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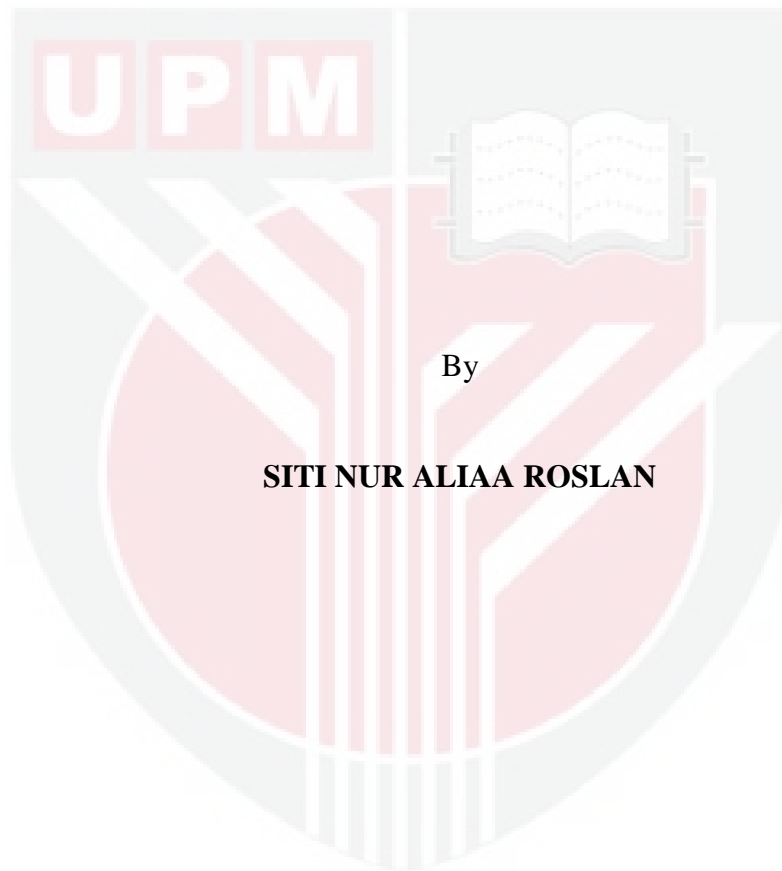
***DEVELOPMENT OF BUILDING COMFORT INDEX AND MODEL IN A  
TROPICAL URBAN ENVIRONMENT***

**SITI NUR ALIAA ROSLAN**

**FK 2017 118**



**DEVELOPMENT OF BUILDING COMFORT INDEX AND MODEL IN A  
TROPICAL URBAN ENVIRONMENT**



By

**SITI NUR ALIAA ROSLAN**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
in Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

**July 2017**

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## DEDICATION

*I dedicate this thesis to my mama,*

*Yg. Bhg. Professor Dr. Normaliza Abd Rahim...*

*I hope I am making your everyday special XOXOXO*



This abstract of the thesis is presented to the Senate of Universiti Putra Malaysia in fulfilling the requirement of the Degree of Doctor of Philosophy

**DEVELOPMENT OF BUILDING COMFORT INDEX AND MODEL IN A TROPICAL URBAN ENVIRONMENT**

By

**SITI NUR ALIAA ROSLAN**

**July 2017**

**Chairman : Associate Professor Helmi Zulhaidi Mohd Shafri, PhD**  
**Faculty : Engineering**

This study investigates on the internal climate modeling of buildings in an urban area situated at the Infrastructure University Kuala Lumpur (IUKL). The factors that contribute to the effect of building climate are being identified and the building climate information portrays by using the Geographical Information System (GIS). The main contributing factors of building climate are building design, building material, orientation of the building towards the sun and surrounding climate around the building. These factors contribute to the comfort condition of the rooms within the buildings. The main objective of this study is to develop a building climate modelling using a geospatial technologies which includes to investigate the building climate factors based on the building climate data collected from building samples, producing building comfort index (BCI) of each building that the building climate data and information collected based on the contributing factors and demonstrate a 3D model of building geometry from a 2D building map and building height information by using geographical information system (GIS). In order to collect the required data and information, several devices will be used. They are temperature meter, humidity meter, and noise recognizer. The building comfort data collected from each room are room temperature, room humidity and room temperature. The study area is in Kajang, Selangor area, which is being identified as an urban area. Buildings chosen are composed of ten (10) buildings in Infrastructure University Kuala Lumpur (IUKL). Data are collected from different types of rooms namely laboratories, classrooms, offices, library, and many other function of the room. Identification and discussion will be focusing on the influence of climate change towards building performance and building climate, the influences of climate change in areas that affects building performance and building climate. Building Comfort Index (BCI) is being developed based on the individual building temperature comfort index, building humidity comfort index and building noise comfort index. The results of the study revealed that the building climate index (BCI) for all buildings in IUKL comprise of six (6) buildings are having BCI of Comfortable and four (4) buildings with BCI of Less Comfortable. The building climate model (BCM) also portrayed in three dimensional

