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).

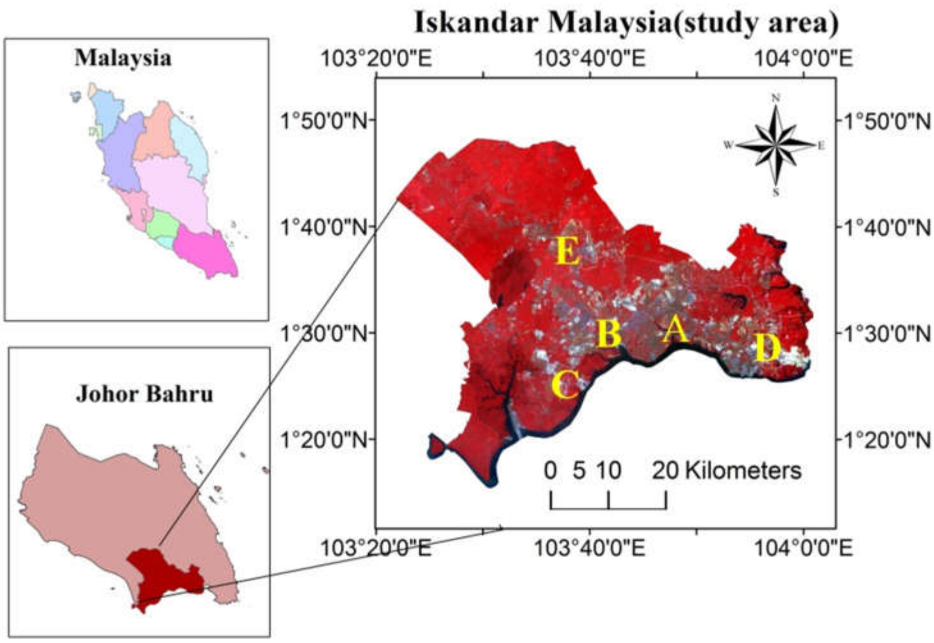

Figure 1.1 Iskandar Malaysia region shown through a Landsat image (the right panel five flagship zones are denoted as A-E). IM is at the southern tip of Peninsular Malaysia. This is part of a multinational extended metropolitan region that includes Johor Bahru in Malaysia, Riau in Indonesia, as well 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.

REFERENCES

Abdullah, S. A. and Nakagoshi, N. (2007). Forest fragmentation and its correlation to human land use change in the state of Selangor, peninsular Malaysia. *Forest Ecology and Management,* 241**,** 39-48.

Aburas, M. M., Abdullah, S. H., Ramli, M. F. and Ash'aari, Z. H. (2015). Measuring land cover change in Seremban, Malaysia using NDVI index. *Procedia Environmental Sciences,* 30**,** 238-243.

Adnan, R., Ruslan, F. A., Samad, A. M. and Zain, Z. M. (2012). Flood water level modelling and prediction using artificial neural network: Case study of Sungai Batu Pahat in Johor. *Control and System Graduate Research Colloquium (ICSGRC), 2012 IEEE*, 2012. IEEE, 22-25.

Aflaki, A., Mirnezhad, M., Ghaffarianhoseini, A., Ghaffarianhoseini, A., Omrany, H., Wang, Z.-H. and Akbari, H. (2016). Urban heat island mitigation strategies: A state-of-the-art review on Kuala Lumpur, Singapore and Hong Kong. *Cities*.

Ahmad, S. and Hashim, N. M. (2007). Effects of soil moisture on urban heat island occurrences: case of Selangor, Malaysia. *Humanity & Social Sciences Journal,* 2**,** 132-138.

Ahmed, B., Kamruzzaman, M., Zhu, X., Rahman, M. S. and Choi, K. (2013). Simulating land cover changes and their impacts on land surface temperature in Dhaka, Bangladesh. *Remote Sensing,* 5**,** 5969-5998.

Alhuseen, A., Leonhardit, H. and Truk, K. (2012). Detecting Sprawl of Gadarif City-Sudan. *Proceedings in EIIC-1st Electronic International Interdisciplinary Conference*.

Aminu, M., Ludin, A. N. B. M., Matori, A.-N., Yusof, K. W., Dano, L. U. and Chandio, I. A. (2013). A spatial decision support system (SDSS) for sustainable tourism planning in Johor Ramsar sites, Malaysia. *Environmental earth sciences,* 70**,** 1113-1124.

Aplin, P. (2006). On scales and dynamics in observing the environment. *International Journal of Remote Sensing,* 27**,** 2123-2140.

Aria, E. H., Saradjian, M., Amini, J. and Lucas, C. (2004). Generalized cooccurrence matrix to classify IRS-1D images using neural network. *International Archives of Photogrammetry Remote Sensing and Spatial Information Sciences,* 35**,** 117-122.

Asmala, A. and Abdullah, M. (2007). Mapping urban heat island phenomenon: Remote sensing approach. *Journal-The Institution of Engineers, Malaysia,* 68**,** 25-30.

Atkinson, P. M. and Lewis, P. (2000). Geostatistical classification for remote sensing: an introduction. *Computers & Geosciences,* 26**,** 361-371.

Azevedo, J. A., Chapman, L. and Muller, C. L. (2016). Quantifying the daytime and night-time urban heat island in Birmingham, UK: A comparison of satellite derived land surface temperature and high resolution air temperature observations. *Remote Sensing,* 8**,** 153.

Baranyi, J. and Roberts, T. A. (1994). A dynamic approach to predicting bacterial growth in food. *International journal of food microbiology,* 23**,** 277-294.

Bawahidi, K. S. Y. (2005). *Integrated Land Use Change Analysis For Soil Ersion Study In Ulu Kinta Catchment [S623. B354 2006 f rb].* Universiti Sains Malaysia.

Bhaskaran, S., Paramananda, S. and Ramnarayan, M. (2010). Per-pixel and object-oriented classification methods for mapping urban features using Ikonos satellite data. *Applied Geography,* 30**,** 650-665.

Bhattacharya, P. (2015). Globalization, Urban Informalisation and Slum Formation in India: A Comparative Study With World Scenario.

Bonafoni, S. (2015). Spectral index utility for summer urban heating analysis. *Journal of Applied Remote Sensing,* 9**,** 096030-096030.

Bonan, G. B. (2008). Forests and climate change: forcings, feedbacks, and the climate benefits of forests. *science,* 320**,** 1444-1449.

Bongaarts, J. (2014). United Nations, department of economic and social affairs, population division, sex differentials in childhood mortality. *Population and Development Review,* 40**,** 380-380.

Boretti, A. A. (2012). Short term comparison of climate model predictions and satellite altimeter measurements of sea levels. *Coastal Engineering,* 60**,** 319-322.

Brenner, N. and Schmid, C. (2014). The 'urban age'in question. *International Journal of Urban and Regional Research,* 38**,** 731-755.

Brooks, E. B., Thomas, V. A., Wynne, R. H. and Coulston, J. W. (2012). Fitting the multitemporal curve: A Fourier series approach to the missing data problem in remote sensing analysis. *IEEE Transactions on Geoscience and Remote Sensing,* 50**,** 3340-3353.

Bruijnzeel, L. A. (2004). Hydrological functions of tropical forests: not seeing the soil for the trees? *Agriculture, ecosystems & environment,* 104**,** 185-228.

Burgess, D., Lewis, P. and Muller, J.-P. (1995). Topographic effects in AVHRR NDVI data. *Remote Sensing of Environment,* 54**,** 223-232.

Cai, G., Du, M. and Xue, Y. (2011). Monitoring of urban heat island effect in Beijing combining ASTER and TM data. *International Journal of Remote Sensing,* 32**,** 1213-1232.

Caselles, V., Coll, C. and Valor, E. (1997). Land surface emissivity and temperature determination in the whole HAPEX-Sahel area from AVHRR data. *International Journal of Remote Sensing,* 18**,** 1009-1027.

Chander, G. and Markham, B. (2003). Revised Landsat-5 TM radiometric calibration procedures and postcalibration dynamic ranges. *IEEE Transactions on geoscience and remote sensing,* 41**,** 2674-2677.

Chapelle, O., Haffner, P. and Vapnik, V. N. (1999). Support vector machines for histogram-based image classification. *IEEE transactions on Neural Networks,* 10**,** 1055-1064.

Chase, T., Pielke Sr, R., Kittel, T., Nemani, R. and Running, S. (2000). Simulated impacts of historical land cover changes on global climate in northern winter. *Climate Dynamics,* 16**,** 93-105.

Chavanavesskul, S. (2009). Management of the urban spatial setting to determine the effect of urban heat island on the Bangkok Metropolis, Thailand. *Sustainable Development and Planning IV,* 1**,** 153.

