IMPACT OF LAND USE AND LAND COVER CHANGE ON LAND SURFACE TEMPERATURE IN ISKANDAR MALAYSIA USING REMOTE SENSING TECHNIQUE

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Dedicated to my beloved parents and family, whom without their love and support this research would have never been completed.

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ABSTRACT

Iskandar Malaysia is one of the impressive development projects ever undertaken in Malaysia that has been experiencing rapid rate of land use change since 2006. Land use change is due to the urban expansion and reduction in natural green areas resulted from enhanced economic growth. The three objectives of this study are (i) to estimate the land use and land cover changes (LULC) in Iskandar Malaysia from 1989 to 2014, (ii) to investigate the effect of LULC changes on land surface temperature (LST) change in the study area and (iii) to predict the LST by 2025. Remote sensing data namely Landsat (Landsat 5, 7 and 8) and Moderate Resolution Imaging Spectroradiometer (MODIS) of Terra product (MOD11A1) were used to classify various LULC and to calculate the LST in Iskandar Malaysia. There are two digital classification techniques used to classify and test the different LULC in this study area. Maximum Likelihood Classification (MLC) technique provided higher accuracies compared to the Support Vector Machine (SVM) technique. Consequently, the classified satellite images using the MLC technique were used to monitor changes in LULC in Iskandar Malaysia. LST was extracted using mono window. The mean LST using Geographic Information System (GIS) analysis according to LULC shows that water areas recorded the highest night time LST value, while forest recorded the lowest day time LST value. Urban areas are the warmest land use during the day and the second warmest land use during the night time. Moreover, the weighted average used to predict the mean LST of entire Iskandar Malaysia, it was found that if green space increases LST value would decrease by 0.5°C. To predict the effect of LULC changes on mean LST of each LULC types linear curve fitting model was used. According to the results, the mean night LST from 2000 to 2025 will increase in Iskandar Malaysia as urban (20.89°C to 22.39°C±0.45), mangrove (20.88°C to 22.59°C±0.50), forest (20.39°C to 21.04°C±0.18), oil palm (20.39°C to 21.25±0.25), rubber (20.34°C to 22.36°C ± 0.57), and water (21.61 °C to 23.31°C ± 0.51). The results show increment in day time at urban (29.26°C to 32.78°C±1.07), mangrove (26.23°C to 28.82 °C±0.89), forest (25.76°C to 27.54°C±0.49), oil palm (27.02°C to 29.54±0.70), rubber (26.49°C to 27.24°C ±0.29), and water (26.10 °C to 28.77 °C ± 0.8) respectively. Moreover, the relationship between LST and several impervious and vegetation indexes show that there is a strong relationship between impervious indexes and LST, and an inverse relationship between vegetation indexes and LST. Finally, this study concluded that replacing green natural area with improvise surface can increase the land surface temperature and have negative effect on urban thermal comfort.

