

MEASUREMENT OF RAPID LANDSCAPE FRAGMENTATION IN ISKANDAR
MALAYSIA

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This thesis is dedicated to the honour of the following departed pillars of my life:

Alhaji Salisu Barau (1927-2007) Father

Alhaji Tasiu Barau (1938 - 2009) Uncle

Hajiya Maryam Salisu Barau (1952-2012) Sister

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Destruction has appeared on land and on sea for what men's hands have earned (Quran 30:40).

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ABSTRACT

Scientific projections have revealed that rapid and capital driven low-density urbanisation grossly undermines local and global environmental sustainability, with these effects set to become even more devastating in the near future. Landscape's socio-ecological functions and services are bound to be affected by this form of rapid urban-industrial growth. The national planning instruments of countries such as Malaysia do not envisage some of the effects of this form of urbanisation on the landscapes. This study examines the problem of rapid fragmentation of landscape in Iskandar Malaysia as a special economic zone. The study adapted multiple data collection methods and various data analyses. The methods include field-based observations, public perceptions, and expert surveys, while land use and land cover data as well as capital-influx data were also analysed. This process helped the study to effectively measure the multiple dimensions of the study problem. The land use datasets for 2006 and 2010 were analysed using 11 landscape metrics to compute changes in landscape structure characteristics – area, shape, edge, diversity, connectivity, and contiguity. The study findings suggested that between 2006 and 2010, Iskandar Malaysia witnessed rapid changes in its landscape composition and configuration. The sharp increase in built-up areas from 13.5% in 2006 to 26.3% in 2010 has affected social and ecological processes in a number of ways. This capital driven rapid urbanisation has affected agricultural landscapes, mangroves and unprotected forests. Field observations revealed that landscape fragmentation has negatively affected upland ecosystems, landscape aesthetics, public safety, and landscape experiences. Public perceptions on effects of the fragmentation varied with people's area of residence, age, and gender. The study also engages with broader sustainability discourse by establishing links between fragmentation of landscapes and urban morphology change, increasing carbon emissions, and human-wildlife conflict. Others include road users' safety, land tenure, gentrification of ecological resources, public health, and environmental human rights issues. Thus, landscape fragmentation analysis is crucial to unravelling the complexities of urbanisation, globalisation, human-land interactions, and science and policy in the new urban age. Finally, the study underscores the need to entrench urban planning practices that reflect on and respect local environmental, cultural and social values of landscapes in order to achieve transformation to sustainable urbanisation in the emerging economies.

ABSTRAK

Unjuran saintifik telah mendedahkan bahawa kepesatan dan pelaburan didorong oleh pambandaran berkepadatan rendah amat menjejaskan kelestarian alam sekitar setempat dan global, dengan kesan-kesan ini dijangka menjadi lebih serius pada masa akan datang. Fungsi dan perkhidmatan sosio-ekologi landskap pasti terjejas dengan bentuk pertumbuhan bandar-industri yang pesat. Instrumen perancangan nasional seperti yang diamalkan Malaysia tidak menggambarkan beberapa kesan bentuk pambandaran sebegini terhadap landskap. Kajian ini mengenalpasti masalah fragmentasi landskap yang berkembang pesat di Iskandar Malaysia sebagai sebuah zon ekonomi khas. Kajian mengadaptasi beberapa kaedah pengumpulan data dan pelbagai teknik analisis. Kaedah tersebut termasuklah pemerhatian di lapangan, tinjauan persepsi orang awam serta mengambil kira pendapat daripada pakar-pakar. Di samping itu data guna tanah dan modal kemasukan data turut dianalisis. Proses ini telah membantu kajian ini untuk secara efektif mengukur kepelbagaian dimensi permasalahan kajian. Data guna tanah tahun 2006 dan 2010 digunakan untuk menganalisa 11 metrik landskap dengan menghitung perubahan ruang landskap, bentuk, pinggir, kepadatan, kesalinghubungan dan perdampingan. Analisis mendapati, antara tahun 2006 dan 2010, Iskandar Malaysia menyaksikan perubahan pesat dalam komposisi landskap dan konfigurasi. Peningkatan mendadak kawasan tepu bina daripada 13.5% pada 2006 kepada 26.3% pada 2010 telah mempengaruhi proses sosial dan ekologi dalam beberapa cara. Perbandaran yang pesat telah menjejaskan landskap pertanian, paya bakau serta hutan yang tidak dilindungi. Pemerhatian tapak telah mendedahkan bahawa fragmentasi landskap telah member kesan negatif kepada ekosistem tanah tinggi, estetika landskap, keselamatan awam, dan pengalaman landskap. Persepsi orang awam mengenai kesan fragmentasi berbeza mengikut kawasan kediaman, umur dan jantina. Kajian ini juga terlibat dengan wacana kelestarian lebih luas dengan mewujudkan hubungan antara fragmentasi landskap dan perubahan morfologi bandar, meningkatkan pengeluaran karbon, konflik manusia-hidupan liar. Selain itu, keselamatan pengguna jalan raya, pemilikan tanah, gentrifikasi sumber ekologi, kesihatan awam, dan isu-isu hak asasi manusia berkaitan alam sekitar juga turut terlibat dengan wacana kelestarian. Maka, analisis fragmentasi landskap adalah penting untuk merungkai kerumitan pambandaran, globalisasi, perhubungan manusia-tanah, dan sains serta dasar di era pambandaran baharu. Kesimpulannya, kajian ini menekankan keperluan untuk mengukuhkan amalan perancangan bandar yang berkesan disamping menghormati persekitaran setempat, budaya dan nilai sosial landskap untuk mencapai transformasi pambandaran lestari dalam situasi ekonomi yang meningkat.