in order to give better view to the end users. A mathematical equation was obtained from the data collected by using the statistical power formula and tolerances of the data were being obtained from predicted data which has 72% tolerance and onto tested data which has 93% tolerance. The results of the study implicate building manager, architect, building surveyor, town planner and building user. It is hoped that further studies focus on obtaining the BCI of the buildings once in every three months of the year.



Abstrak tesis ini yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

## **PEMBANGUNAN INDEKS DAN MODEL BAGI KESELESAAN BANGUNAN DALAM TROPIKAL ALAM SEKITAR**

Oleh

**SITI NUR ALIAA ROSLAN**

**Julai 2017**

**Pengerusi ; Profesor Madya Helmi Zulhaidi Mohd Shafri, PhD**  
**Fakulti : Kejuruteraan**

Kajian ini mengkaji mengenai pemodelan iklim dalaman bangunan di kawasan bandar yang terletak di Universiti Infrastruktur Kuala Lumpur (IUKL) itu. Faktor-faktor yang menyumbang kepada kesan membina iklim sedang dikenal pasti dan maklumat iklim bangunan menggambarkan dengan menggunakan Sistem Maklumat Geografi (GIS). Faktor penyumbang utama bangunan iklim adalah reka bentuk bangunan, bahan, orientasi bangunan itu ke arah matahari membina dan sekitar iklim sekitar bangunan. Faktor-faktor ini menyumbang kepada keadaan keselesaan yang bilik dalam bangunan. Objektif utama kajian ini adalah untuk membangunkan satu model iklim bangunan menggunakan teknologi geospasial termasuk untuk menyiasat faktor-faktor iklim bangunan berdasarkan data iklim bangunan yang dikutip daripada sampel bangunan, menghasilkan indeks bangunan keselesaan (BCI) setiap bangunan yang iklim bangunan data dan maklumat yang dikumpul berdasarkan faktor penyumbang dan menunjukkan model 3D membina geometri daripada 2D bangunan peta dan ketinggian bangunan dengan menggunakan sistem maklumat geografi (GIS). Dalam usaha untuk mengumpul data dan maklumat yang diperlukan, beberapa peranti akan digunakan. Mereka meter suhu, meter kelembapan, dan bunyi Pengecam. Data yang bangunan keselesaan dikumpul dari setiap bilik adalah suhu bilik, kelembapan bilik dan suhu bilik. Kawasan kajian adalah di Kajang, kawasan Selangor, yang dikenal pasti sebagai kawasan bandar. Bangunan yang dipilih adalah terdiri daripada sepuluh (10) bangunan di Universiti Infrastruktur Kuala Lumpur (IUKL). Data dikumpul daripada pelbagai jenis bilik iaitu makmal, bilik darjah, pejabat, perpustakaan, dan banyak fungsi lain dari bilik. Pengenalan dan perbincangan akan memberi tumpuan kepada pengaruh perubahan iklim ke arah membina prestasi dan bangunan iklim, pengaruh perubahan iklim di kawasan yang memberi kesan membina iklim prestasi dan bangunan. Indeks Keselesaan Bangunan (BCI) sedang dibangunkan berdasarkan indeks keselesaan suhu bangunan individu, membina indeks keselesaan kelembapan dan indeks keselesaan bunyi bangunan. Keputusan kajian menunjukkan bahawa indeks iklim bangunan (IKB) bagi semua bangunan di IUKL terdiri daripada enam (6) bangunan menghadapi BCI daripada selesa dan empat (4) bangunan dengan BCI

Kurang Selesa. Model iklim bangunan (BCM) juga digambarkan dalam tiga dimensi untuk memberi gambaran yang lebih baik kepada pengguna. Persamaan matematik diperoleh daripada data yang dikumpul dengan menggunakan formula kuasa statistik dan had terima data telah diperolehi daripada data meramalkan yang mempunyai 72% toleransi dan ke data diuji yang mempunyai 93% toleransi. Keputusan kajian yang mengaitkan pengurus, arkitek bangunan, membina juruukur, perancang bandar dan bangunan pengguna. Adalah diharapkan kajian selanjutnya memberi tumpuan kepada mendapatkan IKB bangunan sekali setiap tiga bulan dalam setahun.