ABSTRAK

Iskandar Malaysia adalah salah satu projek pembangunan mengkagumkan yang telah dijalankan di Malaysia yang mengalami kadar perubahan guna tanah yang pesat sejak 2006. Perubahan guna tanah adalah disebabkan oleh pertambahan kawasan bandar dan pengurangan kawasan hijau semula jadi hasil daripada penambahbaikan pertumbuhan ekonomi. Tiga objektif kajian ini adalah (i) untuk menganggarkan perubahan kawasan litupan dan guna tanah (LULC) di Iskandar Malaysia dari tahun 1989 hingga 2014, (ii) untuk mengkaji kesan perubahan LULC terhadap suhu permukaan tanah (LST) dalam kawasan kajian dan (iii) meramal LST pada tahun 2025. Data penderiaan jauh seperti Landsat (Landsat 5, 7 dan 8) dan spektroradiometer pengimejan resolusi sederhana (MODIS) produk Terra (MOD11A1) telah digunakan untuk mengklasifikasi pelbagai jenis LULC dan mengira LST di Iskandar Malaysia. Terdapat dua teknik pengkelasan digital yang digunakan untuk mengklasifikasi dan menguji LULC yang berbeza dalam kajian ini. Teknik kebolehjadian maksimum (MLC) memberi ketepatan yang lebih tinggi berbanding dengan teknik sokongan mesin vektor (SVM). Oleh itu teknik klasifikasi imej satelit dengan menggunakan MLC telah dipilih untuk memantau perubahan LULC di Iskandar Malaysia. LST telah diekstrak menggunakan algoritma tetingkap mono bagi semua imej Landsat. Nilai min analisis menggunakan sistem maklumat geografi (GIS) merujuk kepada LULC menunjukkan bahawa kawasan air mencatatkan nilai LST yang paling tinggi pada waktu malam, manakala hutan mencatatkan nilai LST terendah pada waktu siang. Kawasan bandar adalah kawasan guna tanah yang paling panas pada waktu siang dan guna tanah kedua paling panas pada waktu malam. Tambahan pula, purata wajaran yang diguna untuk meramalkan min LST seluruh Iskandar Malaysia mendapati bahawa jika terdapat peningkatan kawasan hijau, nilai LST akan berkurangan sebanyak 0.5^{o}C. Model pemadanan lengkung linear telah digunakan untuk meramal kesan perubahan LULC kepada nilai min setiap jenis LULC. Berdasarkan keputusan yang diperoleh, min LST pada waktu malam dari tahun 2000-2025 akan meningkat di kawasan bandar (20.89 ° C hingga 22.39 ° C ± 0.45), bakau (20.88 ° C hingga 22.59 ° C ± 0.50), hutan (20.39 ° C hingga 21.04 ° C ± 0.18), kelapa sawit (20.39 ° C hingga 21.25 ± 0.25), getah (20.34 ° C hingga 22.36 ° C ± 0.57), dan air (21.61 ° C hingga 23.31 ° C ± 0.51). Hasil kajian menunjukkan peningkatan pada waktu siang di kawasan bandar (29.26 ° C hingga 32.78 ° C ± 1.07), bakau (26.23 ° C hingga 28.82 ° C ± 0.89), hutan (25.76 ° C hingga 27.54 ° C ± 0.49), kelapa sawit (27.02 ° C hingga 29.54 ± 0.70), getah (26.49 ° C hingga 27.24 ° C ± 0.29), dan air (26.10 ° C hingga 28.77 ° C ± 0.8). Selain itu, hubungan diantara LST dan beberapa indeks telap air dan tumbuhan menunjukkan bahawa terdapat hubungan yang kuat antara indeks telap dan LST, dan hubungan sebaliknya di antara indeks tumbuhan dan LST. Kesimpulan daripada kajian ini mendapati bahawa menggantikan kawasan hijau semula jadi dengan permukaan yang dibaik pulih boleh meningkatkan suhu permukaan tanah dan mempunyai kesan negatif ke atas keselesaan haba bandar.

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ABBREVIATIONS

AMSR	-	Advanced Microwave Scanning Radiometer
ANN	-	Artificial Neural Network
ANOVA	-	Analysis Of Variance
ASTER	-	Advanced Space borne Thermal Emission and Reflection
AVHRR	-	Advanced Very High Resolution Radiometer
BI	-	Bare Soil Index
BUI	-	Built-Up Index
CO_2	-	Carbon Dioxide
CERES	-	Clouds and the Earth's Radiant Energy System
CDPI	-	Comprehensive Development Plan
DN	-	Digital Numbers
DOA	-	Department of Agriculture Malaysia
EOS	-	Earth Observing System
EPA	-	Environmental Protection Agency
ETM+	-	Enhance Thematic Mapper Plus
FAO	-	Food and Agriculture Organization
GHG	-	Green House Gasses
GIS	-	Geographical Information System
GLM	-	General Linear Model
GMS	-	Geostationary Meteorological Satellite
GOES	-	Geostationary Operational Environmental Satellite
GRVI	-	Green Ratio Vegetation Index
HRV	-	Visible High-Resolution
PA	-	Producer’s accuracy
UA	-	User’s accuracy
OA		Overall Accuracy
IFOV	-	Instantaneous Field of View
IGBP	-	International Geosphere and Biosphere Programme