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LIST OF ABBREVIATION

| | | |
|---------|---|-----------------------------------------------------------------|
| AAAS | - | American Association for Advancement of Science |
| AHP | - | Analytic Hierarchy Process |
| ASEAN | - | Association of Southeast Asian Nations |
| AWMFD | - | Area Weighted Mean Fractal Dimension |
| AWMPSI | - | Area Weighted Mean Patch Shape Index |
| CA | - | Class Area |
| CBD | - | Convention on Biological Diversity |
| CFT | - | Central Flow Theory |
| CHANS | - | Coupled Human and Natural Systems |
| CONTAG | - | Contagion |
| CDP | - | Comprehensive Development Plan |
| CPT | - | Central Place Theory |
| CIESIN | - | Center for International Earth Science Information Network |
| ELC | - | European Landscape Convention |
| ELECTRE | - | Elimination and Choice Expressing Reality |
| FDI | - | Foreign Direct Investment |
| FELDA | - | Federal Land Development Authority |
| FELCRA | - | Federal Land Consolidation and Rehabilitation Authority |
| GIS | - | Geographic Information System |
| GLTN | - | Global Land Tools Network |
| ICLARM | - | International Centre for Living Aquatic Resources Management |
| ICSU | - | International Council for Science Union |
| IGBP | - | International Geosphere and Biosphere Project |
| IMS-GT | - | Indonesia-Malaysia-Singapore Growth Triangle |
| KEJORA | - | KemajuanJohorTenggara [Southern Johor Development] |
| IRDA | - | Iskandar Regional Development Authority |
| LPI | - | Large Patch Index |
| LSI | - | Landscape Shape Index |
| LULCC | - | Land and Land Cover Change |
| LUCC | - | Land Use and Cover Change |
| MAUT | - | Multi-Attribute Utility Theory |
| MAVT | - | Multi-Attribute Value Theory |
| MPS | - | Mean Patch Shape |
| MSC | - | Multimedia Super Corridor |

| | | |
|---------------|---|---------------------------------------------------------------------|
| NKEAs | - | National Key Economic Areas |
| NKRAs | - | National Key Result Areas |
| NEP | - | National Environmental Policy |
| NPP | - | National Physical Planning |
| PDT | - | Peripheral Dependency Theory |
| PROMETH EE | - | Preference Ranking Organization Method for Enrichment Evaluation |
| PSSD | - | Patch size Standard Deviation |
| SDGs | - | Sustainable Development Goals |
| SES | - | Socio-ecological Systems |
| SEZ | - | Special Economic Zones |
| SJER | - | Southern Johor Economic Region |
| SIJORI | - | Singapore-Johore-Riau |
| TCPA | - | Town and Country Planning Act |
| TOPSIS | - | Technique for Order Preference by Similarity |
| TPDD | - | Total Planning and Development Doctrine |
| TVA | - | Tennessee Valley Authority |
| UTM | - | Universiti Teknologi Malaysia |
| UNCED | - | United Nations Conference on Environment and Development |
| WCED | - | World Commission on Environment and Development |
| WMO | - | World Meteorological Organisation |
| WSSD | - | World Summit on Sustainable Development |