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My siblings, nieces and and nephews;  
Aiman Roslan, Lana, Vivy & Adam...  
Maisarah Roslan, Zulhemi, Sofea & Mateen...  
Mustaqim Roslan...  
Widad Roslan & Yusuff...  
Alim Roslan...

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I certify that a Thesis Examination Committee has met on 14 July 2017 to conduct the final examination of Siti Nur Aliaa Roslan on her thesis entitled "Development of Building Comfort Index and Model in a Tropical Urban Environment" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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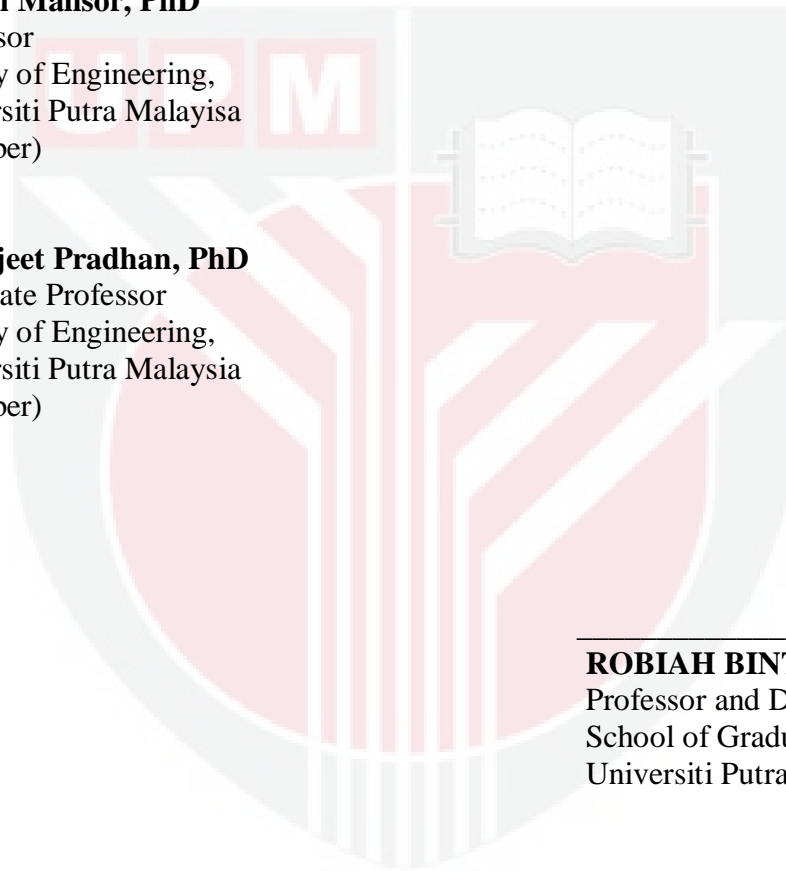
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## Declaration by graduate student

I hereby confirm that:

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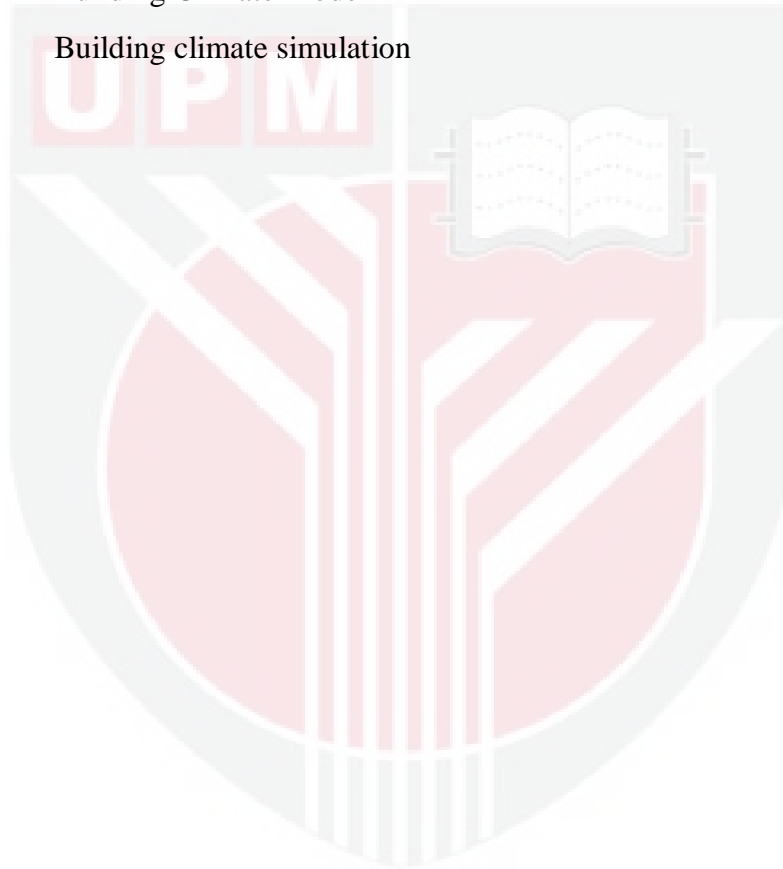
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## LIST OF ABBREVIATIONS

BCM	Building Climate Model
IUKL	Infrastructure University Kuala Lumpur
GIS	Geographical Information System
GPS	Global Positioning System
BCI	Building Comfort Index
SPSS	Statistical Software Package for Social Sciences





# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

This study undertakes on micro climate modeling of building in an urban area. Factors that contribute the effect of building climate are being identified and the building climate information being portrayed onto a Geographical Information System (GIS). Building in general is being presented in many shapes and functions. It depends and being adapted throughout history for many factors such as history, materials that the building are made of, the surrounding weather condition, value and prices of the land, surrounding land conditions, the purpose of the building and the aesthetical reasons of the building. There are many functions related to a building being made such as structure, climate control, energy saving, aesthetical values, user comfort and others that related to the purpose of the building being built in the first place. Building climate is one of the main things in determining the effectiveness the building function. Building climate in general can be defined as the internal condition of a building, which includes the temperature, humidity, air direction as well as noise within the walls of the building. Thus, building climate model can be defined as a model that enables the illustration of physical view of the building, which usually being portrayed in a GIS environment.

### 1.2 Background of study

Malaysia is made of two (2) land parts, peninsular Malaysia and east Malaysia (The Malaysia Rainforest, 2013). Peninsular Malaysia consists of 12 states that is, Perlis Indera Kayangan, Kedah Darul Aman, Perak Darul Ridzuan, Selangor Darul Ehsan, Wilayah Persekutuan, Negeri Sembilan Darul Khusus, Melaka, Johor Darul Takzim, Pahang Darul Makmur, Terengganu Darul Iman and Kelantan Darul Naim. Whilst, in east Malaysia there are two states; Sabah and Sarawak. In total, there are 14 states in Malaysia (Figure 1).



**Figure 1 : Map of Malaysia**

Being one of the tropical countries in the world, the weather in Malaysia is warm or hot and rain throughout the year. In general, the amount of rain that majority of the states in Malaysia received is less than 200mm. In fact, Peninsular Malaysia, especially in south Perak, Selangor, Negeri Sembilan, Melaka, Johor and East Pahang receive less than 100mm of rain and being categorized under 60% of mean value. However, in certain area such as north west of Perlis, Kedah and north Perak receive more than the normal mean value of rain, within the range of 300mm to 400mm. Hence, Peninsular Malaysia has a record number of rainy days ranged from 5 to 18 days (Malaysian Meteorological Department, 2013).

In Malaysia, there are many types of buildings of which the shape and design are inspired through years by history, aesthetical values as well as influences from other countries. There are many types of buildings available such as residential, office and business purpose, learning centre, public building and others. Residential buildings are from single storey, double storey, strata type (high-rise) and multi-storey type, as well as bungalow and others. Office and business purpose building are factories, shop lots building of single storey to multi-storey, historical building and tourist attraction building. Learning centre buildings are school ranging from nursery, day care centre, primary school, secondary school and higher education like colleges and universities. Public buildings are general building that are used by people like court, ministry administration building, transportation centre and others.