Chen, J. M. (1996). Evaluation of vegetation indices and a modified simple ratio for boreal applications. *Canadian Journal of Remote Sensing,* 22**,** 229-242.

Chen, X.-L., Zhao, H.-M., Li, P.-X. and Yin, Z.-Y. (2006). Remote sensing image-based analysis of the relationship between urban heat island and land use/cover changes. *Remote sensing of environment,* 104**,** 133-146.

Cheval, S., Dumitrescu, A. and Bell, A. (2009). The urban heat island of Bucharest during the extreme high temperatures of July 2007. *Theoretical and Applied Climatology,* 97**,** 391-401.

Childs, P. P. and Raman, S. (2005). Observations and numerical simulations of urban heat island and sea breeze circulations over New York City. *Pure and Applied Geophysics,* 162**,** 1955-1980.

Clarke, J. F. (1972). Some effects of the urban structure on heat mortality. *Environmental research,* 5**,** 93-104.

Clement, M. (2015). Local Growth and Land Use Intensification: A Sociological Study of Urbanization and Environmental Change.

Coburn, C. and Roberts, A. C. (2004). A multiscale texture analysis procedure for improved forest stand classification. *International journal of remote sensing,* 25**,** 4287-4308.

Cochran, N. (2014). Detection of urban heat islands in the Great Lakes Region with GLOBE student surface temperature measurements.

Cohen, J. (1968). Weighted kappa: Nominal scale agreement provision for scaled disagreement or partial credit. *Psychological bulletin,* 70**,** 213.

Congalton, R. G. (1991). A review of assessing the accuracy of classifications of remotely sensed data. *Remote sensing of environment,* 37**,** 35-46.

Congalton, R. G. and Green, K. (2008). *Assessing the accuracy of remotely sensed data: principles and practices.* CRC press.

Congalton, R. G., Oderwald, R. G. and Mead, R. A. (1983). Assessing Landsat classification accuracy using discrete multivariate analysis statistical techniques. *Photogrammetric Engineering and Remote Sensing*.

Conrad, C., Fritsch, S., Zeidler, J., Rücker, G. and Dech, S. (2010). Per-field irrigated crop classification in arid Central Asia using SPOT and ASTER data. *Remote Sensing,* 2**,** 1035-1056.

Corlett, R. T. and Primack, R. B. (2011). *Tropical rain forests: an ecological and biogeographical comparison.* John Wiley & Sons.

Cui, Y. Y. and De Foy, B. (2012). Seasonal variations of the urban heat island at the surface and the near-surface and reductions due to urban vegetation in Mexico City. *Journal of Applied Meteorology and Climatology,* 51**,** 855-868.

Dai, X. and Khorram, S. (1999). Remotely sensed change detection based on artificial neural networks. *Photogrammetric engineering and remote sensing,* 65, 1187-1194.

Das, M. and Ghosh, S. K. (2014). Short-term prediction of land surface temperature using multifractal detrended fluctuation analysis. *India Conference (INDICON), 2014 Annual IEEE*, 2014. IEEE, 1-6.

Davis, M. P., Reimann, G. P. and Ghazali, M. (2005). Reducing Urban Heat Island Effect with Thermal Comfort Housing and Honeycomb Townships. *Conference on Sustainable Building South East Asia*, 2005. 13.

Deng, J., Zhang, Y., Qin, B. and Shi, K. (2015). Long-term changes in surface solar radiation and their effects on air temperature in the Shanghai region. *International Journal of Climatology,* 35**,** 3385-3396.

Dewan, A. M. and Corner, R. J. (2014). Spatiotemporal analysis of urban growth, sprawl and structure. *Dhaka Megacity.* Springer. 99-121.

Dewan, A. M. and Yamaguchi, Y. (2009). Using remote sensing and GIS to detect and monitor land use and land cover change in Dhaka Metropolitan of Bangladesh during 1960–2005. *Environmental monitoring and assessment,* 150**,** 237-249.

Dixon, B. and Candade, N. (2008). Multispectral landuse classification using neural networks and support vector machines: one or the other, or both? *International Journal of Remote Sensing,* 29**,** 1185-1206.

Domenikiotis, C., Loukas, A. and Dalezios, N. (2003). The use of NOAA/AVHRR satellite data for monitoring and assessment of forest fires and floods. *Natural Hazards and Earth System Science*. 3, 115-128.

Dontree, S. (2010). Relation of land surface temperature (LST) and land use/land cover (LULC) from remotely sensed data in Chiang Mai—Lamphun basin. *SEAGA conference*.

Dousset, B. (1989). AVHRR-derived cloudiness and surface temperature patterns over the Los Angeles area and their relationships to land use. *Geoscience and Remote Sensing Symposium, 1989. IGARSS'89. 12th Canadian Symposium on Remote Sensing., 1989 International*, 1989. IEEE, 2132-2137.

Dousset, B. and Gourmelon, F. (2003). Satellite multi-sensor data analysis of urban surface temperatures and landcover. *ISPRS journal of photogrammetry and remote sensing,* 58**,** 43-54.

Eastman, J. R. and Filk, M. (1993). Long sequence time series evaluation using standardized principal components. *Photogrammetric Engineering and remote sensing,* 59**,** 991-996.

Eliasson, I. and Svensson, M. (2003). Spatial air temperature variations and urban land use—a statistical approach. *Meteorological Applications,* 10**,** 135-149.

Elsayed, I. S. (2012). Mitigation of the urban heat island of the city of Kuala Lumpur, Malaysia. *Middle-East Journal of Scientific Research,* 11**,** 1602-1613.

Engelman, R. (2009). The state of world population 2009. Facing a changing world: Women, population and climate. *The state of world population 2009. Facing a changing world: Women, population and climate.* UNFPA.

EPA, D. (2009). Integrated science assessment for particulate matter. *US Environmental Protection Agency Washington, DC*.

Essa, W., Verbeiren, B., van der Kwast, J., Van de Voorde, T. and Batelaan, O. (2012). Evaluation of the DisTrad thermal sharpening methodology for urban areas. *International Journal of Applied Earth Observation and Geoinformation,* 19**,** 163-172.

Falcucci, A., Maiorano, L. and Boitani, L. (2007). Changes in land-use/land-cover patterns in Italy and their implications for biodiversity conservation. *Landscape ecology,* 22**,** 617-631.

Fall, S., Niyogi, D., Gluhovsky, A., Pielke, R. A., Kalnay, E. and Rochon, G. (2010). Impacts of land use land cover on temperature trends over the continental United States: assessment using the North American Regional Reanalysis. *International Journal of Climatology,* 30**,** 1980-1993.

Fan, F., Weng, Q. and Wang, Y. (2007). Land use and land cover change in Guangzhou, China, from 1998 to 2003, based on Landsat TM/ETM+ imagery. *Sensors,* 7**,** 1323-1342.

Fang, G. (2015). Prediction and Analysis of Urban Heat Island Effect in Dangshan by Remote Sensing. *International Journal on Smart Sensing & Intelligent Systems,* 8.

FAO. (2001). FAOSTAT agriculture data. Available at: http://faostat.fao.org/ (Accessed 5 June 2002)

Firdaus, R., Nakagoshi, N., Idris, A. and Raharjo, B. (2014). The Relationship Between Land Use/Land Cover Change and Land Degradation of a Natural Protected Area in Batang Merao Watershed, Indonesia. *Designing Low Carbon Societies in Landscapes.* Springer. 239-251.

Fischer, E. M., Seneviratne, S., Vidale, P., Lüthi, D. and Schär, C. (2007). Soil moisture–atmosphere interactions during the 2003 European summer heat wave. *Journal of Climate,* 20**,** 5081-5099.

Fischer, S., Klinkenberg, R., Mierswa, I. and Ritthoff, O. (2002). Yale: Yet Another Learning Environment–Tutorial. *Colloborative Research Center,* 531.

Fish, P. D., Bennett, G. C. and Millard, P. H. (1985). Heatwave morbidity and mortality in old age. *Age and ageing,* 14**,** 243-245.

Fisher, J. I. and Mustard, J. F. (2004). High spatial resolution sea surface climatology from Landsat thermal infrared data. *Remote Sensing of Environment,* 90**,** 293-307.

Foody, G. M. and Doan, H. (2007). Variability in soft classification prediction and its implications for sub-pixel scale change detection and super resolution mapping. *Photogrammetric Engineering & Remote Sensing,* 73**,** 923-933.

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., Chapin, F. S., Coe, M. T., Daily, G. C. and Gibbs, H. K. (2005). Global consequences of land use. *science,* 309, 570-574.

