SITE SUITABILITY ANALYSIS OF PARKS IN ISKANDAR MALAYSIA USING GIS AND ANALYTICAL HIERARCHY PROCESS

FATEEN NABILLA BINTI RASLI

UNIVERSITI TEKNOLOGI MALAYSIA

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FATEEN NABILLA BINTI RASLI

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Dedicated to:

My beloved ayah and umi,
Rasli bin Ismail and Norliza binti Mohamad Yamin…

My little sisters and brother,
Fateen Nadia binti Rasli, Fateen Nadhira binti Rasli, late Puteri Darwina binti Rasli, Nur Syaznie Aliya binti Rasli and Adam Aliff bin Rasli…

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ABSTRACT

The development activities are primarily for the economical purposes for Malaysia. Therefore the developments keep growing year by year rapidly to achieve the vision. As the urbanization is taking place, more people will be needed to accomplish the development and this will lead to increasing of population, transportation and industrial activities. Different problems also occur such as immethodical increase of population, physical extension of cities causelessly as well as increasing in social and environmental pollutions. Environmental problems occurs as increasing population, transportation and industrial activities will release much greenhouse gases and this will make that particular area warm and high in CO_2 concentration. These all possible impacts will make things worse and will bring the negative impacts to the society related. To overcome this environmental problem, Low Carbon Society (LCS) is the best way to be initiated. The usage of hybrid car, low carbon bulb and low carbon building materials is some of the applications to reduce the CO_2 concentration in the city. In this study, the focus will be low carbon cities in the aspect of urban park as a way to reduce carbon as the trees will be planted to consume carbon. Therefore to balance and overcome these problems, urban green space or urban park can be created for both purposes of aesthetic and recreation role. The community in urban parks will act as preserving and balancing the urban environment as well as regulating pollution air. The objectives of this study are to conduct site suitability analysis in Iskandar Malaysia (IM) to find suitable location for urban park development and proposing tree species suitable for parks. The result of this study display the site suitability maps produced by using the integration method of Analytical Hierarchy Process (AHP) and Geographic Information System (GIS) for six different types of parks that were suitable to be developed in IM and list of tree species that can be considered to add in Malaysia's parks based on their carbon storage and sequestration level. For this study, tree species that can help to increase carbon sequestration in parks are

pterocarpus indicus, tabebuia rosea, syzygium grande, peltophorum pterocarpum, khaya senegalensis and fagraea fragrans as the trees can store a really high carbon from the atmosphere as they record 1,601, 1,308, 1,012, 905, 746, and 639 tonne C respectively. On the other hand, the tree species that is suitable to be planted in roadsides are Samanea saman, Khaya senegalensis, Pterocarpus indicus, Peltophorum pterocarpum, Swietenia macrophylla, Syzygium grande, Tabubuia rosea, Khaya grandifoliola, Terminalia catappa, Cinnamomum iners, Arfeuillea arborescens and Mangifera indica. These tree species store tremendous amount of carbon with the records of 31,270, 12,127, 12,032, 10,266, 7,628, 7,541, 3,692, 2,940, 2,009, 1,948, 1,450 and 1,237 tonne C respectively.

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AHP	-	Analytical Hierarchy Process
CO_2	-	Carbon Dioxide
CI	-	Consistency Index
CR	-	Consistency Ratio
DEM	-	Digital Elevation Model
GIS	-	Geographic Information System
GHG	-	Green House Gases
IM	-	Iskandar Malaysia
IRDA	-	Iskandar Regional Development Authority
JPBD	-	*Jabatan Perancangan Bandar dan Desa*
LCS	-	Low Carbon Society
LCC	-	Low Carbon Cities
LST	-	Land Surface Temperature
MCDA	-	Multi Criteria Decision Analysis
MSW	-	Municipal Solid Waste
NASA	-	National Aeronautics and Space Administration
SCA	-	Spatial Cluster Analysis
UHI	-	Urban Heat Island
WLC	-	Weighted Linear Combination

