*THE INFLUENCE OF URBAN PARK TYPES ON VEGETATION
CHARACTERISTICS AND MICROCLIMATE CONDITION*

FELIXITA ANAK JUNIS

FH 2019 35

THE INFLUENCE OF URBAN PARK TYPES ON VEGETATION CHARACTERISTICS AND MICROCLIMATE CONDITION

By

FELIXITA ANAK JUNIS

**A Project Report is Submitted in Partial Fulfilment of the Requirements for the
Degree of Bachelor of Forestry Science in the
Faculty of Forestry
Universiti Putra Malaysia**

2019

DEDIDCATION

For my beloved mother Linda Anak Sanik,

Also my siblings Julia Yoummaccys, Diana and Francesca

Thank you for always being there with me and support me in financial during my
studies. I love all of you.

To my fellow friends Syaza Syahirah Nordin, Nor Afifah Yahya, Nur' Izzah Hanani,
Tan Xiu Han Intan Farha Shamim, Sathiya Rubini Satimurty, Rasyiffa' Hayati and
Mohamad Mizan Mat Nawi

Thank you for your encouragement, support, times and sacrifices that you have
given.

This project is also dedicated to my late father who has been the strength for all
struggles for me to complete this degree. You have been encouraging me to further
my studies and supporting me. Only God can repay all your sacrifices and rest in
peace. I will always miss you and love you.

Thank you and God bless all of you.

ABSTRACT

Global warming introduces meteorological hazards where it has caused the rising of air temperature, storm, flash flood and heat wave which were caused by greenhouse effects and forest loss due to the increasing population of humans. In order to satisfy human needs, more forest area needs to be cleared off where rapid urbanization has caused more vegetation replaced with sealed surfaces and built area. Thus, from this issue we can see how green spaces such as urban park play an important role in maintaining vegetation characteristics and modifying microclimate condition at urban areas. However, different types of urban parks have different influencing on the vegetation characteristics and microclimate condition because each type of urban park has its own landscape design and tree species selection. Therefore, this study aimed to determine the vegetation characteristics of different types of urban park; and to investigate the influence of different type of urban park on microclimate condition. This study was conducted at three different types of urban parks in Putrajaya which were forest based park, recreation based park and agriculture based park. The finding from this study has shown that the type of urban park did significantly influenced the vegetation characteristics and microclimate condition where each urban park had different air temperature, wind speed, relative humidity and solar radiation reduction. This study has shown that Taman Rimba Alam was significantly different in vegetation characteristics and microclimate condition compared to Taman Saujana Hijau and Taman Warisan Pertanian. For example, Taman Rimba Alam are able to reduce up to 2°C air temperature, 6% relative humidity, 0.1 m/s wind speed and 717 W/m^2 solar radiation. Moreover, the findings from this study will be beneficial to urban park planner to have a proper planning in the future in deciding the type of urban park and how it can help in overcoming global warming. In addition, this study also shows that it is important to include shading factors in designing urban park for a cooler and comfortable condition.