Foody, G. M. and Mathur, A. (2004). A relative evaluation of multiclass image classification by support vector machines. *IEEE Transactions on geoscience and remote sensing,* 42**,** 1335-1343.

Fu, A. (2014). Urban Growth and LULC Change Dynamics Using Landsat Record of Region of Waterloo from 1984 to 2013.

Fuchs, R., Herold, M., Verburg, P. H., Clevers, J. G. and Eberle, J. (2015). Gross changes in reconstructions of historic land cover/use for Europe between 1900 and 2010. *Global change biology,* 21**,** 299-313.

Fung, T. and LeDrew, E. (1987). Application of principal components analysis to change detection. *Photogrammetric engineering and remote sensing,* 53**,** 1649-1658.

Gao, B.-C. (1995). Normalized difference water index for remote sensing of vegetation liquid water from space. *SPIE's 1995 Symposium on OE/Aerospace Sensing and Dual Use Photonics*. International Society for Optics and Photonics, 225-236.

Garrigues, S., Lacaze, R., Baret, F., Morisette, J., Weiss, M., Nickeson, J., Fernandes, R., Plummer, S., Shabanov, N. and Myneni, R. (2008). Validation and intercomparison of global Leaf Area Index products derived from remote sensing data. *Journal of Geophysical Research: Biogeosciences,* 113.

Gee, O. K. and Sarker, M. L. R. (2013). Monitoring the effects of land use/landcover changes on urban heat island. *SPIE Remote Sensing*, 2013. International Society for Optics and Photonics, 889304-889304-8.

Geist, H. J. and Lambin, E. F. (2002). Proximate causes and underlying driving forces of tropical deforestation: Tropical forests are disappearing as the result of many pressures, both local and regional, acting in various combinations in different geographical locations. *BioScience,* 52**,** 143-150.

Gentemann, C. L., Donlon, C. J., Stuart-Menteth, A. and Wentz, F. J. (2003). Diurnal signals in satellite sea surface temperature measurements. *Geophysical Research Letters,* 30.

Gibbs, H. K., Johnston, M., Foley, J. A., Holloway, T., Monfreda, C., Ramankutty, N. and Zaks, D. (2008). Carbon payback times for crop-based biofuel expansion in the tropics: the effects of changing yield and technology. *Environmental research letters,* 3**,** 034001.

Gil, A., Lobo, A., Abadi, M., Silva, L. and Calado, H. (2013). Mapping invasive woody plants in Azores Protected Areas by using very high-resolution multispectral imagery. *European Journal of Remote Sensing,* 46.

Gill, S. E., Handley, J. F., Ennos, A. R. and Pauleit, S. (2007). Adapting cities for climate change: the role of the green infrastructure. *Built environment,* 33**,** 115-133.

Gimblett, H. (2005). Modelling Human-Landscape Interactions in Spatially Complex Settings: Where are we and where are we going. *MODSIM 2005 International Congress on Modelling and Simulation, Modelling and Simulation Society of Australia and New Zealand*.

Gitelson, A. A., Kaufman, Y. J., Stark, R. and Rundquist, D. (2002). Novel algorithms for remote estimation of vegetation fraction. *Remote sensing of Environment,* 80**,** 76-87.

Gobakis, K., Kolokotsa, D., Synnefa, A., Saliari, M., Giannopoulou, K. and Santamouris, M. (2011). Development of a model for urban heat island prediction using neural network techniques. *Sustainable Cities and Society,* 1**,** 104-115.

Gong, P., Wang, J., Yu, L., Zhao, Y., Zhao, Y., Liang, L., Niu, Z., Huang, X., Fu, H. and Liu, S. (2013). Finer resolution observation and monitoring of global land cover: First mapping results with Landsat TM and ETM+ data. *International Journal of Remote Sensing,* 34**,** 2607-2654.

Green, E. P., Mumby, P. J., Edwards, A. J. and Clark, C. D. (2005). Remote sensing handbook for tropical coastal management.

Grimmond, S. (2007). Urbanization and global environmental change: local effects of urban warming. *The Geographical Journal,* 173**,** 83-88.

Halli, S. S. and Rao, K. V. (2013). *Advanced techniques of population analysis.* Springer Science & Business Media.

Hansen, J., Nazarenko, L., Ruedy, R., Sato, M., Willis, J., Del Genio, A., Koch, D., Lacis, A., Lo, K. and Menon, S. (2005). Earth's energy imbalance: Confirmation and implications. *science,* 308**,** 1431-1435.

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S., Tyukavina, A., Thau, D., Stehman, S., Goetz, S. and Loveland, T. (2013). High-resolution global maps of 21st-century forest cover change. *science,* 342**,** 850-853.

Harlan, S. L., Brazel, A. J., Prashad, L., Stefanov, W. L. and Larsen, L. (2006). Neighborhood microclimates and vulnerability to heat stress. *Social science & medicine,* 63**,** 2847-2863.

Harlan, S. L. and Ruddell, D. M. (2011). Climate change and health in cities: impacts of heat and air pollution and potential co-benefits from mitigation and adaptation. *Current Opinion in Environmental Sustainability,* 3**,** 126-134.

Hereher, M. E. (2016). Recent trends of temperature and precipitation proxies in Saudi Arabia: implications for climate change. *Arabian Journal of Geosciences,* 9**,** 575.

Heumann, B. W. (2011a). An object-based classification of mangroves using a hybrid decision tree—Support vector machine approach. *Remote Sensing,* 3**,** 2440-2460.

Heumann, B. W. (2011b). Satellite remote sensing of mangrove forests: Recent advances and future opportunities. *Progress in Physical Geography,* 35**,** 87-108.

Ho, C. S., Matsuoka, Y., Simson, J. and Gomi, K. (2013). Low carbon urban development strategy in Malaysia–The case of Iskandar Malaysia development corridor. *Habitat International,* 37**,** 43-51.

Holden, A. (2009). The environment-tourism nexus: Influence of market ethics. *Annals of Tourism Research,* 36**,** 373-389.

Holderness, T. d. C. (2013). Quantifying the spatio-temporal temperature dynamics of Greater London using thermal Earth observation.

Hon, J. and Shibata, S. (2013). A review on land use in the Malaysian state of Sarawak, Borneo and recommendations for wildlife conservation inside production forest environment. *Borneo Journal of Resource Science and Technology,* 3**,** 22-35.

Huang, C., Davis, L. and Townshend, J. (2002). An assessment of support vector machines for land cover classification. *International Journal of remote sensing,* 23**,** 725-749.

Huang, Q. and Lu, Y. (2015). The effect of urban heat island on climate warming in the Yangtze River Delta urban agglomeration in China. *International journal of environmental research and public health,* 12**,** 8773-8789.

Huang, X., Zhang, L. and Wang, L. (2009). Evaluation of morphological texture features for mangrove forest mapping and species discrimination using multispectral IKONOS imagery. *IEEE Geoscience and Remote Sensing Letters,* 6**,** 393-397.

Huete, A., Liu, H., Batchily, K. v. and Van Leeuwen, W. (1997). A comparison of vegetation indices over a global set of TM images for EOS-MODIS. *Remote sensing of environment,* 59**,** 440-451.

Hulley, G. C. and Hook, S. J. (2011). Generating consistent land surface temperature and emissivity products between ASTER and MODIS data for earth science research. *IEEE Transactions on Geoscience and Remote Sensing,* 49**,** 1304-1315.

Huth, J., Kuenzer, C., Wehrmann, T., Gebhardt, S., Tuan, V. Q. and Dech, S. (2012). Land cover and land use classification with TWOPAC: Towards automated processing for pixel-and object-based image classification. *Remote Sensing,* 4**,** 2530-2553.

Ibrahim, I., Samah, A. A. and Fauzi, R. (2014). Biophysical factors of remote sensing approach in urban green analysis. *Geocarto International,* 29**,** 807-818.

Im, J. and Jensen, J. R. (2005). A change detection model based on neighborhood correlation image analysis and decision tree classification. *Remote Sensing of Environment,* 99**,** 326-340.

Indonesia, W. (2008). Deforestation, forest degradation, biodiversity loss and CO2 emissions in Riau, Sumatra, Indonesia. *One Indonesian Province's Forest and Peat Soil Carbon loss over a Quarter Cebtury and its Plans for the Future*.

Ishak, A., Hassan, Z. N. C., Edros, N. H., Zamberi, M. H. and Rahman, M. N. A. (2011). The Effect of Local Climate on Urban Heat Island Trend; A Case Study in Urban Areas of Ipoh and Kuantan. *Malaysian Meteorological Department (MMD). Ministry of Science, Technology and Innovation, Kuala Lumpur, Malaysia*.