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Half of the human population currently lives in cities, hence why the United Nations christened the 21st century as the urban century or the new urban age (Bogardi, 2008). Historically speaking, Wu (2010) disclosed that in 1800 only 2% of the human population lived in cities. Subsequently, the number rose to 14%, 30% and 50% in 1900, 1950, and 2000 respectively. Some studies predicted that by 2030, 60% of humans would inhabit cities and urban areas, piling enormous pressure on ecosystems within and beyond their boundaries (Seto *et al.* 2012; Güneralp and Seto, 2013). The global urbanisation trends vary from one region to another. For instance, it is estimated that Asia will see more than 55% of its population urbanised by the year 2030 (Choe and Roberts, 2011). However, Yuen and Kong (2009) suggest that in the Southeast Asian sub-region, urbanisation has reached 100% in Singapore and is likely to reach 50 - 60% in other countries.

Taking Malaysia as an example, its urban population grew dramatically from 26.5% in 1957 to 62% in 2000 (Masron *et al.* 2012). The authors maintain that in the Malaysian context, a human settlement and its adjoining built-up areas with a gazetted population of 10,000 qualify as an urban area. The pattern of Malaysian urbanisation is highly dynamic in space and time, particularly in the Peninsula states. For instance, Penang, Selangor, Melaka and Johor grew by 63 - 88% between the 1950s and 2000, while Kelantan registered only 33% growth (Jamaliah, 2004; Masron *et al.* 2012) and other states fell between these figures. The rapid growth in

Malaysian cities and urban areas is poised to continue. Thus, by the year 2020, Kuala Lumpur, Georgetown, Kuantan and Johor Bahru will be 75% urbanised, as indicated by the *National Urbanisation Policy Document* for Peninsular Malaysia (Federal Town and Country Department, 2006). Invariably, these trends of rapid urbanisation could have some adverse effects on landscapes and human wellbeing now or in the future. According to the First Malaysia Human Development Report (UNDP Malaysia, 2014), the new strategy for rapid and inclusive development in Malaysia includes creation of urban agglomerations where economic activities will be concentrated. This indicates how national development is seeking a solution through urbanisation, although this may also create other challenges.

The unprecedented urbanisation witnessed across the world is, nevertheless, restricted to a tiny proportion of the Earth's surface. Studies suggest that global distribution of urban areas barely covers 2.8% of the total Earth's surface (CIESIN, 2007). Indeed, another estimation puts the total size of global urban built-up areas at as low as 0.3% of the Earth's mass (Martine, 2008). However, recent projections suggest that 60% of global urban regions will be built-up due to the annual 2% increase in the rate of global urban land use, which reduces the global population density and increases fragmentation of landscapes (Angel *et al.* 2011; Seto *et al.*, 2013). According to McGranahan and Satterthwaite (2014), the current global urbanisation process is enmeshed in an extremely complex land transition, which is bound to affect economic development, inequality, social exclusion, and environmental burdens including climate change. Thus, sustainability researchers assume that it is essential to achieve a better understanding of land transitions and interactions, including transnational land deals between distant places through coupled human and natural systems, flows, agents, causes. It is also seen as vital to examine the effects of these interactions (Liu *et al.* 2013).

It is worth noting that the knowledge base for understanding urban growth related challenges is constantly expanding. For example, the contemporary advances in geospatial technologies have made it easier to understand the multiple dimensions of urban environmental change and their wider spatial and temporal implications (Pandey *et al.* 2013; Srinivansan *et al.* 2013). However, cities and towns are not simple phenomena that technological tools can analyse rather simply. They are

complex, dynamic and embedded in social and biophysical milieus. Bettencourt (2013a) hints that complexity and ambiguity are characteristics of cities and urban spaces. The author argues that many scientists perceive a city as an organism, ecosystem or a machine. He adds that urban space complexity is derived from the vast social and infrastructural networks, and functioning of economic and biophysical systems. In addressing the 21st century urban sustainability challenges, researchers need to understand and explain the connections between the problems and people and environmental wellbeing.