ABSTRAK

Aktiviti pembangunan adalah bagi tujuan meningkatkan kemajuan ekonomi Malaysia. Oleh itu pembangunan dan kemajuan ini meningkat bagi mencapai visi dan misi. Dengan urbanisasi yang sedang berlaku, lebih ramai orang diperlukan untuk mencapai pembangunan dan ini akan menyumbang kepada peningkatan aktiviti penduduk, pengangkutan dan industri. Namun begitu dengan peningkatan- peningkatan ini, masalah yang berbeza juga akan berlaku seperti peningkatan penduduk yang tidak teratur, fizikal bandar yang kurang teratur serta peningkatan pencemaran sosial dan alam sekitar. Masalah alam sekitar berlaku kerana penduduk semakin ramai di sesebuah tempat, dimana aktiviti pengangkutan dan perindustrian akan melepaskan gas rumah hijau dengan kadar yang banyak dan akan menjadikan kawasan tersebut semakin panas dan tinggi kandungan karbon. Ini akan memburukkan lagi keadaan dan membawa kesan negatif kepada masyarakat yang terlibat. Bagi mengatasi masalah alam sekitar ini, Low Carbon Society (LCS) adalah cara yang terbaik untuk dimulakan. Penggunaan kereta hibrid, mentol rendah karbon dan bahan-bahan bangunan rendah karbon adalah sebahagian daripada langkah untuk mengurangkan kandungan karbon di bandar. Dalam kajian ini, fokus utama adalah kepada bandar rendah karbon dalam aspek pembinaan taman bandar sebagai satu cara untuk mengurangkan karbon kerana pokok akan ditanam untuk menyerap karbon yang berlebihan. Oleh itu untuk mengimbangi dan mengatasi masalah ini, ruang hijau bandar atau taman bandar boleh diwujudkan untuk kedua- dua peranan sama ada sebagai peranan estetik atau rekreasi. Komuniti di dalam taman-taman bandar akan bertindak sebagai pemelihara dan mengimbangi persekitaran bandar serta mengawal pencemaran udara. Objektif kajian ini adalah untuk menjalankan analisis kesesuaian tapak di Iskandar Malaysia (IM) untuk mencari lokasi yang sesuai untuk pembangunan taman bandar dan mencadangkan spesies pokok yang sesuai untuk ditanam di taman dan juga di tepi jalan utama. Hasil kajian ini memaparkan peta kesesuaian tapak

yang dihasilkan dengan menggunakan kaedah integrasi Proses Analisis Hierarki (AHP) dan Sistem Maklumat Geografi (GIS) untuk enam jenis taman yang sesuai untuk dibangunkan di Iskandar Malaysia dan senarai spesies pokok yang boleh dipertimbangkan untuk ditambah dalam taman Malaysia berdasarkan penyimpanan karbon yang tinggi. Berdasarkan hasil kajian ini, spesies pokok yang sesuai ditanam di taman ialah pterocarpus indicus, tabebuia rosea, syzygium grande, peltophorum pterocarpum, khaya senegalensis dan fagraea fragrans dengan rekod penyimpanan karbon yang tinggi iaitu 1,601, 1,308, 1,012, 905, 746, and 639 tan karbon. Manakala spesies pokok yang sesuai ditanam di sepanjang jalan- jalan ialah samanea saman, khaya senegalensis, pterocarpus indicus, peltophorum pterocarpum, swietenia macrophylla, syzygium grande, tabubuia rosea, khaya grandifoliola, terminalia catappa, cinnamomum iners, arfeuillea arborescens and mangifera indica di amana masing- masing mencatatkan rekod penyimpanan karbon 31,270, 12,127, 12,032, 10,266, 7,628, 7,541, 3,692, 2,940, 2,009, 1,948, 1,450 dan 1,237 tan karbon.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The world economy is rising day by day making the urban population rising directly proportional to it. One of the most salient features that characterize human development during the past millennium is accelerating urbanization (Jianguo *et al.*, 2014). It is predicted that in the next 30 years starting the year 2000 until 2030, the population will double its numbers adding 2 billion more people The same thing goes to the urban regions, as population rising, the built-up urban areas is spreading too. It is stated that these areas will increase by 1.2 million kilometer squares making it triple the amount of global land area in the previous year 2000 (World Bank Organization, 2014). In addition, more than 50% world population are now live in urbanized areas and almost all future global population growth will be taken place in the urbanized area. By the next 35 years on 2050, it is forecasted that the developing and developed areas will cover 64.1% and 85.9% in the world urbanization. If the human population

knows how to handle the urbanization properly, sustainable development can be guaranteed worldwide.

Despite the urbanization, it does bring challenge to the man- kind. This is due to the facilities high demand, jobs, real estate value and housing. As cities develop and urbanization is taking place, more people will be needed to accomplish the development. Majority of humans will live in the cities, refining human well- being while preserving the environment inside and outside urban areas is a great encounter. This is particularly exact for the developing countries because the cities are encountered with more worse environmental and socio economic problems and because their small- and medium-sized cities will be the base to the future urban growth (Jianguo *et al.*, 2014).