Jacob, F., Petitcolin, F., Schmugge, T., Vermote, E., French, A. and Ogawa, K. (2004). Comparison of land surface emissivity and radiometric temperature derived from MODIS and ASTER sensors. *Remote Sensing of Environment,* 90**,** 137-152.

Jamei, E. and Ossen, D. R. (2012). Intra urban air temperature distributions in historic urban center. *American Journal of Environmental Sciences,* 8**,** 503.

Jia, K., Wei, X., Gu, X., Yao, Y., Xie, X. and Li, B. (2014). Land cover classification using Landsat 8 operational land imager data in Beijing, China. *Geocarto International,* 29**,** 941-951.

Jiang, J. and Tian, G. (2010). Analysis of the impact of land use/land cover change on land surface temperature with remote sensing. *Procedia environmental sciences,* 2**,** 571-575.

Jimenez-Munoz, J.-C. and Sobrino, J. A. (2008). Split-window coefficients for land surface temperature retrieval from low-resolution thermal infrared sensors. *IEEE geoscience and remote sensing letters,* 5**,** 806-809.

Jin, M. (2004). Analysis of land skin temperature using AVHRR observations. *Bulletin of the American Meteorological Society,* 85, 587-600.

Jin, M. and Dickinson, R. E. (2010). Land surface skin temperature climatology: benefitting from the strengths of satellite observations. *Environmental Research Letters,* 5, 044004.

Johnson, D. P., Wilson, J. S. and Luber, G. C. (2009). Socioeconomic indicators of heat-related health risk supplemented with remotely sensed data. *International Journal of Health Geographics,* 8, 57.

Jomo, K. S., Chang, Y. T. and Khoo, K. J. (2004). *Deforesting Malaysia: the political economy and social ecology of agricultural expansion and commercial logging.* Zed Books.

Jusoff, K. (2009). Land use and cover mapping with airborne hyperspectral imager in Setiu, Malaysia. *Journal of Agricultural Science,* 1, 120.

Jusuf, S. K., Wong, N. H., Hagen, E., Anggoro, R. and Hong, Y. (2007). The influence of land use on the urban heat island in Singapore. *Habitat International,* 31, 232-242.

Kanniah, K. D., Sheikhi, A., Cracknell, A. P., Goh, H. C., Tan, K. P., Ho, C. S. and Rasli, F. N. (2015). Satellite images for monitoring mangrove cover changes in a fast growing economic region in southern Peninsular Malaysia. *Remote Sensing,* 7, 14360-14385.

Karimi, Y., Prasher, S., Patel, R. and Kim, S. (2006). Application of support vector machine technology for weed and nitrogen stress detection in corn. *Computers and electronics in agriculture,* 51, 99-109.

Kathiresan, K. and Rajendran, N. (2005). Coastal mangrove forests mitigated tsunami. *Estuarine, Coastal and shelf science,* 65, 601-606.

Kavzoglu, T. and Colkesen, I. (2009). A kernel functions analysis for support vector machines for land cover classification. *International Journal of Applied Earth Observation and Geoinformation,* 11, 352-359.

Kawamura, M., Jayamana, S. and Tsujiko, Y. (1996). Relation between social and environmental conditions in Colombo Sri Lanka and the urban index estimated by satellite remote sensing data. *The Internatonal Archives of Photogrammetry and Remote Sensing,* 31, 321-326.

Keramitsoglou, I., Kiranoudis, C. T., Ceriola, G., Weng, Q. and Rajasekar, U. (2011). Identification and analysis of urban surface temperature patterns in

Greater Athens, Greece, using MODIS imagery. *Remote Sensing of Environment,* 115**,** 3080-3090.

Kestens, Y., Brand, A., Fournier, M., Goudreau, S., Kosatsky, T., Maloley, M. and Smargiassi, A. (2011). Modelling the variation of land surface temperature as determinant of risk of heat-related health events. *International journal of health geographics,* 10**,** 7.

KeTTHa (2007) Low Carbon Cities Framework and Assessment System Malaysia:Ministry of Energy, Green Technology and Water).

Kidane, Y., Stahlmann, R. and Beierkuhnlein, C. (2012). Vegetation dynamics, and land use and land cover change in the Bale Mountains, Ethiopia. *Environmental Monitoring and Assessment,* 184**,** 7473-7489.

King, M. D., Kaufman, Y. J., Menzel, W. P. and Tanre, D. (1992). Remote sensing of cloud, aerosol, and water vapor properties from the Moderate Resolution Imaging Spectrometer (MODIS). *IEEE Transactions on Geoscience and Remote Sensing,* 30**,** 2-27.

Kiusalaas, J. (2010). Numerical methods in engineering. New York: cambridge university press.

Kjellstrom, T., Friel, S., Dixon, J., Corvalan, C., Rehfuess, E., Campbell-Lendrum, D., Gore, F. and Bartram, J. (2007). Urban environmental health hazards and health equity. *Journal of urban health,* 84**,** 86-97.

Koh, L. P. and Wilcove, D. S. (2008). Is oil palm agriculture really destroying tropical biodiversity? *Conservation letters,* 1**,** 60-64.

Kong, F., Yin, H., James, P., Hutyra, L. R. and He, H. S. (2014). Effects of spatial pattern of greenspace on urban cooling in a large metropolitan area of eastern China. *Landscape and Urban Planning,* 128**,** 35-47.

Koomen, E., Rietveld, P. and de Nijs, T. (2008). Modelling land-use change for spatial planning support. Springer.

Kovats, R. S. and Hajat, S. (2008). Heat stress and public health: a critical review. *Annu. Rev. Public Health,* 29**,** 41-55.

Kuang, W. (2012). Spatio-temporal patterns of intra-urban land use change in Beijing, China between 1984 and 2008. *Chinese Geographical Science,* 22**,** 210-220.

Kubota, T. and Ossen, D. R. (2009). Spatial characteristics of urban heat island in Johor Bahru City, Malaysia. *Proceedings of the 3rd South East Asian*

Technical Universities Consortium (SEATUC'09), Johor Bahru, Malaysia, 39-44.

Kuching, S. (2007). The performance of maximum likelihood, spectral angle mapper, neural network and decision tree classifiers in hyperspectral image analysis. *Journal of Computer Science,* 3**,** 419-423.

Kumar, K., Kumari, K. and Bhaskar, P. (2013). Artificial Neural Network Model for Prediction of Land Surface Temperature from Land Use/Cover Images. *International Journal of Advanced Trends in Computer Science and Engineering,* 2**,** 87-92.

Lambin, E. F., Geist, H. and Rindfuss, R. R. (2006). Introduction: local processes with global impacts. *Land-use and land-cover change.* Springer. 1-8.

Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., Coomes, O. T., Dirzo, R., Fischer, G. and Folke, C. (2001). The causes of land-use and land-cover change: moving beyond the myths. *Global environmental change,* 11**,** 261-269.

Lang, R., Shao, G., Pijanowski, B. C. and Farnsworth, R. L. (2008). Optimizing unsupervised classifications of remotely sensed imagery with a data-assisted labeling approach. *Computers & Geosciences,* 34**,** 1877-1885.

Latif, M. S. (2014). Land Surface Temperature Retrival of Landsat-8 Data Using Split Window Algorithm-A Case Study of Ranchi District. *Int J Eng Dev Res (IJEDR),* 2**,** 3840-3849.

Lawrence, D. and Vandecar, K. (2015). Effects of tropical deforestation on climate and agriculture. *Nature Climate Change,* 5**,** 27-36.

Lee, H.-Y. (1993). An application of NOAA AVHRR thermal data to the study of urban heat islands. *Atmospheric Environment. Part B. Urban Atmosphere,* 27**,** 1-13.

Lee, J., Lee, S. S. and Chi, K. H. (2010). Development of an urban classification method using a built-up index. *Sixth WSEAS International Conference on Remote Sensing, Iwate Prefectural University, Japan*.

Li, C., Wang, J., Wang, L., Hu, L. and Gong, P. (2014). Comparison of classification algorithms and training sample sizes in urban land classification with Landsat thematic mapper imagery. *Remote Sensing,* 6**,** 964-983.

Li, X. and Yeh, A. (1998). Principal component analysis of stacked multi-temporal images for the monitoring of rapid urban expansion in the Pearl River Delta. *International Journal of Remote Sensing,* 19**,** 1501-1518.

Li, X. and Yeh, A. G.-O. (2004). Analyzing spatial restructuring of land use patterns in a fast growing region using remote sensing and GIS. *Landscape and Urban planning,* 69**,** 335-354.