IHDP	-	International Human Dimension Programme
IM	-	Iskandar Malaysia
INSAT	-	Indian National Satellite System
IPCC	-	Intergovernmental Panel On Climate Change
IRDA	-	Islander Regional Development Authority
K	-	Kelvin
LAI		Leaf Area Index
LDCM	-	Landsat Data Continuity Mission
LMT	-	Logistic Model Tree
LR	-	Logistic Regression
LSE	-	Land Surface Emissivity
LST	-	Land Surface temperature
LULC	-	Land Use and Land Cover
LULCC	-	Land Use and Land Cover changes
MF-DFA	-	Multifractal Detrended Fluctuation Analysis
MISR	-	Multi-angle Imaging SpectroRadiometer
MLC	-	Maximum Likelihood Classification
MODIS	-	Moderate Resolution Imaging Spectroradiometer
MOPITT	-	Measurements of Pollution in the Troposphere
MSR	-	Modified Simple Ratio
MVIs	-	Microwave Vegetation Indices
NADMO	-	National Disaster Management Organization
NASA	-	National Aeronautics and Space Administration
NDBaI	-	Normalized Difference Bareness Index
NDWI-GAO	-	Normalized Difference Water Index
NDVI	-	Normalized Difference Vegetation Index
NOAA	-	National Oceanic and Atmospheric Administration
NN	-	neural network
OLI	-	Operational Land Imager
R	-	Pearson Correlation Coefficient
RBF	-	Radial Basis Function
RS	-	Remote Sensing
RMSE	-	Root Mean Square Error
ROI	-	Region Of Interest ROI
RPE		Relative Prediction Error

SDS	-	Scientific Data Sets
SLC	-	Scan Line Corrector
SMA	-	Spectral Mixture Analysis SMA
SPOT	-	Satellite Pour l'Observation de la Terre
SST	-	See Surface Temperature
SUHI	-	Surface Urban Heat Island
SVF	-	Sky View Factor
SVM	-	Support Vector Machine
SWI	-	Split Window Algorithm
Ta	-	Air Temperature
TB	-	Brightness Temperature
TIRS	-	The Thermal Infrared Sensor
TM	-	Landsat thematic mapper
TS	-	Land Surface Temperature
UBL	-	Urban Boundary Layer
UCL	-	Urban Canopy Layer
UHI	-	Urban Heat Island
UHII	-	Urban Heat Island Intensity
UI	-	Urban Index
UNCED	-	United Nations Conference on Environment and Development
USGS	-	United States Geological Survey
VIGR EEN	-	Vegetation Index Green
VNIR	-	The visible and near-infrared
WGS	-	World Geodetic System
UTM	-	Universal Transverse Mercator
TOA	-	Top-of-atmosphere reflectance

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CHAPTER 1

INTRODUCTION

1.1 Research background

The last three decades have witnessed a substantial increase in urban population. Today, it includes more than half of the total population of the world (Brenner and Schmid, 2014; Bongaarts, 2014). Predictions indicate that, by 2050, 65% of people in the world will live in urban areas. This increase occurs at the expense of the rural regions (Zhao *et al.*, 2008). Transformation of urban land is the most multifaceted and irreparable change to land use, which has been the subject of many studies across the world (Kuang, 2012; Jiang and Tian, 2010; Xiao and Weng, 2007).

In 2014, four most urbanized regions are Northern America with 82%, Latin America and the Caribbean with 80%, and Europe with 73% living in urban areas. On the other hand, Asia and Africa have remained mostly rural with only 48 and 40%, respectively, of populations living in urban areas. During the future decades, the expectation is that all regions be urbanized further. It is predicted that, by 2050, Asia and Africa will be urbanized in a speed higher than other regions 64% and 56%, respectively (Bhattacharya, 2015).

Urbanization is the process by which cities and towns developed and grow into larger areas. It includes the movement of people from rural to urban areas as well as movements among towns and cities. Particularly in developing countries, rapid urbanization will bring about one of the critical issues in the global change during the 21st century, which has potential to affect hugely the human dimensions (Sui and Zeng, 2001). Formerly, land use has been usually thought as a local environmental problem; though, it is becoming an important global problem. The need to provide food, water, fibre, and shelter for more than six billion people has resulted in worldwide change to air, farmlands, water resource and forests (Foley *et al.*, 2005).