ABSTRAK

Pemanasan global telah menyebabkan perubahan cuaca yang drastik sehingga menyebabkan berlakunya peningkatan suhu, ribut, banjir kilat dan gelombang yang disebabkan oleh kesan rumah hijau dan kehilangan kawasan hutan; akibat daripada perningkatan populasi manusia. Bagi memenuhi keperluan manusia, banyak kawasan hutan perlu dibuka sehingga menyebabkan banyak kawasan hijau diganti dengan permukaan yang ditutup dan kawasan pembangunan. Oleh yang demikian, melalui isu ini kita boleh melihat bagaimana kawasan – kawasan hijau seperti taman boleh memainkan peranan yang penting dalam mengekalkan keadaan vegetasi dan mengubah keadaan mikroiklim di kawasan bandar. Namun, jenis – jenis taman bandar mempunyai kesan yang berbeza terhadap struktur vegetasi dan keadaan mikroiklim kerana setiap taman mempunyai reka bentuk, pemilihan spesies dan tujuannya yang tersendiri. Oleh yang sedemikian, tujuan kajian ini adalah untuk menentukan kriteria vegetasi pada taman – taman bandar yang berbeza dan untuk mengetahui kesan jenis taman pada keadaan mikroiklim taman – taman bandar. Kajian ini telah dijalankan di tiga kawasan taman bandar yang berlainan di Putrajaya iaitu taman berasaskan hutan, taman berasaskan rekreasi dan taman berasaskan agrikultur. Hasil daripada kajian ini telah menunjukkan bahawa jenis taman – taman bandar mempengaruhi ciri -ciri vegetasi dan keadaan mikroiklim dimana setiap taman – taman bandar mempunyai pengurangan suhu, kelajuan angin, kelembapan relatif dan radiasi matahari yang berbeza. Melalui kajian ini Taman Rimba Alam lebih signifikant dalam ciri – ciri vegetasi dan keadaan mikroiklim berbanding Taman Saujana Hijau dan Taman Warisan Pertanian. Sebagai contoh, Taman Rimba Alam mampu mengurangkan lebih dari 2°C suhu, 6% kelembapan relatif, 0.1 m/s kelajuan angin and 717 W/m^2 radiasi matahari. Tambahan pula, hasil daripada kajian ini dilihat dapat membantu perancang taman – taman bandar dalam melakukan perancangan dengan lebih terperinci dan teratur dalam menentukan jenis taman – taman bandar yang ingin ditubuhkan serta bagaimana taman – taman tersebut mampu menangani isu pemanasan global. Tambahan pula,kajian ini juga menunjukkan bahawa faktor teduhan perlu di pertimbangkan dalam mereka bentuk taman – taman bandar bagi memperoleh keadaan yang sejuk dan selesa.

ACKNOWLEDGEMENTS

Foremost, I would like to express my sincere gratitude to my supervisor Dr. Ruzana Adibah Binti Mohd Sanusi for the continuous support, patience, motivation, time and her knowledge. Her guidance has helped in completing my final year project to be completed on time. I could not have imagined having a better advisor for my final year project. I also want to express my gratefulness to Mr. Kamil, Mr. Faizal and Mrs. Noorfaizan our faculty staffs for their helps in lending me equipment that are needed for this project.

APPROVAL SHEETS

I certify that this research project report entitled "The Influence of Urban Park Types on Vegetation Characteristics and Microclimate Condition" by Felixita Anak Junis has been examined and approved as a partial fulfilment of the requirements for the Degree of Bachelor of Forestry Science in the Faculty of Forestry, Universiti Putra Malaysia.

_____

Dr. Ruzana Adibah Binti Mohd Sanusi

Faculty of Forestry

Universiti Putra Malaysia

(Supervisor)

_____

Prof. Dr. Mohamed Zakaria Bin Hussin

Dean

Faculty of Forestry

Universiti Putra Malaysia

Date: June 2019

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

UHI   Urban Heat Island
UNEP   United Nations Environment Programme
UNFCCC   United Nation Framework Convention on Climate Change
GLAMA   Gap Light Analysis Mobile Apps
ANOVA   Analysis of Variance
LSD   Least Significant Difference
PCI   Park Cool Island

CHAPTER 1

INTRODUCTION

1.1 General Background

Since mid-20 century, climate scientist observed the changes of Earth's climate. The observations are involving various weather phenomenon such as high temperature, precipitation and storm. The changes in Earth's climate are known as global warming, which is the increasing of the air temperature near the surface of earth (Selin & Mann, 2018). The changes of climate are seen to be changing from time to time and one of the main factors that caused the climate change is human activities (Selin & Mann, 2018). Global warming happened due to increased number of humans that has caused greenhouse effects, forest loss, infertile land and biodiversity loss (Grimmond, 2007). The increased number of humans in urban area means that the number of their activities also increased in order to satisfy everyone needs in the cities.

The changes of climate has caused global warming to happened (Ahmad & Hossain, 2015) and it also will affecting food security (Dyer, 2011) because global warming will give a great impact to environment (UNEP and UNFCCC, 2002). In addition, due to this, unfavourable weather events such as storms, floods (Bebbington & Larrinaga-Gonzalez, 2008) and heat wave (Othman *et al.,* 2016) happened. Global warming phenomenon happened due to urbanization in urban area (Grimmond, 2007) since the industrial revolution (Selin & Mann, 2018). In addition, Grimmond (2007) explained that the urban areas are the biggest contributor to global warming because these areas are the major sources of anthropogenic carbon dioxide

1

emissions. The emissions of carbon dioxide are from the fuels that are burned for air conditioning, transport and industrial processes. 90% of anthropogenic carbon emissions are found out to be generated from urban areas (Svirejeva-Hopkins et al., 2004). Moreover, the magnitude of global carbon sinks has been reduced due to the land clearing such as deforestation and demands of goods and resources (Grimmond, 2007).