As all these activities of urban development increases, this will lead to increasing population, transportation and industrial activities. Different problems also occur along this increment such as social problem, infrastructural and environmental problems. The exposure to climate and disaster risk also increases. Environmental problems happened as increasing population, transportation and industrial activities will release much greenhouse gases (GHG) for instance carbon dioxide (CO_2) , nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO) causing high polluted gas filling the world generally and urbanized area specifically, then increase the land surface temperature (LST) which lead to the urban heat island (UHI) phenomenon.

For the phenomenon of UHI, most cities and villages create their own heat island. This happens as the temperature inside a city is higher than outside area due to climatic factors as well as less concealed heat in a city because of less transpiration due to inadequate green zones or green spaces. It is also because of man-made precipitation drainage, bigger heat capacity of building walls and asphalt covering, changes of radiation balance in cities including

industrial haze (Lokoshchenko, 2014). Because of the climatic change and the UHI phenomenon, this leads to the increment of cities temperature. The weakening of comfortable condition, vulnerable exposure to the population and increasing the pollution problem is some of the effects from the high ambient temperature (Santamouris, 2012). Built- up areas are the high vulnerable areas which then lead to temperature rise, energy intake and air pollution (Chun & Guldmann, 2014).

Referring to National Aeronautics and Space Administration official website (NASA, 2014), the global temperature and global CO_2 content level keep increasing year by year. The latest measurement made by NASA in November 2014 shows the reading of 399.3 parts per million (ppm) of global CO_2 contents compared to the year 2005 which shows the reading of 378 ppm. It is a worrisome increment of 22 ppm of CO_2 level in a decade period.

1.2 Problem Statement

CO_2 is one of the major greenhouse gases released via human activities such as deforestation and burning fossil fuels. It is also released from the natural process of human respiration and volcanic eruptions. Therefore, all of these activities contribute to the rise of CO_2 from the development of urbanized areas which many complications may come along to this process. The greatest concerned problem related with the urban progress is the rising LST and the GHG release especially from the transportation and industrial activities.

Approximately 49% of the total GHG emissions in Malaysia were contributed by the transportation related activities (Lim & Lee, 2012). Because of this problem, the local climate has been changed along with the global climate change. In order to overcome this environmental problem, Low Carbon Society (LCS) is the best way to be initiated. The usage of hybrid car, low carbon bulb and low carbon building materials is some of the applications to reduce the carbon content in the city that aims towards in reducing the GHG emissions (Ghaffar *et al.*, 2013).

Following the LCS concept, Malaysia also has started to adopt low carbon strategies in several cities in the country. In an economic zone in Malaysia centered on Johor Bahru, also known as Iskandar Malaysia (IM), efforts are being undertaken by the development authority, planners, and many organization in order to make the region and people as a low carbon cities and societies respectively by 2025. Low carbon strategies will be formulated for power generation, industry, commercial, residential and transportation sectors (Low Carbon Society Blueprint for Iskandar Malaysia, 2013). CO2 that is already in the atmosphere will be reduced by adopting the blue and green infrastructure.

The blue and green infrastructure is one of the important features in urban areas. This is because due to the deforestation for development, the temperature increases making less temperature can be trapped by the trees. Therefore, the green spaces adopted can be a medium to reduce CO_2. The urban park communities can preserved and balanced the environment and also regulating polluted air by absorbing the excessive CO_2, reducing high temperature in urban areas and function well as thermal comfort.

Urban parks or generally green spaces are a part of physical extent of the city that can contain specific function. As urban region increasing, different problems occur to that particular region especially the effect to the environment which will cause the increase in environmental pollutions. Therefore, urban park has found its important roles. The roles are preserving as well as balancing the urban environment and also regulating air pollution.

These green spaces are the most crucial features in green corridors. This is because green infrastructure helps in lowering CO_2 contents. Specifically in urbanized areas, these green spaces which are covered mostly by trees will helps in CO_2 storage and sequestration, moderating the city temperature and thus reducing the polluted gas emission.

The green and blue infrastructures are also being highlighted in the project so that LCS plan can be effectively adopted in Malaysia generally and IM specifically. The problem existed in IM now is the existing green environment is only 32, 777.33 hectares covering only 15.9% of the total area. Therefore with the existing population of 1.35 million people in IM, the ratio of people to the green and blue infrastructures is only 41 people per hectare for IM (Comprehensive Development Plan 2006-2025 for South Johor Economic Region, 2006). This is not enough green environment therefore there is a need in additional green spaces pertaining to the circumstance. This study attempt to increase the number of suitable parks to the existing parks in IM by finding the suitable location of the parks to increase the cooling effect and overcome the circumstance of insufficient green environment in IM.