The many circumstances outlined above have transformed cities and urban areas into human dominated landscapes where the increasing pressures on the Earth's system threaten sustainability. According to Höjer *et al.* (2011), the unprecedented human dominance of the environment started in the early 18th century during the Industrial Revolution, which galvanised changes in energy, industrial production, mechanisation, and transportation patterns. This development liberated cities from their previous experiences, namely a reliance on proximate ecosystems for energy and other resources as was the case in pioneer urban areas some 6,000 years ago. By and large, there is no universal definition of what a changing urban area is, as this is not adequately explained even in disciplines like Geography, Sociology, Urban Planning and Economics (Bhatta, 2010). Thus, the key terms employed by researchers to define urban change are three-fold, namely: urban growth, urban development and urbanisation. Urban development is concerned with the process of transforming rural areas into urban areas, as well as enjoying new lifestyles and values that have implications for a given location's spatial characteristics. On the other hand, urban growth entails the process of significant increase in the demographic and spatial traits of towns and cities. The third term, urbanisation, originally referred to a social process of human behavioural changes developed through associating with cities. Nowadays, the term embraces the socio-spatial and ecological implications of urban expansion.

For most developing countries, the challenges posed by urban growth, including pollution and environmental degradation, are related to urban land use, land management systems, or land tenure administration (UN-Habitat/GLTN, 2010; Primdhal *et al.* 2013). Researchers from across urban related disciplines have failed

to reach a consensus on the terms that define the processes of urban growth. Hence, they use different concepts, tools and approaches when defining and examining cities in relation to their demography, morphology, land use and land cover systems. Bhatta (2010) argued that the term ‘urban landscapes’ is the most suitable because the urban landscape is embedded in physical, socioeconomic, infrastructural, biophysical, and institutional sub-systems. The key challenges associated with unbridled urbanisation include urban heat island, depletion and pollution of water resources, increased greenhouse emissions, biodiversity loss, social inequality and increasing poverty (Buyantuyev and Wu, 2010; Wu, 2010). As such, rapid urbanisation and industrialisation is one of the major sources of pressure that is pushing the Earth into a human-induced pseudo-geological era, namely the Anthropocene – an age of very intensive and global wide human dominance of the environment. According to Crutzen (2011), the Anthropocene emerges because of the direct consequences of hyper-urbanisation and industrialisation. In contrast with other geologic ages, the Anthropocene is defined by the deepening and fast degradation of the life supporting environmental systems.

Another alarmist concept is that of planetary boundaries, developed by Rockstrom *et al.* (2009) to illustrate the eminent global environmental system’s vulnerability. The nine planetary boundaries comprise climate change, ocean acidification, stratospheric ozone depletion, disruption of the nitrogen and phosphorus cycles, global freshwater use, land use changes, biodiversity loss, atmospheric aerosol loading, and pollution by chemicals. It is difficult to assume that rapid urbanisation and landscape change are not contributing to crossing the nine boundaries. As rapid urban growth continues in most developing regions, what Forman (2008) views as the ripe need for pragmatic and interdisciplinary perspective in managing these challenges becomes more justifiable. The time-space telescoping theory (Marcotullio, 2008) explains that industrialising countries of the 21st century follow a dual track of rapid growth amidst increasing concern for pollution and commitment to sustainability. On the other hand, most of the developed countries have had an intensive and yet slow pattern of industrialisation during the 20th century. It is important to trace the nature and outcomes of environmental transitions in order to properly understand their effect on society. To achieve this, social scientists use path dependency theory to unravel how changes in institutions, actors

and rules evolve over time and directly affect the present conditions of human vulnerability (Wilson, 2012).

Some of the most dramatic environmental changes took place in the late 20th century, when countries of the Southeast Asian region started to industrialise rapidly. Yuen and Kong (2009) observed that, as these countries industrialise, globalise and urbanise, they might not be able to withstand the risks associated with all these processes. Part of the more recent strategies for boosting economic growth and rapid industrialisation in Asia comes through development of Special Economic Zones (SEZs). According to Farole and Akinci (2011), SEZs are private and foreign investment-driven geographic expressions that include export-processing zones (EPZs), Free Trade Zones (FTZs), economic cities, technology and industrial parks. SEZs serve as vehicles for creating jobs and producing goods and services through foreign and local investments. Presently, there are over 5,000 special economic zones all around the world (Carter and Harding, 2011). Of these numbers, there are few economic cities and regions that some researchers consider as more committed to environmental sustainability. Iskandar in Malaysia, along with a few other economic regions, falls into this category, as do Singapore, Melbourne (Australia), Barcelona (Spain), and Mexico City (Mexico) (Shen *et al.* 2011).