Malaysia is not exempted in experiencing the global warming phenomenon, where the country has been facing devastating consequence due to the rising of temperature such as flash floods (Akash & Doraisamy, 2015), torrential rain (Gasim, et al., 2014), heat wave (Othman et al., 2016) and hail storms (The Star, 2016). In 2016, United Nation has reported that on the first half of 2016 in Malaysia, the mean global temperature was 1.3°C more warm compared to the late 19th century and it has set to be the hottest year in Malaysia record. Ramakreshnan et al. (2018) explained that the urban heating phenomenon happened in Malaysia is due to the rapid urban development.

In addition, the changing of natural land cover like vegetation into the urban cover has modified the urban climate (Brian & Berry, 2008; Bonan, 2002). The rapid urbanization has reduced the vegetated area and increase the number of built-up surfaces (Buyadi et al., 2013). Decrease of vegetation in urban areas has causes urban areas becomes more warmer compared to rural areas and hence, leads to the occurrence of urban heat island effects (Akbari et al., 2001). Moreover, the causes

2

that leads to urban heat islands phenomenon is due to the condition of the urban area where it is mostly dry, less windy and has a rougher surface compared to rural areas because most of the vegetation surfaces are replaced with the less permeable surface such as paved streets (Robitu et al., 2006). The built-up surfaces in urban areas trapped the solar radiation during a day and re-radiate during night time that will eventually causes global changing the climate condition (Solecki et al., 2004 and Schimidt, 2010).

Vegetation can influence urban climate condition by influencing the environmental variables such as solar radiation, air temperature, relative humidity and wind speed (Wilmers, 1991 and Akbari et al., 2001). Apart from that, the ability of vegetation in influencing urban climate condition is not only through shading and absorbing solar radiation but also through the evapotranspiration (McPherson et al., 1994; Wong et al., 2003; Shashua-Bar et al., 2009). Lu et al. (2012) stated that evapotranspiration from urban green spaces went beyond 14 ha and seen to be able to shows an obvious cooling effect by vegetation.

1.2 Problem Statement

Rapid urban development in cities has caused a problem to urban microclimate because it changes the microclimate condition in urban area, where air temperature in urban area is higher compared to rural area (Ramakreshnan et al., 2018). Akbari et al., (2001), describes this as "Urban Heat Islands" (UHI) effects. In addition, due to the rapid urban development the natural landscape of the area is declining and it automatically becomes the major factor to the changes of urban microclimate.

In addition, vegetation loss at urban area has caused the increasing of heat storage at ground layer and buildings which contributes to the high level of air and surface temperature at urban area compared to rural area (Oke, 1982). The changes of land cover in urban area will lead to the change of surface properties such as heat capacity and conductivity; radiation; roughness length; evaporative conductivity; heterogeneity; Leaf Area Index (LAI) and water characteristics (Molders, 2011). Furthermore, the changes of land cover will automatically be affecting the weather and it will give impact to urban microclimate (Salleh et al., 2013).

The obvious scenario of changes in urban climate in Malaysia can be seen in Kuala Lumpur. Kuala Lumpur is a city that undergoes a rapid urbanization due to its important role to Malaysia economy. Thus, due to rapid urbanization, the city facing a hotter condition where during the past decade, the temperature increased 0.6°C per decade and has been set to be the highest UHI value until year 2005 (Davis et al., 2005).

4

Moreover, another example in Shah Alam, the surface temperature between year 1991 and 2001 increased 0.42°C (Buyadi et al., 2013a) due to vegetation loss and man-made material; and between year 1991 and 2009, surface temperature increased 7.2°C because of 17.48% vegetation loss (Buyadi et al., 2013b). While in Putrajaya, the surface temperature between year 1999 and 2006 increased 4.85°C (Salleh et al., 2013) and Putrajaya also has set a highest temperature record which was 39°C in the area with an impermeable surface compared to the forested area which was 32.5°C (Thani et al., 2013).