The design of these buildings are differently presented in different states. For example, shop lots in Kuala Lumpur are generally multiple rows of double storey or more, as compared to shop lots in Terengganu which are generally single storey single row. Same goes to the design of residential building in Kuala Lumpur and Selangor whereby, there are a lot of high-rise residential building as compared to Perak and Kedah which are having less of high-rise residential building. However, there are some building types that have general and specific design such as school design and structure in Selangor are the same as the one in Kelantan. This is because

the design and structure of every schools in Malaysia are being controlled by the ministry since year 2000 (Ali, Keong, Zakaria, Zolkafli & Akashah, 2013).

The materials that were used for a building also changes throughout the year. Long ago, Malaysia used to have buildings made of timber and in 1930's, Malaysia is one of the leading countries that used timber construction in most of construction work. These can be seen in most of the historical building left or being preserved until now for the reference of architecture design and traditional Malay values within a construction of a building. As time goes by and technology booming, the invention and innovation of building construction materials have taken over the timber construction work as the main method of building construction (Kiozo & Derlukiewicz, 2012). Nowadays, many things need to be taken into consideration when deciding which method to use for building construction. Other than the need to meet the end user or customer requirement, the architects and civil engineers also need to design and built buildings referring to the budget provided by the land developer.

Subsequently, there are many people involved in the building construction process. A real estate agent is needed to estimate the value of the land so that the construction work will be carried out. Land surveyor is needed to do the preliminary survey of the area, to carry and setting out survey while construction is the ongoing process to ensure the buildings are being built on the correct point and deformation or monitoring survey once the construction work is finished. This is to ensure the safety of the building and confirm with the project manager that the building is on the correct position and according to the site plan that was provided by the civil engineer earlier. A quantity surveyor is needed to estimate the costing of the whole construction project, varying from the cost of the materials, workers and others (East & Love, 2011). In the end, the land developer together with the project manager and civil engineer will bring the final plan to get the approval letter from the local authority for the tenant to occupy the building. Just before the approval, the building needs to be tested on whether or not the building is following the act set by the respective Occupational Safety and Health (OSHA).

The architecture and design of buildings in Malaysia have many background histories. For example, the architecture of buildings in Kuala Lumpur city centre is a mix of Asian traditions, Malay Islamic inspirations, old colonial influences (since Malaysia was under the domination of British long time ago), modern and post-modern mixed. Most of Kuala Lumpur's colonial buildings were built towards the end of 19th and 20th century since Kuala Lumpur is a relatively young city. These buildings have Tudor, Neo-Gothic, Moorish or Grecian-Spanish style and design or architecture (Utaberta, Hassanpour & Mohd. Arsyad Bahar, 2012). Most of the designs have been changed for the usage and catering local resources and to occupy the climate of Malaysia, which is hot and humid throughout the year.

As for building design, Malaysia has produced a large number of architects who are able to produce good designs and have their landmarks around the world. To name

one, an architect from Malaysia is one of the architects for Makkah Royal Clock Tower in Makkah, Saudi Arabia. One of the famous Malaysian architects is Hijjas Kasturi who designed Menara Maybank, Menara Telekom, Bangunan Tabung Haji, Putrajaya Convention Centre, Shah Alam Selangor Stadium and the list goes on. In short, architecture and building environment field consist of professionals who are working close together in the construction industry to serve people in Malaysia (Moser, 2010).

The climate in Malaysia has two seasons since it is positioned on the equator line. Through the years, the temperature in Malaysia has risen due to thinning of ozone layer and greenhouse gases effect. During 1980's, the temperature in Kuala Lumpur, Malaysia is maximum of 25°C throughout the year. However, nowadays the temperature goes up to 32°C at a time or sometimes more. Since the temperature has risen through the years, air conditioner has been used widely around Malaysia and the main reason being is to give comfort to people during warm days. But, the effect of widely used air conditioner for the surrounding temperature is risen compared to normal days. These air conditioners are usually being used in the government and private administration buildings as well as the ministries, higher learning institutions, business buildings such as shopping malls and residential buildings. It can safely said that in Kuala Lumpur and Selangor areas, the ratio of air conditioner and residential unit are 1:40. This highly usage of air conditioners resulting in high electricity energy consumption which contributes to one of the problems for people maintaining their cost of living especially in an urban and developing areas. Prices of basic housing needs and utilities are increasing from time to time making comfort as a struggle to survive.