Rapid growth of urbanization has led to numerous economic, environmental, and social issues. The most important one of these effects is relative warmth of urban areas compared with rural surroundings. Natural vegetation has been replaced with impermeable surfaces such as roads, driveways, parking lots, rooftops, patios, sidewalks, pools, and compacted soils. Changes that have occurred due to urbanization to the land use and land cover have resulted in substantial environmental implications, including the reduction of evapotranspiration increase in surface runoff, increased transfer and storage of sensible heat, and dramatic reductions in quality of air and water (Weng and Lu, 2008; Wilson *et al.*, 2003).

The above-mentioned changes can negatively affect the issues such as energy efficiency, landscape aesthetics, living quality, and human health in urban environments. For instance, since there is a low amount of available moisture for latent heat transfer, most of the surface energy is disappeared as sensible heat whose transfer causes the involved media temperature to be changed. When there is no moisture, heat energy is transferred directly from surfaces to atmosphere through radiation (Oke, 1982; Fischer *et al.*, 2007). This phenomenon, known as the urban heat island (UHI), cause an increase in temperature of the urban atmosphere in comparison with rural areas (Oke, 1982; Gobakis *et al.*, 2011; Voogt and Oke, 2003).

Principally, UHI resulted from the heat-storing structures that augment the cities' heat capacity. In a number of studies, several anthropogenic heat sources have been recognized, e.g., heat released from the air conditioning machines, anthropogenic emissions of carbon dioxide from fossil fuels that are burnt for heating and cooling, industrial processes, transportation as significant contributor to global warming (Childs and Raman, 2005; Grimmond, 2007). These factors have a greater influence in regions in which energy is consumed intensely and there is low net radiation. The urban surfaces imperviousness also augments UHI by inhibition of the evaporative cooling (Lynn *et al.*, 2009).

1.2 Problem statement

During the past three decades, Malaysia has experience a rapid development in industry, agriculture, tourism, and dams and highways constructions (Holden, 2009; Aminu *et al.*, 2013). With the increase of population and economic activities in many agricultural regions, infrastructures have developed rapidly towards inlands. Due to these activities, the country has faced with some threatening phenomena such as increasingly clearing of forest areas, devastation of water resources, and damage of hill slopes, which, in turn, have resulted in other hazardous issues to environment, e.g., landslides and soil loss (Bawahidi, 2005; Adnan *et al.*, 2012).

Change occurred to land use/cover including deforestation has known as one of the most important causes of the climate change. After the combustion of fossil fuels, this is the second important anthropogenic source of carbon dioxide emmision to atmosphere, (Van der Werf *et al.*, 2009). Deforestation has a big contribution to the enhancement of atmospheric greenhouse gases, which leads to global warming (Bonan, 2008).

Based on reports released by the Intergovernmental Panel on Climate Change, from 1880 to 2012, averaged over all ocean and land surfaces, the global temperature has warmed approximately by 0.85 °C. In the globe's Northern Hemisphere, the 30-year period from 1983 to 2012 has been the warmest climate during the past 1400 years (Pachauri *et al.*, 2014). Lawrence and Vandecar (2015) carried out an investigation on the deforestation phenomenon occurred in tropical rainforests in three areas of the world, namely central Africa, the Amazon basin, and southeast Asia.

A large number of studies have been conducted using climate models in order to make simulation of what happens if these forests are completely removed, and it was extensively indicated that deforestation in the tropical areas has a tremendous impact on the global climate as a whole. As a tropical country, Malaysia suffers from deforestation because of serious increase of anthropogenic pressures on natural resources (Jomo *et al.*, 2004). Between 2000 and 2012, this country has witnessed the highest rate of deforestation in the world the loss translates to 47,278 square kilometers (18,244 square miles), an area larger than Denmark (Hansen *et al.*, 2013).

In Malaysia, human interventions have caused a substantial threat to natural environments, e.g., deforestation (land use/covr changes), which has severe influence on a variety of environmental processes (Lim *et al.*, 2010; Salleh *et al.*, 2013). Changes occurred to land-cover and land-use directly affect biological diversity (Sala *et al.*, 2000; Falcucci *et al.*, 2007), and it has contribution to regional and local climatic changes involving the global warming (Chase *et al.*, 2000;Staudt *et al.*, 2013). These changes can also have negative impact on susceptibility of people as well as economic, climatic, or socio-political issues (Sujaul *et al.*, 2010; Yin *et al.*, 2011; Wu *et al.*, 2013).