1.3 Aim and Objectives

The aim of this study is to propose suitable locations to be developed as parks in IM and suitable tree species to be planted in these parks to reduce CO_2 content in the urbanized areas. This aim will be achieved by adopting the following objective:

(i) to conduct site suitability analysis in Iskandar Malaysia finding the most potential areas to be developed as parks (Recreation Park, Playground Lot, Playground Park, Neighbour Park, Local Park and Urban Park);

(ii) to determine and propose via literature survey suitable tree species that can act to lowering CO_2 content in the urban atmosphere

1.4 Scope

This study covers the entire Iskandar Malaysia (IM) region. IM was chosen in this study as it is the rapid developing area in Johor, therefore this area implementing parks in its area to act as lowering CO_2 content in that particular region. The site selection for six types of parks in IM will follows and considers the parameters in accordance to the Town and Regional Planning Department of Peninsular Malaysia guidelines.

There are six types of parks will be analysed in this study which are Recreation Park, Playground Lot, Playground Park, Neighbour Park, Local Park and Urban Park conducted based on three parameters. The parameters are size, accessibility distance from main road and slope degree allowed. The contour lines provided for this study did not covered Pontian parts as the parts are mainly

covered by mangrove forests thus the result will be acknowledged without Pontian mangrove area. Originally there are four parameters set by JPBD including the resident population size but this parameter cannot be provided because of the outdated survey conducted for the population size in Iskandar. Moreover, this study focused on different types of parks in IM. If the residents' population size is included in the parameters, this will lead to only urban park that can be developed in IM thus abandoning the park size parameter where more park hierarchy can be developed in the region.

For this study, Geographic Information System (GIS) tool was used to select and analyses the suitable locations sites in IM. Analytical Hierarchy Process was integrated with GIS in analysing parks' location. AHP is a powerful tool to be integrated with GIS in site suitability analysis. This is because rather than giving only specific area and location which is suitable to develop parks, AHP will give range of location from least suitable to most suitable location. Therefore this is important to users especially for the decision makers to decide the suitable areas to be considered in their plans.

Apart from site suitability analysis using AHP and GIS, the identification of suitable tree species to be planted was determined based on literature survey. This identification is very crucial as to know which tree species will be of highly useful to absorb CO_2 content at maximum rate. The better the storage and sequestration of CO_2 by the trees, the better the cooling effect of the parks.

1.5 Study Area

IM covers entire district of Kulaijaya and also Johor Bahru, and several sub- districts of Pontian. For the local administration, it covers five local authorities which are the Johor Bahru City Council (MBJB), Johor Bahru

Tengah Municipal Council (MPJBT), Pasir Gudang Municipal Council (MPPG), Kulaijaya Municipal Council (MPKu) and Pontian District Council (MDP). IM was managed by Iskandar Regional Development Authority (IRDA), a Malaysian organization body tasked with the vision of evolving Iskandar Malaysia into strong economic region.