An urban area is defined as an area with the minimum population of 1000 persons and with population density of at least 400 persons per square kilometre. The territory outside urban area is called rural area (Statistic Canada, 2011). According to Zhang *et al.*, (2010), global urbanization trends present challenges including increased energy consumption that result in air and water pollution and ecosystem degradation, and local climate modification resulting from enhanced heat storage and release from built structures (i.e the urban heat island effect). Mapping an urban area is one of complicated things to do, yet important since a person will know the area being covered, for instance, in a developing country like Malaysia. Urban land is usually defined as areas being characterized by buildings, asphalt, concrete, suburban gardens, and systematic street pattern. There are several classes of urban development as well. They include residential, commercial, industrial, transportation, communications, utilities and mixed urban. Undeveloped land on the other hand being used as cemeteries, golf courses and urban parks is recognized within urban areas (USGS, 2013).

As for building envelopes, Kim & Han (2012), claim that the building envelopes fulfil many functions such as structure, climate control, energy savings and generation, aesthetics, psychological well-being, and occupant comfort. Building climate can be in terms of building temperature, pressure, humidity and wind speed. By analyzing the climate of the building, this will help in the future building

planning and development. Materials chosen to be used when constructing a building depends on the purpose of a building. Building materials are materials that are used for construction purposes. Some of the materials that are occurring naturally, which have been used to construct building are clay, rocks, sand, wood, twigs and leaves. Man-made or synthetically made materials for building construction are also being used and the use of these materials are segmented into specific specialty trades, such as carpentry, insulation, plumbing and roofing work. These materials are actually making the building looks nicer or in another word, the make-up of habitats and structures including homes. There are many factors that contribute to climate of a building including building materials, orientation of the building towards the sun, building design and the surrounding climate of the building.

### 1.3 Problem Statement

Buildings with tropical surrounding climate are exposed to a lot of high humidity and big amount of solar heat (Azizuddin Abd Aziz, Sumiyoshi & Akashi, 2017). The typical environment of humid and hot weather all year round makes it a necessary to operate air-conditioning without any break in between throughout the year (Azizuddin Abd Aziz *et. al.*, 2017).

A study by Yeo, Yoon & Yee (2013) stated that building climate being one of the ways to solve environment and energy construction model for urban planning purpose. However, the factors that contribute to the building climate were not discussed in detail in order to ensure the environment suitability and energy saving efficiency in urban planning for the future. Generally, the contributing factors to the building climate are building material, building design, building orientation towards the sun as well as building surrounding climate. In construction site material layout study by Su, Andoh, Cai, Pan, Kandil & Said (2012) stated that the use of GIS in the study really helps the construction project manager to visualize the site area. However, the study suggested that better view could be obtained if the use of 3 dimensional (3D) in the project is used so that spatial temporal conflicts and mitigation measures improve the material accessibility and wasting of time. A decision support system (DSS) in GIS is one of the advantages in using GIS to determine the contributing factors to the building climate. On the other hand, conceptualization of spatial relationship (CSR) analysis is used by Xin (2012) for urban management information systems and planning analysis that was designed in GIS. However, in the study by Xin (2012) stating that relationship factors involved was single factors from both sides, being determined by either a decision support system or spatial relationship analysis.

Demonstrating and portraying building in 3D is much practical rather than in 2D. Other than being able to know the design of the building, it also enables viewer to relate the building climate with the physical characteristics of the building easily. By inserting the building climate information within the 3D building map, the viewer will automatically understand the purpose of the map in relation to building climate and contributing factors. It also gives idea to the viewer on the condition of the

building when looking at the micro climate modelling of the buildings in the study area. This information will contribute into the proposing of future building infrastructure to meet the end user requirement as well as the comfort of the residents in the future.

It is an advantage to know the climate of a building and factors that contributes to the building climate. Mapping the building climate onto the map of an area will be an advantage as well as updating information of the area. In this study, an urban area will be chosen as the study area. The reason of choosing an urban area is that there will always be a development in that area. Then a map of the area will be portrayed into three-dimensional (3D) in a GIS. Building climate information will be inserted into the buildings. The rationale of producing a micro climate model is to relate with the contributing factors of the building climate, which then will be used to propose building infrastructure in the future.

#### **1.4 Significance of the Study**

The significant of the study includes matters that related directly and indirectly to work of the land developer, town and regional planner, community and individuals.