Lillesand, T. M., Kiefer, R. W. and Chipman, J. (2004). Remote Sensing and Image Interpretation. New York: JohnWiley and Sons. I

Lillesand, T., Kiefer, R. W. and Chipman, J. (2014). *Remote sensing and image interpretation.* John Wiley & Sons.

Lim, H., Tan, K., Teh, H., Sim, C., MatJafri, M., Abdullah, K. and Nawawi, M. (2010). A new 3.2 meter spatial resolution land cover/use map over USM campus, Penang Malaysia. *World Applied Sciences Journal,* 9**,** 811-818.

Liou, T.-S. and Wang, M.-J. J. (1992). Fuzzy weighted average: an improved algorithm. *Fuzzy sets and Systems,* 49**,** 307-315.

Liu, H. and Weng, Q. (2008). Seasonal variations in the relationship between landscape pattern and land surface temperature in Indianapolis, USA. *Environmental Monitoring and Assessment,* 144**,** 199-219.

Liu, Q. and Gong, F. (2013). Monitoring land use and land cover change: a combining approach of change detection to analyze urbanization in Shijiazhuang, China.

Liu, L. and Zhang, Y. (2011). Urban heat island analysis using the Landsat TM data and ASTER data: A case study in Hong Kong. *Remote Sensing*, 3, 1535-1552.

Lo, F.-c. (1996). *Emerging world cities in Pacific Asia.* United Nations Publications.

Lu, D., Hetrick, S. and Moran, E. (2010). Land cover classification in a complex urban-rural landscape with QuickBird imagery. *Photogrammetric Engineering & Remote Sensing,* 76**,** 1159-1168.

Lu, D. and Weng, Q. (2007). A survey of image classification methods and techniques for improving classification performance. *International journal of Remote sensing,* 28**,** 823-870.

Lynn, B. H., Carlson, T. N., Rosenzweig, C., Goldberg, R., Druyan, L., Cox, J., Gaffin, S., Parshall, L. and Civerolo, K. (2009). A modification to the NOAH LSM to simulate heat mitigation strategies in the New York City metropolitan area. *Journal of Applied Meteorology and Climatology,* 48**,** 199-216.

Ma, W., Zhou, L., Zhang, H., Zhang, Y. and Dai, X. (2016). Air temperature field distribution estimations over a Chinese mega-city using MODIS land surface temperature data: the case of Shanghai. *Frontiers of Earth Science,* 10**,** 38-48.

Maduako, I., Yun, Z. and Patrick, B. (2016). Simulation and Prediction of Land Surface Temperature (LST) Dynamics within Ikom City in Nigeria Using Artificial Neural Network (ANN). *Journal of Remote Sensing & GIS,* 5.

Magnussen, S., Boudewyn, P. and Wulder, M. (2004). Contextual classification of Landsat TM images to forest inventory cover types. *International Journal of Remote Sensing,* 25**,** 2421-2440.

Majid, M. R. and Hardy, H. (2010). Changes in Residential Design and Planning Approches: The Effects on Impervious Surface.

Mallick, J., Rahman, A. and Singh, C. K. (2013). Modeling urban heat islands in heterogeneous land surface and its correlation with impervious surface area by using night-time ASTER satellite data in highly urbanizing city, Delhi-India. *Advances in Space Research,* 52**,** 639-655.

Mallinis, G., Koutsias, N., Tsakiri-Strati, M. and Karteris, M. (2008). Object-based classification using Quickbird imagery for delineating forest vegetation polygons in a Mediterranean test site. *ISPRS Journal of Photogrammetry and Remote Sensing,* 63**,** 237-250.

Magnussen, S., Boudewyn, P. and Wulder, M. (2004). Contextual classification of Landsat TM images to forest inventory cover types. *International Journal of Remote Sensing,* 25, 2421-2440.

Makridakis, S., Wheelwright, S. C. and Hyndman, R. J. (2008). *Forecasting methods and applications*. John Wiley & Sons.Man, Q., Guo, H., Dong, P., Liu, G. and Shi, R. (2014). Support vector machines and maximum likelihood classification for obtaining land use classification from Hyperspectral imagery. *Proceedings of the International Geoscience and Remote Sensing Symposium (IGARSS), Québec, Canada*, 2014. 2878-2881.

Manandhar, R., Odeh, I. O. and Ancev, T. (2009). Improving the accuracy of land use and land cover classification of Landsat data using post-classification enhancement. *Remote Sensing,* 1**,** 330-344.

Mandalia, H. M. and Salvucci, M. D. D. (2005). Using support vector machines for lane-change detection. *Proceedings of the human factors and ergonomics society annual meeting*, 2005. SAGE Publications, 1965-1969.

Mather, P. M. and Koch, M. (2010). Preprocessing of Remotely-Sensed Data. *Computer Processing of Remotely-Sensed Images: An Introduction, Fourth Edition*, 87-124.

Matson, M., Mcclain, E. P., McGinnis Jr, D. F. and Pritchard, J. A. (1978). Satellite detection of urban heat islands. *Monthly Weather Review,* 106**,** 1725-1734.

Matsunaga, T., Sawabe, Y., Rokugawa, S., Tonooka, H. and Moriyama, M. (2002). Early evaluation of ASTER emissivity products and its application to environmental and geologic studies. *International Symposium on Optical Science and Technology*, 2002. International Society for Optics and Photonics, 20-30.

McMorrow, J. and Talip, M. A. (2001). Decline of forest area in Sabah, Malaysia: relationship to state policies, land code and land capability. *Global Environmental Change,* 11**,** 217-230.

Melgani, F. and Bruzzone, L. (2004). Classification of hyperspectral remote sensing images with support vector machines. *IEEE Transactions on geoscience and remote sensing,* 42**,** 1778-1790.

Miller, R. B. and Small, C. (2003). Cities from space: potential applications of remote sensing in urban environmental research and policy. *Environmental Science & Policy,* 6**,** 129-137.

Ming, D.-P., Luo, J.-C., Shen, Z.-F., Wang, M. and Sehng, H. (2005). Research on information extraction and target recognition from high resolution remote sensing image. *Cehui Kexue/ Science of Surveying and Mapping,* 30**,** 18-20.

Mohammed, S. Z. B. (2004). *The influence of urban heat towards pedestrian comfort and the potential use of plants and water as heat ameliorator in Kuala Lumpur city centre area.* School of Graduate Studies, Universiti Putra Malaysia.

Morain, S. A. (1998). A brief history of remote sensing applications, with emphasis on Landsat. *People and Pixels: Linking Remote Sensing and Social Science. Committee on the Human Dimensions of Global Environmental Change, National Research Council. National Academy of Science Press, Washington, DC.*

Morris, K. I., Salleh, S. A., Chan, A., Ooi, M. C. G., Abakr, Y. A., Oozeer, M. Y. and Duda, M. (2015). Computational study of urban heat island of Putrajaya, Malaysia. *Sustainable Cities and Society,* 19**,** 359-372.

Mountrakis, G., Im, J. and Ogole, C. (2011). Support vector machines in remote sensing: A review. *ISPRS Journal of Photogrammetry and Remote Sensing,* 66**,** 247-259.

Muttitanon, W. and Tripathi, N. (2005). Land use/land cover changes in the coastal zone of Ban Don Bay, Thailand using Landsat 5 TM data. *International Journal of Remote Sensing,* 26**,** 2311-2323.

Nagendra, H. and Gopal, D. (2010). Street trees in Bangalore: Density, diversity, composition and distribution. *Urban Forestry & Urban Greening,* 9**,** 129-137.

Navulur, K. (2006). *Multispectral image analysis using the object-oriented paradigm.* CRC press.

Nichol, J. (2005). Remote sensing of urban heat islands by day and night. *Photogrammetric Engineering & Remote Sensing,* 71**,** 613-621.

Nichol, J. E. (1994). A GIS-based approach to microclimate monitoring in Singapore's high-rise housing estates. *Photogrammetric Engineering and Remote Sensing,* 60**,** 1225-1232.

Niclòs, R., Valiente, J. A., Barberà, M. J., Estrela, M. J., Galve, J. M. and Caselles, V. (2009). Preliminary results on the retrieval of Land Surface Temperature from MSG-SEVIRI data in Eastern Spain. *EUMETSAT 2009: Proceedings of Meteorological Satellite Conference*, 2009. 21-25.

Noguchi, K., Richter, A., Rozanov, V., Rozanov, A., Burrows, J., Irie, H. and Kita, K. (2014). Effect of surface BRDF of various land cover types on geostationary observations of tropospheric NO2. *Atmospheric Measurement Techniques,* 7**,** 3497.

