IMPROVEMENT OF OUTDOOR TEMPERATURE TOWARDS SUSTAINABLE CAMPUS: A CASE STUDY OF UNIVERSITI TUN HUSSEIN ONN MALAYSIA

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DEDICATION

Foremost, I would like to express my very profound gratitude to my family members especially to my mother and my sister, Noorain binti Mohd Zinal for their patience, motivation, morale and emotional support along the way. To my beloved mother and father, I am sorry for being away from home several times because I need to work hard and juggle between my work and studies. – All our sacrifices worth it now. In addition, thank you to my lovely friends Cik Ain for always supporting me and be there for me through thick and thin even though we only get to know each other in the middle of this Master's journey. Besides that, I am grateful to Dr. Maimunah binti Johari and her father for their editing assistance and support to get this thesis done. I would also like to express my deepest appreciation to my supervisor, Ts. Dr. Norpadzlihatun binti Manap for her continuous support and encouragement for my Master's studies and research, also for her enthusiasm, and immense knowledge. Last but not least, I would like to thank Universiti Tun Hussein Onn, Malaysia for supporting me throughout the research works. I wish I could mention more names, but to those who I did not mention here, please know that I am very thankful to you. Once again, thank you

ABSTRACT

Sustainable campus design needs comprehensive planning that considers universities' campus as a whole: buildings and its surrounding environment. Universiti Tun Hussein Onn Malaysia (UTHM) is located at suburban area at Johor with well and still in progress of development due to meets demand of student facilities. The transformation of landscape and surrounding environment tends increase air temperature. Results of this factor causes to reduce the outdoor thermal comfort of student and reduce healthy level. The objective of this research is to predict the ambient temperature of reference area by using Screening Tool for Estate Environment Evaluation (STEVE Tool) and to provide the comparison of field measurement and STEVE tools. In order to achieve this objective, the daily minimum (T_{min}), average (T_{avg}) and maximum (T_{max}) air temperature for six station of this campus have been developed and validated based on a long-term field measurement. The pavement (PAVE), building (BDG), green plot area ratio (GnPR), average height area (AvgHT), sky view factor (SVF), total wall area (WALL) and result of the temperature (T_{max}, T_{min} and T_{avg}) are automatically calculated by STEVE tools from the 3D models. The results show that the percentage different of temperature between STEVE tools and field measurement is in range of 0.9-1.0% and strongly indicated STEVE tools are suitable to use as temperature prediction tool

ABSTRAK

Reka bentuk kampus yang mampan memerlukan perancangan yang komprehensif dan menyeluruh terhadap semua: aspek rekabentuk bangunan dan persekitarannya. Universiti Tun Hussein Onn Malaysia (UTHM) terletak di kawasan pinggir bandar di Johor dan sentiasa berusaha dalam meningkatkan kualiti pembangunan serta memenuhi permintaan kemudahan pelajar. Transformasi landskap dan alam sekitar adalah cenderung kepada peningkatkan suhu luar. Hasil daripada faktor ini kebiasaanya akan menyebabkan penurunan kadar keselesaan pelajar dan mungkin akan mempengaruhi kesihatan. Objektif kajian ini adalah untuk meramal suhu persekitaran kawasan dengan menggunakan Alat Saringan untuk Penilaian Persekitaran Estet (STEVE Tool) dan menyediakan perbandingan suhu lapangan. Hal yang demikian adalah bagi menganalisis kadar minimum suhu (Tmin), purata suhu (Tavg) dan suhu maksimum (Tmax) harian bagi enam stesen kampus yang telah dipilih. Turapan (PAVE), bangunan (BDG), nisbah kawasan plot hijau (GnPR), kawasan ketinggian purata (AvgHT), faktor pandangan langit (SVF), jumlah luas dinding (WALL) dan hasil suhu (Tmax, Tmin dan Tavg) dikira secara automatik oleh alat STEVE daripada model 3D. Keputusan menunjukkan bahawa peratusan perbezaan suhu antara alat STEVE dan pengukuran medan adalah dalam julat 0.9-1.0% dan alat STEVE sangat dipersutujui sesuai digunakan sebagai alat ramalan suhu.