The information for future building infrastructure will be used by the land developer to manage new land development project within the same study area or other area as in the same condition as the study area i.e. urban and developing area. The developer needs to have discussion with the civil engineers in terms of the design, structure and materials of the future building. The developer also needs to approach an architect to propose a design to meet the end user requirement, then required land surveyor to carry out initial survey to know the topographical features of the area. A quantity surveyor will need to produce an estimation value of the total cost of the proposed building. All these steps need to be under the supervision of site project manager according to the plan that has been made by the town and regional planner officer.

The town and regional planner has made the initial design of the area that needs to be developed. The design will include on whereabouts of buildings (including types of buildings) in order to organise and arrange the area. The planner will propose on the location of housing streets, shops, shop houses, school, recreation area and other matter that need to be included in a newly developed area. The plan is made based on the information provided by the land developer. From costing to the construction material for the area, as well as the land area and topographical information are the factors that are taken into consideration when planning this developing area.

The surrounding community will also be affected from the development of this newly land development work. The community involves family members of adult and children, general workers, service provider, teachers, students etc. The residents are people who are living within the existing area of the neighbourhood community

and will be using the facilities provided. More job opportunities as well as facilities area available within a close range distance. This newly developed area will not affect the current climate condition of the community, since the factors of building climate has been taken into consideration when designing and planning the new area. In fact, probably this new area will give more comfort to the current community in terms of daily life activities as well as being comfortable in their own homes.

The individuals are within the range of user and seller of building and land, as well as tenants and residents in the developed area. These individuals need to be easily comfortable when occupying these buildings and enjoy while carrying out their daily activities. Knowing the climate of the building that they are occupying or living in would be a huge advantage for these individuals since their work and life related issue will be around this factors. These individuals will know the contributing factors the building climate that they are living in and will be able to improve their living pattern to get the desire building climate condition that are comfortable.

### **1.5 Limitation of the Study**

This part will discuss the limitation of the study varying from the study area, types of building being chosen, building climate data collected, building climate factors that contribute to the building climate data and GIS being chosen as the environment to portray the data and information.

The limitation of the study includes the study area being located in Selangor, being one of the states in Malaysia that receives the least amount of rain. In general, the weather in Malaysia being hot and humid throughout the year. This limits the building climate data obtained from building that is having the environment of more hot and less humid through the year (MMD, 2013).

Infrastructure University Kuala Lumpur (IUKL) is located in the district of Kajang, within the state of Selangor in Malaysia. This study is using ten (10) buildings within IUKL with different types of rooms making the building, namely classroom, computer lab, equipment lab, administration office, library, auditorium and others. Each types of building need the minimum three rooms from each floor of sampling for the building climate data information. The types of building chosen are within the university area only. The reason being is that the university is located within an urban area and the easy access can be obtained to enter the rooms.

Three (3) types of building climate data is collected from all ten (10) buildings. The data are room temperature, room humidity and room noise. Based on these data, factors that contribute to the building climate is determined. Some factors are building materials, building orientation towards the sun, building surrounding climate and building design. These factors are taken into consideration to ensure the current occupants of the building, maintain the comfort and hence propose for future

building infrastructure as well as to maintain the building climate to maximize the comfort of the individuals who are going to occupy the building.

This study will be analysed by using the statistical analysis method that is multiple regression analysis. The purpose is to see the relationship between the building comfort contributing factors and the building comfort index produced. The result will enable the user to see the level of tolerance between the collected data and expected data.

Hence the limitation of this study would give the opportunities for further research in the same area that would enhance the findings of research of this study.

## **1.6 Objective**

The general objective of this study is to create a building comfort index (BCI) of an urban area. The specific objectives of this study are to;

1. investigate and analyse the building climate factors based on the building climate data collected from building samples
2. develop building comfort index (BCI) based on the building climate data
3. create a 3D simulation model based on the BCI

## **1.7 Research Questions**

1. What are the building climate factors that contribute to the building climate condition?
2. To what extent that the building comfort index would reflect the real world situation?
3. To what extent the contributing factors of building climate in relation to building climate data and information? How to model the impact of varying factors on building microclimate?