From the urban heat islands and urban warming phenomenon, tree plays important role in modifying urban microclimate. According to Federer (1976), either it is a hardwood species or conifer species, trees are capable to evaporate water as much as 250,000 kcal a day. Moreover, there are five major effects of vegetation on urban microclimate which are shading effect, ground temperature effect, surface temperature effect, short-wave reflection effect and wind effect (Scudo, 2002). The capability of vegetation to control air movement is based on the geometry, tree height, permeability, and crown (Scudo, 2002). Generally, trees in urban area help in modifying environmental variables by providing shade to building and surfaces by blocking heat from solar radiation; cooling the air by evapotranspiration process and reduce wind speed (Akbari et al., 2001). Specifically, Scudo (2002) explained that an individual leaf is able to transmit 20% of radiation, absorb 55% radiation and reflect 25% of radiation. In addition, Rowntree (1986) also stated that tree act as natural "air conditioner" because it has a cooling effect.

Keresztesova and Rozova (2013) also claim that the temperature of surfaces that covered by vegetation compared to paved surface can differ up to 12°C. Moreover, vegetation is an important element in urban environment because it can improve thermal comfort at urban area through its cooling effects (Klein & Rozova, 2014). However, each tree has different morphology and the cooling effects provided by each tree are also different. Armson et al. (2012) stated that tree with elliptical canopy provide more shading because of the inclination of the sun. Table 1.1 shows how vegetation structure can influence the urban microclimate.

Table 1.1: Microclimate mitigation strategies by structural vegetal characteristics

			1	2	3	4	5	6	7	8	9	10	11
Structural	Geometry	Columnar	/	/		/		/		/	/	/	/
		Pyramidal	/		/		/		/	/	/	/	/
		Horizontal branching	/	/		/						/	
		Roundhead	/		/		/		/	/	/	/	/
	Deposition	Continuous	/		/		/		/	/	/	/	/
		Irregular		/		/		/			/	/	
		Group	/		/		/		/	/	/	/	/
	Height	High	/	/		/		/		/	/	/	/
		Medium	/	/	/	/	/	/	/	/	/	/	/
		Low		/		/		/		/	/	/	/
		Very low		/		/		/		/			
	Transmission	High		/		/		/					
		Middle	/	/		/		/					
		Low	/			/		/					
	Permeability	High										/	
		Middle									/	/	/
		Low								/		/	/
	Crown	Deciduous	/		/	/	/	/	/	/	/	/	/
		Evergreen	/	/	/		/		/	/	/	/	/

Source: Scudo (2002)

Notes:

1. Shading
2. Surface temperature control (increasing)
3. Surface temperature control (decreasing)
4. Ground temperature control (increasing)
5. Ground temperature control (decreasing)
6. Reflection control – short wave (increasing)
7. Reflection control – short wave (decreasing)
8. Wind obstruction
9. Wind deviation
10. Wind filtration
11. Wind channelling

From the explanation above, we can see how the presence trees at urban areas can influence urban climate and urban heat islands effects through its cooling effects characteristics. Therefore, the presence of green spaces such as urban parks contributes in reducing the temperature at urban area due to the cooling effects (Wang et al., 2015, Moufida & Djamel, 2012), mitigates UHI (Akbari et al., 2001) and reduces surface runoff (Yang et al., 2016). Moufida and Djamel (2012) also stating that the coolest area during daytime at urban area is urban parks because the presence of trees helps to cool the area. However, regardless of the cooling benefits of urban park, each park has different landscape design with a different vegetation structure and this can affect the cooling benefits at each park (Fung & Jim, 2017). Ren et al. (2013) explained that the cooling effects of each park are depending on the characteristics of urban parks.