Specifically, the southern coast of Johor-Iskandar Malaysia (IM) region (the study area) undergoes the highest rate of economic growth in the country. Since 2006, the region having significantly developed key physical infrastructure developments, has experienced a rapid rate of changes to land use / land cover. If deforestation in this region continues, it will negatively affect the aquatic organisms, environmental stability, and the biodiversity of the flora and fauna, and it may cause some microclimate changes (Clement, 2015).

As a result, there is an urgent need to efficiently monitor the land use/cover change (LULCC) types and analyze its relationship with land surface temperature in a way to create a baseline data/information that helps us underestand the effects of LULCC on the changes occurred to the land surface temperature. It can greatly alleviate the LULC changes in IM, hence reducing the urban surface temperature.

Numerious studies have been carried out on LULCC in Malaysia e.g study by Jusoff (2009), Sujaul *et al*.,(2010), Tan *et al*., (2011). Reynolds *et al*., (2011) and Aburas *et al*.,(2015). But only, a limited research has been conducted on LULCC in Iskandar Malaysia (Deilami *et al*., 2014; Majid and Hardy, 2010). The results obtained indicate that forest regions have been reduced and their function has changed (Wicke *et al*., 2011). However, none of these studies has analyzed the impacts of these changes on land surface temperature (LST) and any simulation and prediction study has not been performed with regard to future effects of LULCC on LST. This study, will investigate the relationship between LST and LULCC during both day and night times and required analyses have been done to find the probability of existence of UHI in a long term (from 1989 to 2014), and it also made prediction about day and night LST changes by 2025 based on LULCC.

1.3 Aim and Objectives

This research aims at analyzing the effects of land usage and land cover changes on the land surface temperature in a rapidly developing economic area in Iskandar Malaysia. Three objectives are set for this study are as follow:

1. To analyze the land use and land cover changes occurred in Iskandar Malaysia between 1989 and 2014 using Landsat data and SVM and MLC classifres.
2. To examine the relationship between land use and land cover and surface temperature using zonal statistic function for both day and night time.
3. To predict the land surface temperature in Iskandar Malaysia by 2025 via considering the changes in land use and land cover and applying linear curve fitting and weighted average model.

1.4 Research Questions

This study, taking the Iskandar Malaysia as case study, tried to answer the following questions:

1) What is the rate of land use/land cover (LULC) changes in Iskandar Malaysia region?
2) What is the characteristics of the land surface temperature pattern relative to land use/land cover (LULC) in Iskandar Malaysia region?
3) What is the effect of future LULC changes on future land surface temperature changes?

1.5 Significant of Study

The nature and process of climate change must be better understood. The way it affects the natural vegetation and urban landscape should be also investigated. For this purpose, detailed investigations will be carried out on the temperature of the land surface and different types of land cover as significant consequences that climate changes bring about. These investigations help scholars and practitioners to forecast the natural hazards and discriminate such threatened areas (Propastin and Kappas, 2008). In addition, for environmental management and urban planning, it is very important to monitor the types of land cover and measure the influences of human activities, e.g., UHI and climate change (Nagendra and Gopal, 2010).

Research on land use changes is of a great importance since local and global changes occurred to land use can be accompanied with changes in biogeochemical cycles, climate, sediment transport, biodiversity, and surface energy, which have major effects upon the Earth system (Rindfuss *et al.*, 1998).

Issues related to land use are important variables in regional climates and for prediction of futures ecosystems and the amount of methane and carbon emission. To understand the changes to land use becomes increasingly important for the development of planetary management strategies, involving the international regimes for forests, climate, and biodiversity.

The results obtained from this research can contribute to the identification of the relationships between IM's development and land use and land cover changes in this region, and the effects of these changes on microclimate, especially on the land surface temperature. Iskandar Malaysia is developing increasingly towards being an exemplary, sustainable, world-class city; therefore, it is of a great important to deal with the UHI phenomenon in a way to moderate it appropriately.