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LIST OF SYMBOLS AND ABBREVIATIONS

T_{min}	Minimum temperature
T_{avg}	Average Temperature
T_{max}	Maximum Temperature
TSV	Thermal Sensation Value
ºC	Degree Celsius
F	Fahrenheit
K	Kelvin
SVF	Sky View Factor
GnPR	Green Plot Ratio
AvgHT	Average height
HBDG	Average height to building area ratio
ALB	Albedo
PAVE	Pavement
WALL	Total wall surface area
$SOLAR_{total}$	Total solar radiation of the day
$SOLAR_{max}$	Maximum solar radiation of the day

m/s	Meter per second
Watt/m^2	Watt per meter square
%	Percent
<	Lower than

CHAPTER 1

INTRODUCTION

1.1 Background of research

The Intergovernmental Panel on Climate Change (IPCC) has made a clear statement that climate change is already happening where the world is currently 1°C warmer than in pre-industrial times (Myles *et al*., 2018). A harsh environment can negatively impact human health, primarily driven by climate change. In Malaysia, climate change is evident through frequent flood events caused by rising sea levels and temperatures. More importantly, the Ministry of Health Malaysia has reported many cases caused by heat stress and heatstroke. This includes 52 cases of heat cramps (hyperthermia, spasms of large muscle), 126 cases of heat exhaustion (fatigue, collapse), 22 cases of heatstroke (nausea, coma), and two deaths (Ministry of Health Malaysia, 2016).

Malaysia's Ministry of Science, Technology, and Innovation (MOSTI) expressed concern and advised the nation to develop mitigation measures to cope with climate change. In this notion, Malaysia is currently striving to realize its vision to achieve the Sustainable Development Goals (SDGs) 2030 through the 12th Malaysia Plan (12th MP), which can help to mitigate climate issues (Chua, 2018). In this regard, the commitment to achieve the Agenda 2030 for Sustainable Development Goals has been aligned with the strategies and initiatives of the 12th MP.

Under the 12th MP, Malaysia's government places enhancement in green development towards sustainability as the 4th place under the six crucial elements of the strategic Malaysia Plan (Figure 1.1). Pursuing green growth for sustainability and

resilience in Malaysia involves addressing critical issues, especially climate change that caused increasing temperature.

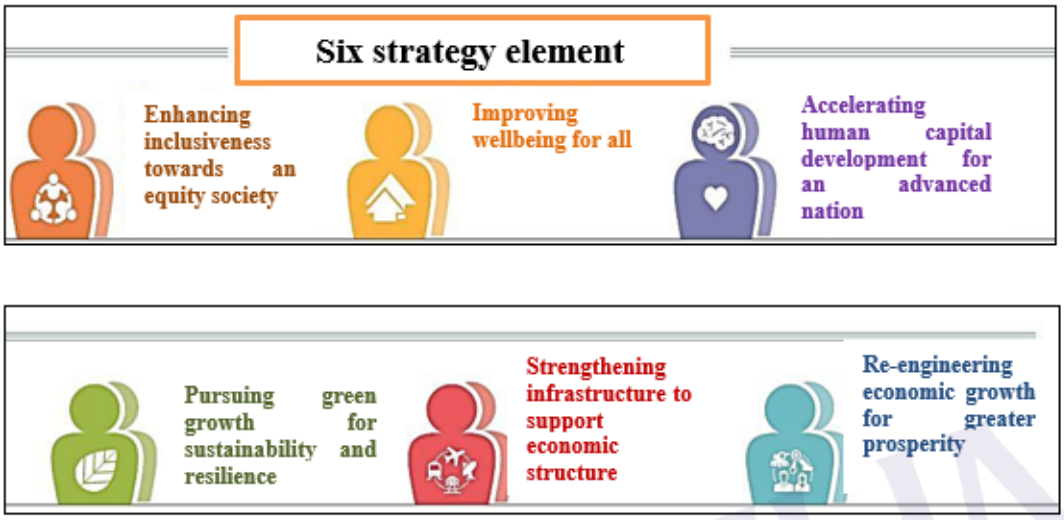

Figure 1.1: Six strategy element of the 12th Malaysia Plan (Chua, 2018).

Sustainable development (SD) in each and every field is need of the hour. Research and innovation in education for sustainable development is emerging and important part of education system. The United Nations Decade of Education for Sustainable Development (ESD) has highlighted that enhancing implementation and promoting sustainable development can be started at higher education institutions, including universities. Universities can be considered townships due to their size, occupancy level, and mixed complex function. Universities have a significant impact on the environment as they have wide (Kumar & Mohapatra, 2021)

1.2 Problem statement

Malaysia's desire to achieve the status of a developed country by the year 2020 will require rapid economic growth and expansion, especially in the urban, industrial and commercial sectors. Economic growth is guided by the principles of sustainable development. The extent to which sustainable development is achieved will ultimately

depend on the ability of the country to monitor and manage the impacts of economic activities on the environment. NGOs continue to advocate national efforts to address such issues as the economics of climate change, the compilation and publication of timely data on GHG emissions, and projections of energy consumption by different end-users (Salleh, 2021).

Most Malaysian is not aware of the effects of global warming. Being in a hot climate country and most likely holed up in their air-conditioned offices, most did not notice the changes in daily temperatures. Rising temperatures from global warming are creating violent storms in Malaysia for the past few years. A disaster caused by climate change or global warming could be defined as a serious disruption to the functioning of a community or a society causes widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources.