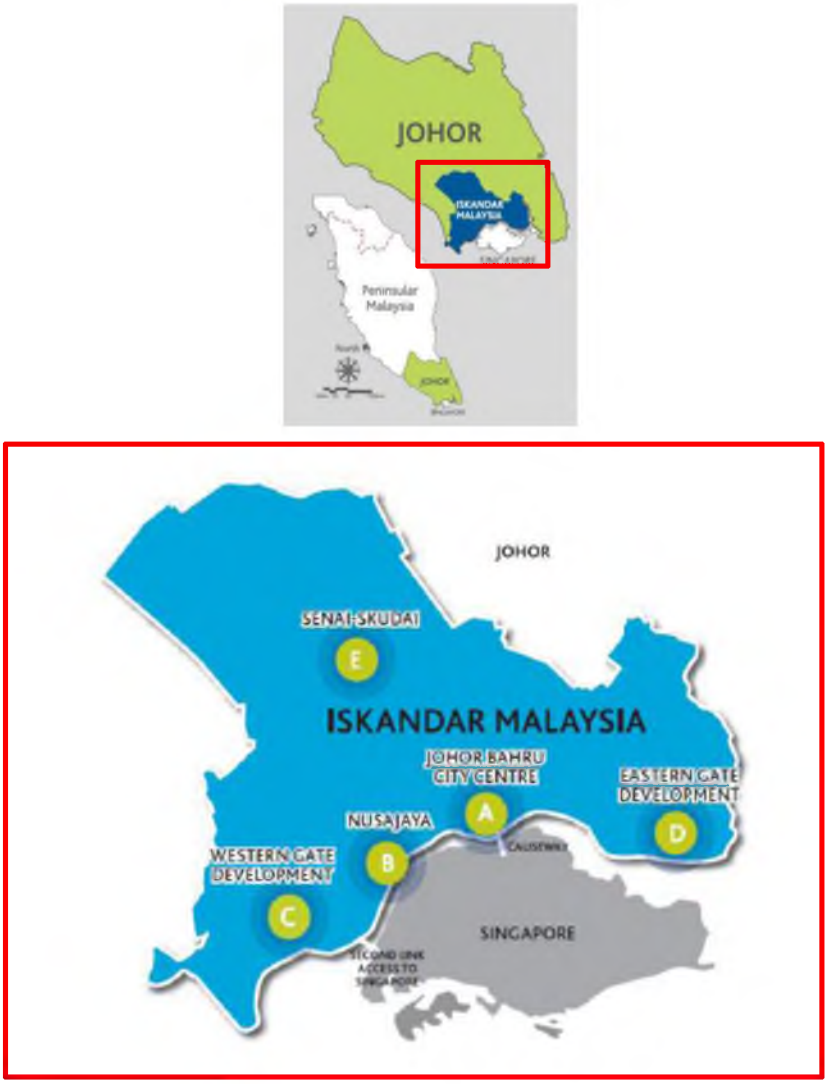

Figure 1.1: Study Area in Iskandar region in Johor, Peninsular Malaysia with the Five Flagships in Iskandar region

(Source: Low Carbon Society Blueprint for Iskandar Malaysia 2025 - Summary for Policymakers)

Iskandar region is located in the Peninsular Malaysia in the south part, in the state of Johor and covered approximately 221,634 hectares (2,216.3 km^2) in area and divided into five flagship zones, A, B, C, D and E. Flagship A covers Johor Bahru City Centre, Flagship B covers Nusajaya area while Flagship C or the Western Gate Development covers Port of Tanjung Pelepas. As for Flagship D or the Eastern Gate Development covers Pasir Gudang area especially Tanjung Langsat Port and Johor Part and last but not least Flagship E covers Senai-Skudai area (Figure 1.1).

1.6 Significance of Study

This research will be useful especially to Iskandar Regional Development Authority (IRDA) as from the results obtained, they can locate which area is really suitable to be developed as parks in IM. Moreover, IRDA can consider developing new green spaces in particular of urban park for the urbanized areas so that this will be one of the way for reducing the high CO_2 content and cooling effect to the particular areas as well as towards society usage. Besides, the identification of tree species to be planted in an urban park can help in lowering carbon content to achieve the Low Carbon Society (LCS) plan. IRDA can also consider to plant those trees that can absorb CO_2 thus increasing the rate of cooling effect.

In conjunction of all these importance, IRDA collaborated with Universiti Teknologi Malaysia (UTM) and Japan International Cooperation Agency (JICA) for the effort and attempt to adopt LCS in IM. The project consist of few sub- actions to be taken and applied in IM. They are regional green corridor network, conservation of mangrove forests, promoting urban forest, new development to retain existing vegetation, low carbon farming in rural areas

and ecotourism and rural- cultural tourism. This shows that LCS is really important and been given attention by many parties.

1.7 Organization of Chapter

This dissertation is divided into five chapters. Chapter One provides a very brief introduction and background of the study. Chapter Two review previous studies that is related to this research. The Low Carbon Society (LCS) concept is explained along with the examples of its application and why LCS is important to the developed and developing countries. Moreover, the roles and importance of urban parks as well as the parameters used to identify suitable areas for urban parks are introduced in this chapter. The role of urban parks in lowering CO2 is also provided. Moreover, the species of trees that can help in lowering CO2 in the city environment are listed. Chapter Three describes the whole process and methods or techniques used to produce the site suitability map for the final output. Chapter Four describes the main results of this study and discusses the implication of the results. Chapter Five summarizes the study and highlights the opinions and recommendations that can be considered for future studies. The next chapter begins with introducing the concept of LCS and its importance followed by the parks roles, site selection methods and the advantages of AHP and GIS integration in determining the suitable and potential locations for parks.

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