Iskandar Malaysia's Comprehensive Development Plan was unveiled in 2006 before the law establishing the region was enacted in 2007. The establishment of this region in Johor in southern Malaysia represents the Malaysian Federal Government's vision for transforming the country's economic base (Khazanah and Nasional, 2006; Rizzo and Khan, 2013). In both geographical and planning sciences, it is well known that the concept of regionalism in national economic development was initiated by the United States through the famous Tennessee Valley Authority (TVA) established in 1933 (Luebke, 1990). Subsequently, many countries have adapted the TVA model in designing their national and sub-national development goals (Ekhbladh, 2002). It is imperative to understand the spatio-temporal and social implications of special economic regions in Asia. In the case of Iskandar Malaysia, this will give researchers and policymakers a better chance to grasp a sound understanding of this kind of low-density urbanisation propelled by local and global capital influx. Importantly, it is

essential to illustrate the social and ecological implications of this form of urban development for society, ecosystems and sustainability pathways.

1.2 Problem Statement

Change in either the form or function of landscape elements is inevitable in the process of rapid urban development. Hence, Iskandar Malaysia is not an exception to this kind of inevitability, particularly as the influx of local and foreign investments continues to grow steadily. Some researchers have made painstaking efforts to explain patterns of urban growth and its impacts on land and land cover changes around the geographical area now designated as Iskandar Malaysia. Some of the studies attribute landscape change in the region to urban sprawl (e.g. Amir, 2006; Noor and Hashim, 2009; Abdul Latif and Fatt, 2012). Such studies measured spatial changes of the built-up areas in and around Johor Bahru. In other words, low-density urbanisation has been part of the area's impending sustainability challenges. Nonetheless, most of the previous studies did not engage with drivers of these and their broader sustainability implications. With this said, there is understanding among researchers that capital influx, regional economy, and the government policy in the development of this low-density region all employ the top bottom approach, and this has drastic consequences for the landscapes (Rizzo and Khan, 2013).

Another problem is that certain existing studies showed little interest in exploring how land use changes affect the population and how the population perceive this problem. For instance, a study by Aminu *et al.* (2014) failed to integrate public views in relation to change in ecosystem services regimes around Pulau Kukup, an important protected ecosystem in the study area. Similarly, Maniam and Singaravelloo (2015) found what they viewed as chasms between conservation policies, rapid growth and interests of local communities in parts of Johor, including Iskandar Malaysia.

Most studies measuring urban land use change in the region, both in past and recent years, have been heavily dependent on satellite images including those with

low resolutions to map patterns of urban land use change. Such studies also referred to generic terms like land cover and land use change as pointers to change in urban growth patterns. However,, it is important to explain the nature of landscape change in terms of landscape types, areal characteristics, shape, configuration, nature of dispersion and connectivity, in order to achieve a better explanation of landscape change dynamics. In fact, due to shortcomings of remote sensing, it has been suggested that even object-based analysis of images may fail to explain the dynamics of urban change (Bhatta, 2010). As such, more analytical measures of spatial and social dynamics of landscape change are needed in order to more thoroughly understand the sustainability risk associated with fragmentation of landscapes.

Some of the previous studies on the study area observed urban land use and land cover change at decadal scale e.g. 1988-1997, 1997-2005 (Majid and Yahya, 2011; Abd and Alnajjar, 2013). However, considering the rapid nature of landscape change in emerging economies, it is important to measure patterns of landscape change within a shorter time span.

It is equally important to incorporate how urban landscape changes affect people in a wider sustainability context. For example, some researchers have established a strong correlation between dengue fever incidence in Malaysia and landscape types, with findings also showing that the highest incidence of this deadly disease is associated with urban land use change (Cheong *et al.* 2014). However, many studies have not explored how fragmentation of landscapes in the context of rapid urbanisation triggers disease outbreak.