## **1.8 Scope of work**

The scope of work for this study will be focusing on the interior climate of the building. The interior data of the rooms will be composed of room temperature, room humidity and room noise. The data will be collected by special devices namely temperature and humidity meter and noise level meter. There will be ten (10) buildings within IUKL that is chosen and from each building, three (3) rooms from each floor will be chosen for their room comfort data to be collected. These rooms will be randomly picked and will be a mixed of rooms functions. The functions of the room varies from class room, lecture hall, staff room, meeting room, hostel room, indoor laboratory as well as outdoor laboratory.



The room comfort data from these rooms will be calculated according to the formula adopted from energy formula. Then, these data will be keyed into the statistical analysis software (SPSS) to obtain the general formula from linear regression analysis.

Then, this formula will be used to calculate the tested building comfort data. The building comfort data is collected from tested buildings, that is composed of rooms from Faculty of Engineering, University Putra Malaysia. The functions of these tested rooms are also vary from classrooms, staffrooms, library, indoor laboratories and outdoor laboratories.

## **1.9 Definition of terms**

### **1.9.1 Building Climate**

The inner condition of the building such as temperature, air pressure, wind speed within the building and humidity of the room. In general term, room temperature being described as common indoor temperature, which usually in the range of 20 °C (68 °F or 293 K) to 25 °C (77 °F or 298 K) (Bellia, De Faldo & Minichiello, 2013). Room air pressure is usually the same as the atmospheric pressure outside (outdoor), in which the standard atmosphere is stated as being 101325pascals or 101.325kPa (Bellia *et al.*, 2013). The effect of wind blowing onto a house will generated difference of pressure up to 20 Pascals between outside and inside of the building structure and it creates variations in the house pressure (Wallhagen, Glaumann & Malmqvist, 2011). Humidity being defined as water vapor in the air, which is the transformation from water to gas state. By having high humidity, it reduces the sweat affect when cooling down the body by reducing the rate of evaporation of moisture from the skin (Wallhagen *et al.*, 2011).

### **1.9.2 Geographical Information System (GIS)**

GIS is a system designed to capture, store, manipulate, analyze, manage and present all types of geographical and geospatial data. In general, GIS integrates hardware, software, capturing data, managing, analyzing and displaying all forms of information referenced geographic. It allows users to view and understand, as well as question, interpret and visualize data in many ways that reveal patterns and relationships as well as trends in the form of globes, maps, reports and charts (Fabbri, Zuppiroli & Ambrogio, 2012).

### **1.9.3 Micro Modeling**

Modeling factors in a micro scale, that is the details of individual buildings (Ural, Hussain & Shan, 2011). For instance, link a row of double storey link houses is called macro model whereas one of the double storey link house is called micro model. Same goes to an administration building in a university campus is said to be macro model whereas one of the offices in the administration building is called micro model.

### **1.9.4 Climate Modeling**

GIS is a computer system which enables the creator to link, add and creates relationship between data and information besides other data manipulation techniques (Fabbri *et al.*, 2012). Building climate data and information such as temperature, air pressure and others that are related to building climate is modeled and portrayed onto a building map by using GIS.

## **1.10 Research Organization**

### **Chapter One**

In this chapter, introduction to the study is lined up. The background study as well as the objective and specific objectives of this study will be stated and explained as well as the definition of terms being used in this study. In the conclusion, research organization of this study is also stated in this chapter.

### **Chapter Two**

In this chapter, literature reviews of topics and subtopics, as well as supporting literature are stated. The literature reviews are circulating around building climate factors, building climate modeling and GIS mapping.

### **Chapter Three**

This chapter describes the study area, method of building climate mapping to be used, factors of building climate to be portray in the map as well as the study area. The method of building climate data collection will also be explained, as well as the software to be used to display the 3D map of the study area.

## **Chapter Four**

In this chapter, the 3D micro climate building model is produced. The analysis of reliability of the building climate information onto the 3D model is being analyzed. The effectiveness of the model will also being tested onto proposing future building infrastructure with good and comfortable building climate to be occupied by user.

## **Chapter Five**

In this final chapter of the study, the main findings and the results of the analysis from the data will be concluded. Significance of the research is being finalized and the research gap has been closed for final conclusion and recommendation for future research is to be recommended.

### **1.11 Conclusion**

Building Climate Modeling for Urban Area by using GIS Mapping Technique is a guideline portraying building climate data onto 3D building in GIS. This chapter explains on the background of the study, problem statement, significant of the study, limitation of the study, objectives, research questions, definition of terms and research organization. The next chapter will discuss the literature review based on studies of building climate and GIS modeling, as well as defining gap of research.

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