Prediction about impact of climate change on public health are general, there are no specific region scenarios is available. Nevertheless, Malaysia can expect significant impact mainly because of its tropical weather with high rainfall and temperatures that make dangerous combinations for air factor, food diseases, and illness due to air pollution. In Malaysia public perception on climate change is not well documented. Hence, this objective, want to discover the perception on climate change. With such poor understanding on structure in the climate system, people are likely to rely on the intuitive "wait and see" strategy that works well in a range of everyday tasks. Universiti Tun Hussein Onn Malaysia (UTHM) mission and vision are plays in an active role in order to ensure the management of research activities is implemented efficiently. At University Tun Hussein Onn Malaysia (UTHM), Sustainable Campus Unit (SCU) is a unit responsible for planning, developing and implementing innovative sustainable solutions in the pursuit of an environmentally sustainable campus. The motto of SCU is **"Reengineering Sustainability"**.

As a part of sustainable development planning, it is imperative to understand the impact of developments on the local climate and how they can influence outdoor thermal comfort. Conveniently, at the microscale level of the built environment, a study by Wong & Yu (2009) found that greenery plays a substantial role in combatting temperature rising and reducing climate change. This is supported by Jusuf & Wong (2013), mentioning that the greenery effect can influence solar radiation and air

temperature. The shading effect from the tree can reduce the amount of radiant energy absorbed and stored by the structure (Kraus, 2015).

However, it is common that designers do not consider how their landscape design can reduce outdoor temperature. This could directly increase outdoor thermal discomfort (Misni, 2012). Studies show that the lack of landscape planning and design due to building development and land cover change have caused the increasing temperature and reduced thermal comfort in the surrounding area (Yang *et al.* 2016).

As we know, UTHM located at Batu Pahat, Johor is one of the 20 public universities that are rapidly growing. There are has a lot of new building construction in progress in order to cater the increasing number of students and staff. According to Gupta *et al*. (2015), the clearing of land areas for development purposes may lead to a change in climate intensity. Therefore, before the new layout or design is prepared, it is critical to assess outdoor temperature and thermal comfort. A study by Razally *et al.* (2018) highlighted that outdoor temperature climate has a profound implication on the user of outdoor spaces and various activities that contributed to occupant liveability and vitality. Moreover, pedestrians are more affected by the outdoor environment as they are directly exposed to the environment instead of car users.

Currently, UTHM is on-going to adapt green building which conducted by Sustainable Campus Unit where their effort to help to make the university greener which is in line with government aim to minimize global warming impact. This fact triggered the need for UTHM to provide more space for greenery, safeguard the environment, and develop sustainable energy. As a mission of UTHM to provide a pleasant, healthy and conducive environment where its staff and students can feel happy, should be improved, of which it's score majorly influenced by its current greenery design and planning efforts. Therefore, to enable sustainability in the UTHM campus, it must enhance its vegetation landscape and green space. Based on the current total score of UI Green-Metric, UTHM is about at rank ten over twenty-eight Best Global Universities in Malaysia. As a mission of UTHM, it is to provide a pleasant, healthy and conducive environment for our staff and students.

In this study, some comments from students are that the temperature within UTHM main campus is uncomfortable. Therefore, as students are the main community who live and study in campus, it is important to understand the importance of outdoor temperature in doing their daily routine all around campus and to identify the current state of landscape provision in UTHM main campus.

In order to evaluate the comfort condition of current landscape, a Likert scale on student's satisfaction on the condition, function and maintenance of existing landscape towards outdoor temperature in UTHM was included in the questionnaire. For the questionnaire, a total of 25 students participated in this study and the interview was conducted with the Department of Development and Maintenance (PPP). We are carried out observation the study areas such as roadsides, parking, recreation areas and buildings as evidence by taking photos around to support the findings at Appendix A.

Findings indicated that in terms of condition of existing landscape around UTHM main campus, there are a few aspects that showed quite low comfortable levels. This generally indicates students are less satisfied with the outdoor temperature of existing landscape around campus.

1.3 Research questions

The research will focus on three main research questions:

i. What is the outdoor condition of existing landscape in UTHM main campus?
ii. What are the importance factors that influence outdoor temperature at UTHM main campus?
iii. How to estimate the potential reducing outdoor temperature of UTHM due to the implementation of the proposed green landscape?

1.4 Research objective

The objective of this study is:

i. To identify the outdoor condition of existing landscape in UTHM main campus.
ii. To investigate the importance factors influencing the outdoor temperature of UTHM.
iii. To estimate the potential reducing outdoor temperature of UTHM due to the implementation of the proposed green landscape.