According to McGranahan and Satterthwaite (2014), there is a consensus among urban scholars that urbanisation is a serious challenge. In the case of the present study area, some researchers argued that the implications of urban sprawl could threaten the future sustainability of Johor Bahru and its surroundings (Yaakup *et al.* 2008; Majid and Yahya, 2011). However, it remains a matter of debate as to whether the concept of sprawl as applied in such studies is appropriate in the context of the present landscape change scenarios in Iskandar Malaysia. The use of the term sprawl may not fit Iskandar Malaysia, with its core city, Johor Bahru, surrounded by

several urban areas that have existed for decades and grow in their own way. These towns are today the fulcrums of Iskandar Malaysia's catalyst projects.

In contrast with this type of decentralised urban form, Brody (2013) observed that planning authorities in developed economies (where the concept of sprawl originates) create policies and measures to discourage sprawl because it poses numerous threats to sustainability. Hence, the effects of landscape change on the landscape of Iskandar Malaysia should be seen in the light of its own characteristics. This is important because, as Couch *et al.* (2007) argue, other areas around the world have (wrongly) adapted the concept, although their experiences with suburbanisation differ significantly from the situation in the US, particularly with regard to many socio-spatial and temporal dimensions. Urban sustainability scholars have cautioned against employing terms and concepts commonly used for Western cities to examine or explain situations of urban areas in the Global South. According to Edensor and Jayne (2012), many conceptual and empirical approaches developed by Western urban scholars neither represent the diversity of the global urban systems, nor fit the challenges faced by cities in the non-Western countries. Similarly, Myers (2011) theorised that cities and towns in the global south are developing in directions that challenge many theories and models developed by the Western urban scholars.

As previously mentioned, Iskandar Malaysia covers many transitional urban areas that are exposed to rapid urbanisation. However, many scholars have dismissed the idea of using the term urban sprawl to explain urban growth in such areas in Southeast Asia (Ginsburg, 1991; Xie *et al.*, 2006; Wu, 2009; Zhu and Guo, 2012). In reference to this, Terry McGee coined the term *desakota* from the two Bahasa Indonesia/Melayu words *desa* (village) and *kota* (town) to explain their inherent spatial and social characteristics (McGee, 1991). This concept is also used by contemporary Asian urban sustainability researchers to explain urbanisation and urban environmental transitions (Sui and Zeng, 2001; McGee *et al.* 2007; Wu, 2009; Shen *et al.* 2011; Zhu and Guo, 2012; Ghazali, 2013). However, most of these researchers have put forth the belief that *desakota* regions, as transitional areas, are vulnerable to global economic inroads and proliferation of modern technologies. Keilly and McGee (2003) used the term fragmentation to explain how urban development impacts on landscapes in the Johor-Singapore-Riau axis of Malaysia,

Singapore and Indonesia multinational metropolitan region. Hence, the concept of fragmentation, in this case, is a good alternative compared to urban sprawl, land use, and land cover change - all of which are quite ambiguous.

Another issue is the apparent gap between urban planning regulations and the recently inaugurated National Landscape Policy with regard to achieving integrated landscape management in Malaysia. For instance, the Second National Physical Plan (NPP-2) makes it mandatory for every housing development project to set aside 10% of land area for public open space (Federal Town and Country Department, 2010). On the other hand, the recent National Landscape Policy (NLP) envisages preservation of biodiversity and visual appeal of Malaysia landscapes through involvement of stakeholders (Ministry of Housing and Local Government, 2013). The problem here is that both instruments focus more on the planned built environment, while the process of developing new built-up areas by investors is bound to affect landscapes in rural and semi-urban areas.

There are a few other critical and yet unverified sustainability challenges linked to rapid landscape change in Iskandar Malaysia. According to Boyd (2011), the recent land development activities in this region have resulted in increased siltation and sedimentation of some rivers in the downstream areas. This problem has affected the livelihoods of certain fishing villages. Similarly, from 2007 to 2010, the region has experienced reoccurrence of flood events, some of which were devastating and inflicted damage on the urban infrastructure while also displacing portions of the population (Badrul Hisham *et al.* 2009; Shafie, 2009). Apparently, these flood events could be attributed to climate change perturbations; however, it is hardly possible to rule out the effects of accelerated land use change. As a low elevation coastal area, Iskandar Malaysia is vulnerable to climate change induced flooding. Therefore, it is important to understand links between landscapes and vulnerability of people and investments that are important to its prosperity.