1.3 Objectives

Therefore, it is important to find out how different urban park types can influence the vegetation characteristics and microclimate condition at urban area. The questions that needed to be answered were (a) How types of park influence vegetation characteristics; and (b) Is the changes of microclimate clearly differ at each urban park due to its types? Thus, the objectives of this project were:

1. To determine the vegetation characteristics of different types of urban park;

2. To investigate the influence of different type of urban park on microclimate condition.

9

REFERENCES

Agency, U. S. (2016). *Using trees and vegetation to reduce heat islands*. Retrieved August 2016, 2016: https://www.epa.gov/heat-islands/using-trees-and-vegetation-reduce-heat-islands

Ahmad, N. N. N. & Hossain, D. M. (2015). Climate change and global warming discourses and disclosures in the corporate annual reports: A Study on the Malaysian Companies. *Procedia - Social and Behaviour Science, 172*, 246 - 253.

Akash, Z. A., & Doraisamy, S. V. (2015). Malaysia flood: impacts and factors contributing towards the restoration of damages. *Journal of Scientific Research and Development, 2*(14), 53 - 59.

Akbari, H., & Taha, H. (1992). The impact of trees and white surfaces on residential heating and cooling energy use in four Canadian cities. *Energy, the International Journal, 17*(2), 141 - 149.

Akbari, H., Pomerantz, M., & Taha, H. (2001). Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. *Solar Energy, 70*, 295 - 310.

Annerstedt, M., Östergren, P., Björk, J., Ghran, P., Skärbäck, E., & Währborg, P. (2012). Green qualities in the neighbourhood and mental health – results from a longitudinal cohort study in Southern Sweden. *The European Journal of Public Health, 22*, 275 - 276.

Armson, D. S. (2012). The effects of tree shade and grass on surface and globe temperatures in an urban area. *Urban Forestry & Urban Greening, 11*(3), 245 - 255.

Barradas, V. L. (1991). Air temperature and humidity and human comfort index in some city parks of Mexico City. *Bio Meteorology, 35*, 24 - 28.

Bebbington, J. & Larrinaga-Gonzalez, C. (2008). Carbon trading: accounting and reporting issues. *European Accounting Review, 17*, 697 - 717.

Behrens, L. (2011). Selecting public street and park trees for urban environment: the role of ecological and biogeographical criteria. Christchurch: Lincoln University.

Björk, J., Albin, M., Grahn, P., Jacobsson, H., Ardö, J., Wadbro, J., Östergren, P., & Skärbäck, E. (2008). Recreational values of the natural environment in relation to neighbourhood satisfaction, physical activity, obesity and wellbeing. *Journal of Epidemiology and Community Health, 62, e2*.

Bonan, G. (2002). Ecological climatology, concepts and applications. *Cambridge University Press, 2*, 8 - 31.

Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010). Urban greening to cool town and cities: A systematic review of the emperical evidence. *Landscape and Urban Planning, 97*, 147 - 155.

Brian, J. & Berry, L. (2008). Urbanization. *Urban Ecology, 1*, 25 - 48.

Brown, R., Vanos, J., Kenny, N. & Lenzholzer, S. (2014). Designing urban parks that ameliorate the effects of climate change. *Landscape and Urban Planning,* 138.

Buyadi, S. N. A., Mohd, W. M. N.W., & Misni, A. (2013a). Green spaces growth impact on the urban microclimate. *Procedia - Social and Behavorial Sciences, 105*, 547 - 557.

Buyadi, S. N. A., Mohd, W. M. N.W., & Misni, A. (2013b). Impact of land use changes on the surface temperature distribution of area surrounding the national botanic garden, Shah Alam. *Procedia - Social and Behavorial Sciences, 101*, 516 - 525.

Chen, J., Saunders, S., Crow, T., Naiman, R., Brosofske, K., Mroz, G. D., Brookshire, B. L., & Franklin, J. F. (1999). Microclimate in forest ecosystem and landscape ecology: variations in local climate can be used to onitor and compare the effects of different management. *Bioscience, 49*(4), 288 - 297.

Corlett, R. & Primack, R. (2005). Dipterocarps: Trees that dominate the asian rainforest. *Arnold Arboretum of Havard University.*

Davis, A. Y., Jung, J., Pijanowski, B. C., & Minor, E. S. (2016). Combined vegetation volume and "greeness" affect urban air temperature. *Applied Geography* , 106 - 114.