Nonomura, A., Kitahara, M. and Masuda, T. (2009). Impact of land use and land cover changes on the ambient temperature in a middle scale city, Takamatsu, in Southwest Japan. *Journal of environmental management,* 90**,** 3297-3304.

Oke, T. (1987). Boundary Layer Climates. Edition, Methuen & Co. *Ltd., Londres*.

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

Omar, M. F., Zulkefle, N. A. and Abu Bakar, A. (2015). The effects of ground surface materials towards the microclimate of parking lots in IIUM Gombak.

Otukei, J. R. and Blaschke, T. (2010). Land cover change assessment using decision trees, support vector machines and maximum likelihood classification algorithms. *International Journal of Applied Earth Observation and Geoinformation,* 12**,** S27-S31.

Overmars, K. P. and Verburg, P. H. (2005). Analysis of land use drivers at the watershed and household level: Linking two paradigms at the Philippine forest fringe. *International Journal of Geographical information science,* 19**,** 125-152.

Owen, T., Carlson, T. and Gillies, R. (1998). An assessment of satellite remotely-sensed land cover parameters in quantitatively describing the climatic effect of urbanization. *International journal of remote sensing,* 19**,** 1663-1681.

Pachauri, R. K., Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., Church, J. A., Clarke, L., Dahe, Q. and Dasgupta, P. (2014). *Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change.* IPCC.

Pal, M. and Mather, P. (2005). Support vector machines for classification in remote sensing. *International Journal of Remote Sensing,* 26**,** 1007-1011.

Paneque-Gálvez, J., Mas, J.-F., Moré, G., Cristóbal, J., Orta-Martínez, M., Luz, A. C., Guèze, M., Macía, M. J. and Reyes-García, V. (2013). Enhanced land use/cover classification of heterogeneous tropical landscapes using support vector machines and textural homogeneity. *International Journal of Applied Earth Observation and Geoinformation,* 23, 372-383.

Patil, M. B., Desai, C. G. and Umrikar, B. N. (2012). Image classification tool for land use/land cover analysis: A comparative study of maximum likelihood and minimum distance method. *Int J Geol Earth Environ Sci,* 2**,** 189-196.

Peacock, R. and MISSOURI, M. (2014). Accuracy Assessment of Supervised and Unsupervised Classification Using Landsat Imagery of Little Rock, ARKANSAS.

Pedelty, J., Devadiga, S., Masuoka, E., Brown, M., Pinzon, J., Tucker, C., Vermote, E., Prince, S., Nagol, J. and Justice, C. (2007). Generating a long-term land data record from the AVHRR and MODIS instruments. *Geoscience and*

Remote Sensing Symposium, 2007. IGARSS 2007. IEEE International, 2007. IEEE, 1021-1025.

Pengelly, L. D., Campbell, M. E., Cheng, C. S., Fu, C., Gingrich, S. E. and Macfarlane, R. (2007). Anatomy of heat waves and mortality in Toronto: lessons for public health protection. *Canadian Journal of Public Health/Revue Canadienne de Sante'e Publique*, 364-368.

Petropoulos, G., Knorr, W., Scholze, M., Boschetti, L. and Karantounias, G. (2010). Combining ASTER multispectral imagery analysis and support vector machines for rapid and cost-effective post-fire assessment: a case study from the Greek wildland fires of 2007. *Natural Hazards and Earth System Sciences,* 10**,** 305.

Petropoulos, G. P., Kalaitzidis, C. and Vadrevu, K. P. (2012). Support vector machines and object-based classification for obtaining land-use/cover cartography from Hyperion hyperspectral imagery. *Computers & Geosciences,* 41**,** 99-107.

Pinheiro, A., Mahoney, R., Privette, J. and Tucker, C. (2006). Development of a daily long term record of NOAA-14 AVHRR land surface temperature over Africa. *Remote Sensing of Environment,* 103**,** 153-164.

Pongracz, R., Bartholy, J. and Dezso, Z. (2006). Remotely sensed thermal information applied to urban climate analysis. *Advances in Space Research,* 37**,** 2191-2196.

Prihodko, L. and Goward, S. N. (1997). Estimation of air temperature from remotely sensed surface observations. *Remote Sensing of Environment,* 60**,** 335-346.

Propastin, P. A. and Kappas, M. (2008). Reducing uncertainty in modeling the NDVI-precipitation relationship: a comparative study using global and local regression techniques. *GIScience & Remote Sensing,* 45**,** 47-67.

Rao, P. K. (1972). Remote sensing of urban heat islands from an environmental satellite. *Bulletin of the American Meteorological Society,* 53**,** 647-&.

Raynolds, M. K., Comiso, J. C., Walker, D. A. and Verbyla, D. (2008). Relationship between satellite-derived land surface temperatures, arctic vegetation types, and NDVI. *Remote Sensing of Environment,* 112**,** 1884-1894.

Rees, W. G. (2013). *Physical principles of remote sensing.* Cambridge University Press.

Reynolds, G., Payne, J., Sinun, W., Mosigil, G. and Walsh, R. P. (2011). Changes in forest land use and management in Sabah, Malaysian Borneo, 1990–2010, with a focus on the Danum Valley region. *Phil. Trans. R. Soc. B,* 366**,** 3168-3176.

Rikimaru, A. and Miyatake, S. (1997). Development of forest canopy density mapping and monitoring model using indices of vegetation, bare soil and shadow. *Available at http:\ www. gisdevelopment. net/aars/acrs/1997/ts5/index. shtmm*.

Rindfuss, R. R., Stern, P. C., Liverman, D. and Moran, E. (1998). People and Pixels: linking remote sensing and social science. *People and Pixels: linking remote sensing and social science*.

Rinner, C. and Hussain, M. (2011). Toronto's urban heat island—Exploring the relationship between land use and surface temperature. *Remote Sensing,* 3**,** 1251-1265.

Rinner, C., Patychuk, D., Bassil, K., Nasr, S., Gower, S. and Campbell, M. (2010). The role of maps in neighborhood-level heat vulnerability assessment for the city of Toronto. *Cartography and Geographic Information Science,* 37**,** 31-44.

Rogan, J. and Chen, D. (2004). Remote sensing technology for mapping and monitoring land-cover and land-use change. *Progress in planning,* 61**,** 301-325.

Rosen, J. (2016). Climate, Environmental Health Vulnerability, and Physical Planning: A Review of the Forecasting Literature. *CPL bibliography,* 31**,** 3-22.

Roth, M., Oke, T. and Emery, W. (1989). Satellite-derived urban heat islands from three coastal cities and the utilization of such data in urban climatology. *International Journal of Remote Sensing,* 10**,** 1699-1720.

Roy, D., Lewis, P. and Justice, C. (2002). Burned area mapping using multi-temporal moderate spatial resolution data—A bi-directional reflectance model-based expectation approach. *Remote Sensing of Environment,* 83**,** 263-286.

Roy, D. P., Boschetti, L., Justice, C. O. and Ju, J. (2008). The collection 5 MODIS burned area product—Global evaluation by comparison with the MODIS active fire product. *Remote Sensing of Environment,* 112**,** 3690-3707.

Roy, D. P., Wulder, M., Loveland, T., Woodcock, C., Allen, R., Anderson, M., Helder, D., Irons, J., Johnson, D. and Kennedy, R. (2014). Landsat-8: Science and product vision for terrestrial global change research. *Remote Sensing of Environment,* 145**,** 154-172.

Rozenstein, O., Qin, Z., Derimian, Y. and Karnieli, A. (2014). Derivation of land surface temperature for Landsat-8 TIRS using a split window algorithm. *Sensors,* 14**,** 5768-5780.

Sala, O. E., Chapin, F. S., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L. F., Jackson, R. B. and Kinzig, A. (2000). Global biodiversity scenarios for the year 2100. *science,* 287**,** 1770-1774.

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

Satyanarayana, B., Mohamad, K. A., Idris, I. F., Husain, M.-L. and Dahdouh-Guebas, F. (2011). Assessment of mangrove vegetation based on remote sensing and ground-truth measurements at Tumpat, Kelantan Delta, East Coast of Peninsular Malaysia. *International Journal of Remote Sensing,* 32**,** 1635-1650.

Sawaya, K. E., Olmanson, L. G., Heinert, N. J., Brezonik, P. L. and Bauer, M. E. (2003). Extending satellite remote sensing to local scales: land and water resource monitoring using high-resolution imagery. *Remote sensing of Environment,* 88**,** 144-156.

Schroeder, T. A., Gray, A., Harmon, M. E., Wallin, D. O. and Cohen, W. B. (2008). Estimating live forest carbon dynamics with a Landsat-based curve-fitting approach. *Journal of Applied Remote Sensing,* 2**,** 023519-023519-20.