Iskandar Malaysia Regional Development Authority (IRDA), as the leading authority coordinating development of the region, has developed several sustainability supporting programmes including the low carbon society blueprint (IRDA, 2011a; Ho *et al.* 2013). Iskandar Malaysia has a well-defined sustainability

roadmap (Shen *et al.* 2011) as well as supporting policies and frameworks such as the Integrated Land Use Blueprint for Iskandar Malaysia (IRDA, 2011b) and the low carbon society blueprint. In tackling the challenges of the new urban age, decision support should not be exclusively dependent on findings drawn from spatially explicit models or techno-fix models. It is important to consider the role of normative dimensions of sustainability. Normative dimensions entail issues relating to the role of ethics, responsibility, equity, and protection of the weaker members of society (Carley, 2011; Moldan *et al.* 2012). Unfortunately, most of the previous studies skipped these issues. Normative dimensions are critical in societies open to rapid urbanisation and capital influx.

1.3 Justification for the Study Area

Iskandar Malaysia may represent a good example of the problem of rapid landscape change in industrialising states of Southeast Asia. Compared to other special economic zones around the world, Iskandar Malaysia covers an area of 2,216.3 km², which is three times bigger than Singapore and two times bigger than Hong Kong (Ho *et al.* 2013). This makes its diverse landscapes more vulnerable to the impacts of rapid urbanisation including change in form, patterns and functions of landscapes, particularly if sustainability standards are not strictly adhered to. Following its designation as a special economic region in 2007, the region is experiencing new forms of land use planning, new land development projects, new economic opportunities and potentials, new planning laws, new urban and peri-urban designs and forms as well as new sustainability strategies and challenges. These changes create new scenarios that can directly affect the landscape in a number of ways. As such, it is important to understand how these changes affect or are related with landscape sustainability.

The strong political will shown by the Malaysian Government is key to the continuing success of Iskandar Malaysia. The Government supported the region with an entry point capital of about US\$ 2.1 billion to develop infrastructure, while the total expected investments stand at US\$100 billion, of which periodic targets were

exceeded in many instances (IRDA, 2011a). This has improved the region's investment climate, with local and international investors continually being drawn towards the area. Some of the key investment areas are in property development. Invariably, landscape elements of the region's large urban and semi urban areas are vulnerable to impacts from investments in recreation and tourism, infrastructure, housing, energy, manufacturing etc. This situation makes the region an important place for investigating the impact of economic development on landscapes of the emerging economies.

The success of capital flow into various sectors of the economy of Iskandar Malaysia has seen the area become a major source of greenhouse gas emission. According to Gouldson *et al.* (2014), energy consumption is projected to rise by 79.4% between 2014 and 2025, while carbon emissions are projected to rise by 83.8% during the same period. The report maintains that most of the emissions will come from commercial, industrial, housing, transport and waste generation. These sources of emission are directly related to the changing patterns of land use. Indeed, the aforementioned projections make the region a good area to understand how changes in landscape contribute to increasing carbon emissions in low-density urban areas and economic regions in particular.

It is also very important to consider the ecological significance of this region in light of the threats that rapid landscape fragmentation could pose to its ecological integrity. According to Hope (2005), Southern Johor, which makes up the majority of present day Iskandar Malaysia, has the highest concentration of flora diversity (about 12, 000 species) per unit area, which is higher than anywhere in Southeast Asia. This region also harbours a number of protected ecosystems including three Ramsar sites, namely Pulau Kukup, Tanjung Piai, and Sungai Pulai, in addition to some parks and green areas. This suggests that the region could present some good example of conflicts between rapid urban development and biodiversity conservation.

Iskandar Malaysia covers swathes of urban and peri-urban landscapes replete with signatures of traditional Malaysian lived environment landscapes, particularly *kampungs* (villages), which provide a good example of the Malaysian cultural

landscapes. These landscapes have existed for a relatively long period of time, representing the Malaysian people's cultural values, conservatism and rural nostalgia (Bunnell, 2002). Presently, most of these urban *kampungs* are vulnerable to rapid urban growth affecting many parts of Malaysia (Ghazali, 2013). Hence, the unfolding development relating to special economic development could trigger devastating impacts on these landscapes. Huen (2009) observed that *kampungs* are common heritage of all Malaysians since the country's three main races, namely the Malays, the Chinese and the Indians, have their own forms of *kampung* landscapes.