Davis, M. P., Nordin, N. A., Ghazali, M., Durak, M. J. & Reimann, G. (2005). Reducing urban heat island effect with thermal comfor housing and honeycomb township. *Conference on Sustainable Building South East Asia.*

Deusker, C., Baker, J., & Mason, D. (2015). East Asia's Changing Urban Landscape: Measuring a Deade of Spatial Growth. *East Asia: The Wold Bank.*

Dimoudi A & Nikolopoulou M. (2003). Vegetation in the urban environment: microclimatic analysis and benefits. *Energy and Building, 35*, 69 - 79.

Dyers, G. (2011). Climate wars the fight for survival as the world overheats. *Oxford: Oneworld.*

Environmental, F. (2010). What is air temperature. Foundriest Environmental Retrieved August 12, 2010: https://www.fondriest.com/news/airtemperature.htm

Federer, C. A. (1976, July). Trees modify the urban microclimate. *Journal of Arboriculture, 2* , 121 - 127.

Finaeva, O. (2017). Role of green spaces in favourable microclimate creating in urban environment (Exemplified by Italian cities). *Materials Science and Engineering, 262*.

Fung, CK. W., & Jim, CY. (2017). Assessing the cooling effects of different vegetation settings in a Hong Kong golf course. *Procedia - Environmental Science, 37*, 626 - 636.

Gasim, M. B., Toriman, M. E. & Abdullahi, M. G. (2014). Floods in Malaysia historical reviews, causes, effects and mitigations approach. *International Journal of Interdisciplinary Research and Innovations, 2*(4), 59 -65.

Geiger, R. (1965). The climate near the ground. *Cambridge: Havard University Press.*

Grimmond, S. (2007). Urbanization and global environmental change: local effects of urban warming. *Cities and Global Environmental Change, 173*, 83 - 88.

Keresztevoza, S., & Rozova, Z. (2013). Influence of vegetation on surface temperature in urban areas. *Folia Oecologica, 40*.

King, D. A., Davies, S. J., Tan, S. & Noor, N. S. M. (2009). Trees approach gravitation limits to height in tall lowland forests of Malaysia. *Functional Ecology, 23*, 284 - 291.

Kleerekoper, L., Esch, M. V., & Salcedo, T. B. (2012). How to make a city climate - proof, addressing the urban heat island effect. *Resources, Conservation and Recycling,64*, 30 - 38.

Klein, J., & Rozova, Z. (2014). Impact of vegetation on microclimate in different layouts of built-up areas in urbanised environment of nitra municipality in spring period. *Mendel a bioklimatologie. Brno*.

Koerniawan, D., M., & Gao, W. (2013). Thermal comfort measurement and comparison of 3 biggest recreation park in Jakarta. *PhD Candidate, Department of Architecture Faculty of Environmental Engineering The University of Kitakyushu Hibikino Campus*.

Konijnendijk, C. C. (2013). Benefits of urban parks. *Copenhagen & Alnarp*.

Kurn, D.M., Bretz, S.E., Huang, B., & Akbari, H. (1994). The potential for reducing urban air temperatures and energy consumption through vegetative cooling.

Linden, J., Fonti, P. & Esper, J. (2016). Temporal variations in microclimate cooling induced by urban trees in Mainz, Germany. *Urban Forestry & Urban Greening* , 198 - 209.

Lu, J., Li, C. D., Yang, Y. C., Zhang, X. H., & Jim, M. (2012). Quantitaive evaluation of urban park cool island factors in mountain city. *Journal of Central South University, 19*, 1657 - 1662.

Maas, J., Dillen, S.M.E. van, Verheij, R.A., & Groenewegen, P.P. (2009). Social contacts as a possible mechanism behind the relation between green space and health. *Health and Place, 15*, 586 - 595.

Maas, J., Verheji, R. A., Groenewegen, P. P., Vries, S. D., & Spreeuwenberg, P. (2006). Green space, urbanity, and health: how strong is the relation. *J Epidemiol Community Health, 60*, 587 - 592.

Martini, A., Biondi, D., & Batista, A. C. (2017). Urban forest components influencing microclimate and cooling potential. *Revist Arvore, 41*.

McPherson, E. G., & Simpson, J. R. (2000). Reducing air pollution through urban forestry. *Proceedings of the 48th Meeting of Carlifornia Pest Council In: Meza H. M. B., 1992* (pp. 33 - 36). Mexico: J. Arboric.