The results, in regard with the land surface temperature for now and by 2025, are applicable to management and policy-making considerations, National Disaster Management Organization (NADMO), weather organizations, ecological management, and Iskandar Regional Development Authority (IRDA). In addition, the results can be used by urban planners to explore the exact hot spots and adopt appropriate strategies for mitigating the UHI intensity. For example, in hot spot regions, to plant trees streets along with establish with green roofs, water bodies, and fountains, or to develop new urban parks along existing lakes and rivers.

1.6 Scope of the study

This study used remote sensing data to detect the LULC changes in Iskandar Malaysia. Remote sensing data technique was used because it has been shown as a suitable tool for monitoring and assessing land use across a wide expanse of land cover in a long period (Shalaby and Tateishi, 2007; Roy *et al.*, 2002). In this study, Landsat TM, ETM^+, and LDCM related to years of 1989, 2000, 2005, 2007, 2009, 2013, and 2014 were applied to LULC classification and their changes were detected. Years between 1989 and 2014 were considered to analyze the Land Use and Land Cover changes (LULCC) and LST in Iskandar Malaysia.

Landsat TM, ETM^+, LCDM, and Terra MODIS satellite data (during day and night time) were employed to derive land surface temperature (LST) of different LULC in IM. Since the Landsat and MODIS provide a particular opportunity for the LST retrieval, because they has a relatively long data record period and are known valuable for monitoring land surface dynamics over large areas (Weng and Fu, 2014; Zeng *et al.*, 2015).

It was because during the 1980s, Malaysian government implemented a new economic policy focused on urbanization and industrialization of the country, which has led to considerable changes to land cover. Data collected during the 2000s are important since IM started seriously its growth in 2006 and massive development has been continuing until now. To classify various LULC of IM, two specific digital image classification techniques were employed in this study. The SVM algorithm is used due to its higher accuracy compared to other methods (Mountrakis *et al.*, 2011), and MLC is also the most commonly-used classification algorithm capable of extracting major land cover classes (Koomen *et al.*, 2008; Srivastava *et al.*, 2012).

Change in future data were analyzed using Curve fitting Matlab tool box, because Curve fitting could involve either interpolation (Kiusalaas, 2010), where an exact fit to the data was required, or smoothing. In which a "smooth" function was constructed, which approximately fitted the data. Weighted average was also used to see the effect of increase or decrease of any type of LULC on entire Iskandar Malaysia LST.

1.7 Study area

The Iskandar Malaysia (IM) development is known as one of the most ambitious projects in Malaysia, which has caused a rapid rate of change to land use since 2006. This region is located between latitudes 1.4833° to 1.6667°N and longitudes 103.4500° to 103.9094° E (Figure 1.1).

