planned residential area in the city. Subsequent to

comparing the condition of thermal climate in an existing urban canyon and in the same canyon with increased building height, it is discovered that the air temperature diminished to some extent in the canyon with increased building height. As a result, temperature humidity index (THI) also reduces in the canyon with increased building height. This was demonstrated with the simulated results that indicating close concurrence with measured data in case of existing canyon with average building height, THI lies in the discomfort level while the proposed canyon with increased building height provides comparatively comfortable condition than the existing canyon.

While focusing the study of outdoor thermal comfort in the cities areas, the other outdoor spaces such as recreational park, university campus and cannot be neglected. Nor Hanisah et al. (2016) has reviewed the study of outdoor thermal comfort for social impact assessment in Kota Damansara, Malaysia. This study was aimed to determine the thermal comfort of outdoor recreational park by using thermal index. In view of the research investigation, the thermal comfort that occur in urban recreational park of Kota Damansara was within the comfort zone and acceptable to its users. In any case, the minimal human settlement in the city exacerbated the development of housing to meet the demand and hence influenced the amount of green regions accessible in the investigation area. Thus, the outcome from this study are vital since it could be valuable for landscape's designer, urban organizer and specialists to make a supportable improvement in Malaysia or everywhere throughout the world.

University campus also one important place that should not be neglected in this thermal comfort study. The outdoor space in the university campus are very related to the comfortability of community in the campus since many outdoor activities were carried out. Previous research by Morteza and Mehdi (2014) was focused on the comparative study of the effects of the sky view factor (SVF) on outdoor thermal comfort in two different campuses of Tehran. This study attempted to demonstrate the effect of different shadow pattern to enhance the adaptation of thermal behaviour of users. The results of this research will contribute to design adaptive shaded open spaces to the thermal behaviour of the users. Conclusion of this study showing that the increasing shaded open spaces by increasing green spaces and trees can create cooler campuses, integrated design of architectural forms and green spaces decreases the high sky exposed open spaces and this means, heat stress mitigation is outcome of the low radiated open spaces.