McPherson, E. G., Nowak, D. J., Heisler, G., & Grimmond, C. S. B. (1994). *Chicago's urban forest ecosystem: Results of the Chicago climate project.* United States Department of Agriculture.

Mitchell, R., & Popham, F. (2008). Effect of exposure to natural environment on health inequalities: an observational population study. *The Lancet, 372*(9650), 1655 - 1660.

Mölders, N. (2011). Land-Use and Land-Cover-Changes: Impact on Climate and Water Quality, *Springer Verlag, 44*.

Moufida, B., & Djamel, A. (2012). Impact of vegetation on thermal conditions outside, thermal modelling of urban microclimate: Case study, the street of republic, Biskra. *Energy Procedia, 18*, 73 - 84.

Nasir, R. A., Ahmed, S. S., & Ahmed, A. Z. (2012). Psychological adaptation of outdoor thermal comfort in shaded green spaces in Malaysia. *Procedia - Social and Behavioral Sciences*, 68, 865 - 878.

National Meteorological Library and Archive. (2011). Microclimates. *Fact sheet 14*.

Nowak, D. J. (2002). The effects of urban trees on air quality. *USDA Forest Service, Syracuse, NY*, 1 - 5.

Nowak, D. J. & Dwyer, J. F. (2007). Understanding the benefits and costs of urban forest ecosystem. *Urban and Community Forestry in the Northeast*, 25 - 46.

Oke, T. R. (1982). The energetic basis of the urban heat island. *Quaterly Journal of the Royal Meteorologicla Society, 108*, 1 -24.

Othman, M., Ash'aari, Z. H., Muharam, F. MM., Sulaiman, W. N. A., Hamisan, H., Mohamad, N. D., & Othman, N. H. (2016). Assessment of drought impacts on vegetation health: a case study in Kedah. *Earth and Environmental Science, 37*.

Perry, R. H., & Green, D. W. (1994). In *Perry's Chemical Engineers' Handbook* (pp. 12 - 7). McGraw-Hill Eqn.

Pidwirny, M. (2006). Plant succession. Physical Geography.net. Retrieved from: http://www.physicalgeography.net/fundamentals/9i.html

PPJ. (2019). Parks and landscape. Perbadanan Putrajaya. Retrieved April 24, 2019: http://www.ppj.gov.my/portal/page?_pageid=311,1&_dad=portal&_schema=PORT AL#1264

Rainforest Journal. (2010). Rainforest info, images and adventure. Rainforest Journal. Retrieved: https://www.rainforestjournal.com/dipterocarp-trees/

Ramakreshnan, L., Aghamohammadi, N., Fong, C. S., Ghaffarianhoseini, A., Wong, L. P., Hassan, N., & Sulaiman, N. M. (2018). A critical review of urban heat island phenomenon in the context of greater Kuala Lumpur, Malaysia. *Sustainable Cities and Society, 39*, 99 -113.

Ren, Z., He, X., Zheng, H., Zhang, D., Yu, X., Shen, G., & Guo, R. (2013). Estimation of the relationship between urban park characteristics and park cool island intensity by remote sensing data and field measurement. *Forests, 4*, 868 - 886.

Robitu, M., Musy, M., Inard, C., & Groleau, D. (2006). Modelling the influence of vegetation and water pond on urban microclimate. *Solar Energy, 80*, 435 - 447.

Rosenfield, A. H., Akbari, H., Romm, J. J., & Pomerantz, M. (1998). Cool communities strategies for heat island mitigation and smog reduction. *Energy and Building, 28*, 51 - 62.

Rowntree, A. (1986). Ecological of the urban forest - introduction to part II. *Urban Ecology, 9*, 229 - 243.

Rutledge, K., McDaniel, M., Boudreau, D., Ramroop, T., Teng, S., Sprout, E., Costa, H., Hall, H., & Hunt, J. (2011). *Urban Area*. Retrieved January 21, 2011: https://www.nationalgeographic.org/encyclopedia/urban-area/

Salleh, S. A., Latif, Z. A., Mohd, W. M. N.W., & Chan, A. (2013). Factors contributing to the formation of an urban heat islandin Putrajaya, Malaysia. *Procedia - Social adn Behavorial Sciences, 105*, 840 - 850.

Schimidt, M. (2010). Ecological design for climate mitigation in contemporay urban living. *International Journal of Water, 5*, 337 - 352.