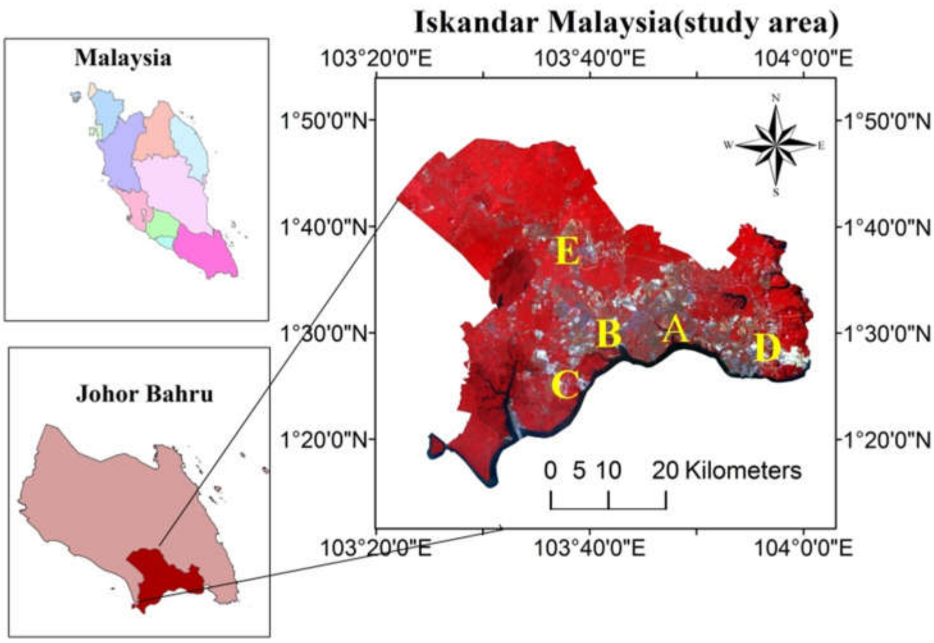

Figure 1.1 Iskandar Malaysia region shown through a Landsat image (the right panel five flagship zones are denoted as A-E). IM is at the southern tip of Peninsular Malaysia. This is part of a multinational extended metropolitan region that includes Johor Bahru in Malaysia, Riau in Indonesia, as well as Singapore (Lo and Yeung, 1996; Ho *et al.*, 2013). In this area, there is a tropical climate with a temperature that ranges between 21 °C and 32 °C, and its annual rate of rainfall is between 2000 to 2500 mm (Sinniah *et al.*, 2013).

Iskandar Malaysia covers an area of roughly 2216.3 km^2, that is, approximately three times the size of Singapore and two times of Hong Kong Island. IM ranks as the second most significant conurbation in Malaysia, which is expected to rival other cities in East Asia, e.g., Singapore and Hong Kong (Yunos and Johar, 2015).

In 2006, IM was established mainly to attract more focused economic and infrastructure investments under the administration of Iskandar Regional Development Authority (IRDA). It involves five local government authorities with five unique Flagship Zones designated as key points for development in IM (see Table 1.1.). These zones are planned to strengthen the existing economic cluster and develop the targeted growth sectors the region involves five local government authorities with five distinctive Flagship Zones designated as key focal points for development in Iskandar Malaysia. These flagship zones have been envisaged to strengthen existing economic cluster as to diversify and develop targeted growth sectors in the future.

Table 1.1: Five flagship zones in Iskandar Malaysia.

Flagship Zones	Area covered	Development
A	Johor Bahru City Centre	New financial district, central business district, waterfront city of Danga Bay, mixed development in Tebrau Plentong and Malaysia/Singapore Causeway
B	Nusajaya	New Johor state administrative centre, Medini Iskandar Malaysia, a medical hub, an "educity", a resort for international tourism and an industrial logistic cluster and residence
C	Western Gate Development	Port of Tanjung Pelepas (PTP), providing a second transportation link for Malaysia/Singapore, a free trade zone, the RAMSAR World Heritage Park and the Tanjung Piai.
D	Eastern Gate Development	Pasir Gudang Port and industrial zone, Tanjung Langsat Port, the Tanjung Langsat Technology Park and the Kim-Kim regional distribution centre
E	Senai-Skudai	Senai International Airport, hubs for cargo and knowledge, a multimodal centre and the MSC Cyberport city.

Iskandar Malaysia is one of the developing Malaysia's economic gateways, and it is predicted to be transformed into greater metropolis by 2025 with 3 million populations. This rapid growth has potential to change considerably the land use in this region, which can lead to huge land cover changes and thereby large impact on the environment and climate of the region.

1.8 Thesis Organisations

This thesis consists of six chapters. Chapter 2 introduces and reviews the causes and consequences of changes occurred to land use and land cover and the effects of these phenomena on climate changes. Additionally, this chapter reviews the studies conducted on land surface temperature, relationships between land use/land cover changes, and changes to land surfce temperarure. The findings reported in this chapter are of high importance to ensure that the study has adopted suitable research methods to address the objectives presented in Section 1.3. The next chapter provides background information needed to understand the land use and land cover change and their various impact to the environment and climate. Chapter 3 specific datasets and methods to achieve the objectives of the study. Chapter 4 and 5 of the thesis described and discussed the main result of the study. More specifically in chapter 4 the results of land use and land cover classifiaction and its changes over the time in IM is presented and discussed. The results of land surface temperature according to land use / land cover is demonstrated and evaluated in chapter 5. This chapter also presents the prediction of LST in Iskandar Malaysia by 2025. Finally, Chapter 6 concludes the whole research and provides recommendations for future studies.

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