1.5 Scope of the study

This study evaluates how greenery planning can reduce the outdoor temperature in a hot-humid tropical environment of the UTHM campus to provide a comfortable environment towards a sustainable campus. The research focuses on helping UTHM's effort enhance its design and planning of vegetation landscape and green space to reduce its outdoor temperature.

UTHM consists of educational buildings as well as high-rise and low-rise residential building in the city, sport facilities, transportation and administration offices. Most of the greenery conditions in UTHM can be categorized as less dense. There are having roadside trees and tree plantings between buildings with a certain distance about 3-10 meters or just an open grassland area. A few places in UTHM can be categorized as having a sparse greenery condition, where only several trees are planted, surrounded by large pavement/ concrete surface. The trees provide a less thermal benefit which is mainly for aesthetical purpose.

The temperature result will be used as the climate background of this study which is data is recorded in the morning until the evening by hourly temperature reading. The data of the temperature are collected manually and referred from Centre of Development and Maintenance (PPP), which provided the master plans, construction details and landscaping information for the building of the study area. In this study, the architects, landscape architect and planner who manage the development of the study area were interviewed to gather information about the general construction, building design and landscaping.

1.6 Significance of the study

This study is the first and the most comprehensive study on the prediction of outdoor temperature at UTHM. This study is vital to implement UTHM's operation strategies and directly support the Constructions Industry Transformation Programme (CITP),

Malaysia's national plan to transform the construction industry from 2016 to 2020. The CITP aims to change the construction industry through four (4) strategic thrusts. One of them is implementing Environmental Sustainability for compliance with environmentally sustainable practices to showcase Malaysia as low carbon, sustainable building, and infrastructure hub (Shaffii, 2017).

Additionally, the Department of Administration and Management (PPP) UTHM can benefit from this research by planning a more strategic landscape that considers its surrounding temperature and mitigates the increasing outdoor temperature. This study can help provide a better understanding of the general outdoor temperature and climate conditions of UTHM. The strategic design suggested in this study can be adopted by architects and planners to design green and sustainable campus development in UTHM and other relevant areas.

1.7 Organization of thesis writing

The thesis writing organization is designed to facilitate the research plan to be more organized and systematic. Under this sub-topic, the researcher explains each chapter in this study. Figure 1.2 shows a flowchart for a summary of writing for thesis organization.

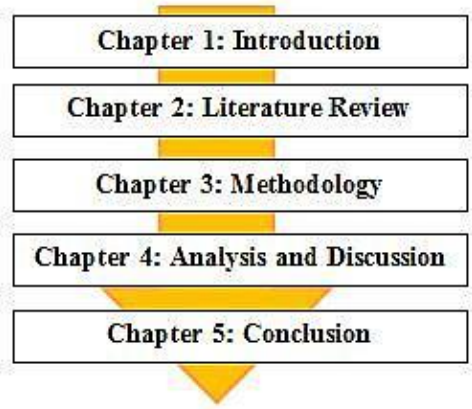

Figure 1.2: Flowchart summary of writing thesis organization.

Chapter 1: Introduction

This chapter explains the introduction of the effects of vegetation, study backgrounds, problem statement, the aim of the study, research objectives, scope of the study, and thesis writing organizations.

Chapter 2: Literature Review

Chapter 2 reviewed critically the research work related to this study, which previous researchers have published. This review aims to obtain an overview of the research and understand the phenomena and issue of study.

Chapter 3: Methodology

This chapter explains the study area, data collection, research design, sampling, and analysis method. The research methodology is divided into three phases; phase 1 involves the preliminary survey and literature review. Phase 2 is regarding data collection and processing. Prediction temperature is used to generate the Climate Predictor data (temperature data) and Development Morphology data (building, pavement, and greenery). Phase 3 is analyzing data and discussion.

Chapter 4: Analysis and Discussion

This chapter presents the analysis results and data collection to achieve the goal of the study. Data analysis is detailed in this chapter; the collected data were analysed according to the methodology procedures stated in Chapter 3. Site survey, observation, and field measurement data had been conducted in every section. The analysis and discussion provided in this chapter are to achieve the research objective.

Chapter 5: Conclusion

This chapter will conclude all previous chapters and provide suggestions to improve future research quality further. The research outcomes are summarized in this chapter, and the finding of the study is discussed thoroughly. The result of each objective is also further highlighted and summarized.

1.8 Conclusion

This study is the first and the most comprehensive outdoor temperature monitoring used on outdoor temperature detecting in the hot spot area. This study can help provide a better understanding of the critical factor influencing outdoor temperature, especially in the UTHM campus, to improve existing and future development by incorporating climate element prediction on its planning and design. This study also has a significant impact on understanding the future outdoor temperature of planning and design development. This implementation also supports a sustainable campus and promotes schemes that the Sustainable Campus Unit (SCU) UTHM has developed.

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