Scudo, G. (2002). Thermal comfort in greenspace. *Proceeding COST 11"Green Structures and Urban Planning"*. Milan.

Selin, H. & Mann, M. E. (2018). Global warming. *Encyclopedia Britannica*. Retrieved November 30, 2018: https://www.britannica.com/science/global-warming

Sharifah Khalizah, S. O. T., Nik Hanita, N. M., & Sharifah Mastura, S. A. (2013). The influence of urban landscape morphology on the temperature distribution of hot-humid urban centre. *Procedia - Social and Behavioral Science, 85*, 356 - 367.

Shashua-Bar, L., & Hoffman, ME. (2004). Quantitative evaluation of passive cooling of the UCL microclimate in hot regions in summer, case study: urban trees and countryard with trees. *Building and Environment, 39*, 99 - 1087.

Shashua-Bar, L., Pearlmutter, D., & Erell, E. (2009). The cooling efficiency of urban landscape strategies in a hot dry climate. *Landscape and Urban Planning, 92*, 179 - 186.

Shirley, H. (1945). Light as an ecological factor and its measurement . *Botanical Review 1*, 497 - 532.

Solecki, WD., Rosensweig, C., Pope, G., Chopping, M., & Goldberg, R. (2004). *Urban heat island and climate change: an assessment of interacting and possible adaptations in the camden, 6*. 39 - 49. New Jersey Region: New Jersey Department of Environmental Protection.

The Star. (2016). Hailstorm and flash flood mayhem in KL. *The Star*. Retrieved from: http://www.thestar.com.my/news/nation/2016/06/04/hailstorm-and-flashflood-

Stigsdotter, U. K., Ekholm, O., Schipperijn, J., Toftager, M., Kamper-Jørgensen, F., & Randrup, T. B. (2010). Health promoting outdoor environments - Associations between green space, and health, health-related quality of life and stress based on a Danish national representative survey. *Scandinavian Journal of Public Health, 38*, 411 - 417.

Svirejeva-Hopkins, A., Schellnhuber, H. J., & Pomaz, V. L. (2004). Urbanised territories as a specific component of the global carbon cycle. *Ecological Modelling, 173*, 295 - 312.

Tahir, H. M. M., & Yousif, T. A. (2013). Modelling the effect of urban trees on relative humidity in Khartoum state. *Journal of Forest Products & Industries*, *2*, 20 - 24.

Thani, S. K. S. O., Mohamad, N. H. N., 7 Abdullah, S. M. S. (2013). The influence of urban landscape morphology on the temperature distribution of hot-humid urban centre. *Procedia - Social and Behavioral Science, 85*, 356 - 367.

Thompson, C. W., Roe, J., Aspinall, P., Mitchell, R., Clow, A., & Miller, D. (2012). More green space is linked to less stress in deprived communities: Evidence from salivary cortisol patterns. *Landscape and Urban Planning, 105*, 221 - 229.

UN. (2016). Pace to be the hottest year ever as climat change trends reach 'new climax'. *UN Daily News*. Retrieved from: http://www.un.org/News/dh/pdf/

UNEP and UNFCCC. (2002). Climate Change Information Kit. *UNEP: France*.

Wang, Y., Bakker, F., & Groot, R. D. (2015). Effects of urban trees on local outdoor mictoclimate: synthesizing field measurementts by numerical modelling. *Urban Ecosyst, 18*, 1305 - 1331.

Wilmers, F. (1991). Effects of vegetation on urban climate and buildings. *Energy and Buildings, 15*, 507 - 514.

Wong, N. H., Cheong, D. K. W., Yan, H., Soh, J., Ong, C. L., & Sia, A. (2003). The rooftop garden on energy consumption of a commercial buildings in Singapore. *Buildings, 35*, 353 - 364.

Yang, P., Xiao, Z. N., & Ye, M.S. (2016). Cooling effect of urban parks and their relationship with urban heat islands. *Atmospheric and Oceanic Science Letters, 9*, 298 - 305.

Zhang, Z., Lv, Y. & Pan, H. (2013). Cooling and humidifying effect of plant communities in subtropical urban parks. *Urban Forestry & Urban Greening, 12*, 323 - 329.