Semrau, A. (1992). Introducing Cool Communities. *American forests*.

Shahmohamadi, P., Che-Ani, A., Ramly, A., Maulud, K. N. A. and Mohd-Nor, M. (2010). Reducing urban heat island effects: A systematic review to achieve energy consumption balance. *International Journal of Physical Sciences,* 5**,** 626-636.

Shalaby, A. and Tateishi, R. (2007). Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt. *Applied Geography,* 27**,** 28-41.

Sham, S. (1973). Observations on the effect of a city's form and function on temperature patterns: a case of Kuala Lumpur. *Journal of Tropical Geography,* 36**,** 60-65.

Sham (1984). The Structure of the Kuala Lumpur Urban Heat Island and its Application in Air Quality Management and Planning, Urbanization and Eco-Development: With Special Reference to Kuala Lumpur, Institute of Advance Studies, Ed., University of Malaya Press

Shupe, S. M. and Marsh, S. E. (2004). Cover-and density-based vegetation classifications of the Sonoran Desert using Landsat TM and ERS-1 SAR imagery. *Remote Sensing of Environment,* 93**,** 131-149.

Shwetha, H. and Kumar, D. N. (2015). Prediction of land surface temperature under cloudy conditions using microwave remote sensing and ANN. *Aquatic Procedia,* 4**,** 1381-1388.

Silván-Cárdenas, J. and Wang, L. (2008). Sub-pixel confusion–uncertainty matrix for assessing soft classifications. *Remote Sensing of Environment,* 112**,** 1081-1095.

Silverman, B. W. (1985). Some aspects of the spline smoothing approach to non-parametric regression curve fitting. *Journal of the Royal Statistical Society. Series B (Methodological)***,** 1-52.

Sinniah, G. K., Shah, M. Z. and Siong, H. C. The Need for Changes in Travel Behaviour towards a Low Carbon Society.

Siti Zakiah, B. M. (2004). The Influence of Urban Heat towards Pedestrian Comfort and the Potential Use of Plants and Water as Heat Ameliorator in Kuala Lumpur City Centre Area, M. Sc. thesis, University Teknologi dan Alam Sekitar, Jabatan Alam Sekitar, Putra Malaysia, Selangor, Malaysia.

Sivakami, C., Meenakshi, S. and Sundram, A. (2010). Application of RS and GIS for Land Use/Land Cover Mapping & Change Detection in Madurai District, TN.

Sobrino, J., Li, Z., Stoll, M. and Becker, F. (1996). Multi-channel and multi-angle algorithms for estimating sea and land surface temperature with ATSR data. *International Journal of Remote Sensing,* 17**,** 2089-2114.

Sobrino, J. A., Jiménez-Muñoz, J. C. and Paolini, L. (2004). Land surface temperature retrieval from LANDSAT TM 5. *Remote Sensing of environment,* 90**,** 434-440.

Sobrino, J. A., Jiménez-Muñoz, J. C., Zarco-Tejada, P. J., Sepulcre-Cantó, G. and de Miguel, E. (2006). Land surface temperature derived from airborne hyperspectral scanner thermal infrared data. *Remote Sensing of Environment,* 102**,** 99-115.

Solecki, W. D., Rosenzweig, C., Parshall, L., Pope, G., Clark, M., Cox, J. and Wiencke, M. (2005). Mitigation of the heat island effect in urban New Jersey. *Global Environmental Change Part B: Environmental Hazards,* 6**,** 39-49.

Song, C., Woodcock, C. E., Seto, K. C., Lenney, M. P. and Macomber, S. A. (2001). Classification and change detection using Landsat TM data: When and how to correct atmospheric effects? *Remote sensing of Environment,* 75**,** 230-244.

Souissi, B., Ouarzeddine, M. and Belhadj-Aissa, A. (2014). Optimal SVM classification for compact polarimetric data using Stokes parameters. *Journal of Mathematical Modelling and Algorithms in Operations Research,* 13**,** 433.

Small, C. (2006). Comparative analysis of urban reflectance and surface temperature. *Remote Sensing of Environment,* 104, 168-189.

Spichtinger, N., Wenig, M., James, P., Wagner, T., Platt, U. and Stohl, A. (2001). Satellite detection of a continental-scale plume of nitrogen oxides from boreal forest fires. *Geophysical Research Letters,* 28**,** 4579-4582.

Spronken-Smith, R. A., Oke, T. R. and Lowry, W. P. (2000). Advection and the surface energy balance across an irrigated urban park. *International Journal of Climatology,* 20**,** 1033-1047.

Sripada, R. P., Heiniger, R. W., White, J. G. and Meijer, A. D. (2006). Aerial color infrared photography for determining early in-season nitrogen requirements in corn. *Agronomy Journal,* 98**,** 968-977.

Srivastava, P. K., Han, D., Rico-Ramirez, M. A., Bray, M. and Islam, T. (2012). Selection of classification techniques for land use/land cover change investigation. *Advances in Space Research,* 50**,** 1250-1265.

Staudt, A., Leidner, A. K., Howard, J., Brauman, K. A., Dukes, J. S., Hansen, L. J., Paukert, C., Sabo, J. and Solórzano, L. A. (2013). The added complications of climate change: understanding and managing biodiversity and ecosystems. *Frontiers in Ecology and the Environment,* 11**,** 494-501.

Stefanski, J. (2015). *Monitoring land use dynamics with optical and radar remote sensing data in western Ukraine.* Freie Universität Berlin.

Story, M. and Congalton, R. G. (1986). Accuracy assessment-A user\'s perspective. *Photogrammetric Engineering and remote sensing,* 52**,** 397-399.

Streutker, D. R. (2002). A remote sensing study of the urban heat island of Houston, Texas. *International Journal of Remote Sensing,* 23**,** 2595-2608.

Streutker, D. R. (2003). Satellite-measured growth of the urban heat island of Houston, Texas. *Remote Sensing of Environment,* 85**,** 282-289.

Su, W., Gu, C. and Yang, G. (2010). Assessing the impact of land use/land cover on urban heat island pattern in Nanjing City, China. *Journal of Urban Planning and Development,* 136**,** 365-372.

Sui, D. Z. and Zeng, H. (2001). Modeling the dynamics of landscape structure in Asia's emerging desakota regions: a case study in Shenzhen. *Landscape and urban planning,* 53, 37-52.

Suhaila, J., Deni, S. M., Zin, W. Z. W. and Jemain, A. A. (2010). Trends in Peninsular Malaysia rainfall data during the southwest monsoon and northeast monsoons seasons: 1975-2004. *Sains Malaysiana,* 39**,** 533-542.

Sujaul, I., Ismail, B., Muhammad, B. G., Mohd, E. T. and Sahibin, A. (2010). Assessment of land use and land cover changes in the Tasik Chini Catchment area, Pahang, Malaysia using the GIS. *Advances in Environmental Biology***,** 404-414.

Sun, Q., Wu, Z. and Tan, J. (2012). The relationship between land surface temperature and land use/land cover in Guangzhou, China. *Environmental Earth Sciences,* 65**,** 1687-1694.

Taha, H., Sailor, D. and Akbari, H. (1992). High-albedo materials for reducing building cooling energy use. Lawrence Berkeley Lab., CA (United States).

Takeuchi, W., Hashim, N. and Thet, K. M. (2010). Application of remote sensing and GIS for monitoring urban heat island in Kuala Lumpur Metropolitan area. *Map Asia 2010 and the International Symposium and Exhibition on Geoinformation, Kuala Lumpur*.

Tan, K., Lim, H. and Jafri, M. M. (2011). Detection of land use/land cover changes for Penang Island, Malaysia. *Space Science and Communication (IconSpace), 2011 IEEE International Conference on*, 2011. IEEE, 152-155.

Tehrany, M. S., Pradhan, B. and Jebur, M. N. (2013). Remote sensing data reveals eco-environmental changes in urban areas of Klang Valley, Malaysia:

contribution from object based analysis. *Journal of the Indian Society of Remote Sensing,* 41, 981-991.

Tenaga, K. and dan Air, T. H. (2011). Low carbon cities framework & assessment system. *Available onlin e: http://esci-ksp. org/wp/wp-content/uploads/2012/04/Low-Carbon-Cities-Frameworkand-Assessment-System. pdf (accessed on 5 December 2015)*.

Torbick, N., Lusch, D., Qi, J., Moore, N., Olson, J. and Ge, J. (2006). Developing land use/land cover parameterization for climate–land modelling in East Africa. *International Journal of Remote Sensing,* 27**,** 4227-4244.

Tran, H., Uchihama, D., Ochi, S. and Yasuoka, Y. (2006). Assessment with satellite data of the urban heat island effects in Asian mega cities. *International Journal of Applied Earth Observation and Geoinformation,* 8**,** 34-48.

Ulutan, D., Lazoglu, I. and Dinc, C. (2009). Three-dimensional temperature predictions in machining processes using finite difference method. *Journal of materials processing technology,* 209**,** 1111-1121.

UN-ECE, F. (2000). Forest Resources of Europe, CIS, North America, Australia, Japan and New Zealand. *New York: United Nations Publication*.

Unger, J. (2008). Connection between urban heat island and sky view factor approximated by a software tool on a 3D urban database. *International Journal of Environment and Pollution,* 36**,** 59-80.

Van der Werf, G. R., Morton, D. C., DeFries, R. S., Olivier, J. G., Kasibhatla, P. S., Jackson, R. B., Collatz, G. J. and Randerson, J. T. (2009). CO2 emissions from forest loss. *Nature geoscience,* 2**,** 737-738.

Vancutsem, C., Ceccato, P., Dinku, T. and Connor, S. J. (2010). Evaluation of MODIS land surface temperature data to estimate air temperature in different ecosystems over Africa. *Remote Sensing of Environment,* 114**,** 449-465.

Veldkamp, A. and Lambin, E. F. (2001). Predicting land-use change. Elsevier.

Vitousek, P. M. (1992). Global environmental change: an introduction. *Annual review of Ecology and Systematics,* 23**,** 1-14.

Voogt, J. A. and Oke, T. R. (2003). Thermal remote sensing of urban climates. *Remote sensing of environment,* 86**,** 370-384.

Wan, Z. (2007). Collection-5 MODIS Land Surface Temperature Products Users' Guide. ICESS.

Wan, Z., Wang, P. and Li, X. (2004a). Using MODIS land surface temperature and normalized difference vegetation index products for monitoring drought in the southern Great Plains, USA. *International Journal of Remote Sensing,* 25**,** 61-72.

Wan, Z., Zhang, Y., Zhang, Q. and Li, Z.-L. (2004b). Quality assessment and validation of the MODIS global land surface temperature. *International Journal of Remote Sensing,* 25**,** 261-274.

Wang, F., Qin, Z., Song, C., Tu, L., Karnieli, A. and Zhao, S. (2015). An improved mono-window algorithm for land surface temperature retrieval from Landsat 8 thermal infrared sensor data. *Remote Sensing,* 7**,** 4268.

Wang, J., Chagnon, F. J., Williams, E. R., Betts, A. K., Renno, N. O., Machado, L. A., Bisht, G., Knox, R. and Bras, R. L. (2009). Impact of deforestation in the Amazon basin on cloud climatology. *Proceedings of the National Academy of Sciences,* 106**,** 3670-3674.

Weng, Q. (2000). Human-environment interactions in agricultural land use in a South China's wetland region: A study on the Zhujiang Delta in the Holocene. *GeoJournal,* 51**,** 191-202.

Weng, Q. (2001). A remote sensing? GIS evaluation of urban expansion and its impact on surface temperature in the Zhujiang Delta, China. *International journal of remote sensing,* 22**,** 1999-2014.

Weng, Q. and Fu, P. (2014). Modeling annual parameters of clear-sky land surface temperature variations and evaluating the impact of cloud cover using time series of Landsat TIR data. *Remote Sensing of Environment,* 140**,** 267-278.

Weng, Q. and Lu, D. (2008). A sub-pixel analysis of urbanization effect on land surface temperature and its interplay with impervious surface and vegetation coverage in Indianapolis, United States. *International journal of applied earth observation and geoinformation,* 10**,** 68-83.

Wenzel, F., Bendimerad, F. and Sinha, R. (2007). Megacities–megarisks. *Natural Hazards,* 42**,** 481-491.

Wicke, B., Sikkema, R., Dornburg, V. and Faaij, A. (2011). Exploring land use changes and the role of palm oil production in Indonesia and Malaysia. *Land use policy,* 28**,** 193-206.

Wilby, R. L. (2003). Past and projected trends in London's urban heat island. *Weather,* 58**,** 251-260.

Wilson, J. S., Clay, M., Martin, E., Stuckey, D. and Vedder-Risch, K. (2003). Evaluating environmental influences of zoning in urban ecosystems with remote sensing. *Remote sensing of environment,* 86**,** 303-321.

Wu, K.-y., Ye, X.-y., Qi, Z.-f. and Zhang, H. (2013). Impacts of land use/land cover change and socioeconomic development on regional ecosystem services: The case of fast-growing Hangzhou metropolitan area, China. *Cities,* 31**,** 276-284.

Wulder, M. A., Masek, J. G., Cohen, W. B., Loveland, T. R. and Woodcock, C. E. (2012). Opening the archive: How free data has enabled the science and monitoring promise of Landsat. *Remote Sensing of Environment,* 122**,** 2-10.

Xiao, H. and Weng, Q. (2007). The impact of land use and land cover changes on land surface temperature in a karst area of China. *Journal of environmental management,* 85**,** 245-257.

Xiao, R.-B., Ouyang, Z.-Y., Zheng, H., LI, W.-f., Schienke, E. W. and WANG, X.-k. (2007). Spatial pattern of impervious surfaces and their impacts on land surface temperature in Beijing, China. *Journal of Environmental Sciences,* 19**,** 250-256.

Xiong, X., King, M. D., Salomonson, V., Barnes, W., Wenny, B. N., Angal, A., Wu, A., Madhavan, S. and Link, D. (2015). Moderate resolution imaging spectroradiometer on Terra and Aqua missions. *Optical Payloads for Space Missions***,** 53.

Xu, Y. and Shen, Y. (2013). Reconstruction of the land surface temperature time series using harmonic analysis. Computers & Geosciences, 61, 126-132.

Yang, C., Everitt, J. H. and Murden, D. (2011). Evaluating high resolution SPOT 5 satellite imagery for crop identification. *Computers and Electronics in Agriculture,* 75**,** 347-354.

Yang, L., Huang, C., Homer, C. G., Wylie, B. K. and Coan, M. J. (2003). An approach for mapping large-area impervious surfaces: synergistic use of Landsat-7 ETM+ and high spatial resolution imagery. *Canadian Journal of Remote Sensing,* 29**,** 230-240.

Yin, J., Yin, Z., Zhong, H., Xu, S., Hu, X., Wang, J. and Wu, J. (2011). Monitoring urban expansion and land use/land cover changes of Shanghai metropolitan area during the transitional economy (1979–2009) in China. *Environmental monitoring and assessment,* 177**,** 609-621.

Youneszadeh Jalili, S. (2013). The effect of land use on land surface temperature in the Netherlands. *Lund University GEM thesis series*.

Yuan, F. and Bauer, M. E. (2007). Comparison of impervious surface area and normalized difference vegetation index as indicators of surface urban heat island effects in Landsat imagery. *Remote Sensing of environment,* 106**,** 375-386.

Yunos, F. and Johar, F. (2015). Social Development Initiative Toward Enhancement of Bumiputera Value in Iskandar Malaysia. *(JOBSTS) Journal of Borneo Social Transformation Studies,* 1.

Zeng, L., Wardlow, B. D., Tadesse, T., Shan, J., Hayes, M. J., Li, D. and Xiang, D. (2015). Estimation of daily air temperature based on MODIS land surface temperature products over the corn belt in the US. *Remote Sensing,* 7**,** 951-970.

Zhang, H., Shi, W. and Liu, K. (2012). Fuzzy-topology-integrated support vector machine for remotely sensed image classification. *IEEE Transactions on Geoscience and Remote Sensing,* 50**,** 850-862.

Zhang, P., Lv, Z. and Shi, W. (2013). Object-based spatial feature for classification of very high resolution remote sensing images. *IEEE Geoscience and Remote Sensing Letters,* 10**,** 1572-1576.

Zhao, H. and Chen, X. (2005). Use of normalized difference bareness index in quickly mapping bare areas from TM/ETM+. *Geoscience and Remote Sensing Symposium, 2005. IGARSS'05. Proceedings. 2005 IEEE International*, 2005. IEEE, 1666-1668.

Zhao, X., Yang, S., Shen, S., Hai, Y. and Fang, Y. (2009). Analyzing the relationship between urban heat island and land use/cover changes in Beijing using remote sensing images. *SPIE Optical Engineering+ Applications*, 2009. International Society for Optics and Photonics, 74541J-74541J-10.

Zhao, Y., Tomita, M., Hara, K., Fujihara, M., Yang, Y. and Da, L. (2008). Detection of Landcover changes with rapid urbanization using remotely sensed data in and around Chongqing, China. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences (ISPRC) No B,* 8**,** 1165-1170.