Finally, the influx of local and international investments also affects land tenure arrangements. Many community and public commons, such as mangroves, are converted into corporate properties. Therefore, this region is a fine example of how land tenure change involving corporate organisations blocks accessibility to common pool resources.

1.4 Research Gap

From what is reported in previous sections, (research problem and justifications for the study area), it is obvious that there are certain research gaps that need to be filled. The specific research gaps identified based on the researcher's insights and prior studies are as follows:

- Most of the previous studies dwelt on explaining spatio-temporal measurements of land use and land cover change arising from rapid urban growth. Such studies are useful for urban and environmental planning decision support, although they cannot explain the multiple sustainability implications of urban landscape change. Thus, simplistic measures of spatial patterns of urban growth may not provide a sufficiently clear understanding of myriad social and ecological sustainability challenges. As such, it is crucial to measure the effects of change in landscape structure (composition and configuration) of the affected urban and peri-urban biophysical and cultural landscape elements being subjected to fragmentation.

- Most of the previous studies apparently ignored the effects of rapid landscape change on the population, including communities located close to the new land development projects. It is imperative to fill this gap by observing and identifying implications of landscape change on the population, and particularly in respect of their interactions with landscape functions and services. At the same time, it is crucial to document how landscape change related to recent land transformation has affected the social wellbeing of the population, including how it has affected biodiversity.
- The role of capital influx and its connection with landscape change is also another seldom-studied problem. Such a study could have revealed what types of investments play a key role in driving landscape change in Iskandar Malaysia. Similarly, revealing the types of land use activities that these investments engage in or create is yet another critical point missing in respect of the unfolding landscape change in Iskandar Malaysia.
- Most of the previous studies relating to land use and land cover changes focussed more on the impacts of urbanisation on vegetation change. If such studies had focussed on landscape fragmentation and its effect on people and landscape, it would have given a more systematic and holistic view of the sustainability implications of this form of rapid urbanisation.
- Similarly, most of the previous studies ignored how rapid urban growth affects and or determines landscape change in the periphery and particularly the agricultural and rural and peri-urban landscapes that have substantially dominated the landscape of the region since before the middle of the 19th century.
- Finally, some of the previous studies offered certain recommendations on how to strengthen sustainability of Iskandar Malaysia, whilst Iskandar Regional Development Authority (IRDA) also designed a number of strategies for achieving sustainability. However, these studies are inadequate in terms of evaluating those policies, programmes and recommendations relating to overall sustainability of the region and the landscape in particular.

1.5 Research Aim and Objectives

The overall aim of the current study is to investigate spatio-temporal dynamics and sustainability implications of rapid landscape fragmentation in Iskandar Malaysia. This is with a view to understanding drivers, trends and threats to landscape sustainability and to understand how this affects the local population. In order to realise this aim, the following objectives were set:

- a) Identify the spatio-temporal patterns of rapid landscape fragmentation
- b) Examine the socio-ecological implications of landscape fragmentation
- c) Identify the drivers of rapid landscape fragmentation
- d) Evaluate the effectiveness of existing sustainable landscape management strategies

1.6 Research Questions

In order to achieve the research aim and objectives, a few research questions were designed in the context of this study and the wider research interest. These questions are as follows:

- a) How does fragmentation affect landscape structure and what landscape types and functions are most affected?
- b) In what ways does rapid landscape fragmentation affect local communities and local biodiversity?
- c) What types of investments accelerate rapid landscape fragmentation and to what extent do they affect landscape sustainability?

- d) How connected are the current sustainability strategies to the overall sustainability needs of the special economic region and landscapes in particular?

In order to address the proposed questions and the study objectives, the approach guiding this study is the human dimensions paradigm, which Koehn *et al.* (2013) called an applied social science. This approach is relevant to the study objectives and research questions, as it essentially seeks to broaden the systematic understanding and explanation of human-natural resource dynamic relationships (Meeks *et al.* 2011; Loomis and Peterson, 2013). Highlights of the significance of the human dimensions approach in the context of global and local environmental change are given in Chapter 4. The human dimensions approach lends support to coupling of methods and theories to arrive at more elaborate and in-depth analysis of environmental change. Hence, this study largely focusses on integration of various forms of data that tackle both spatially explicit aspects of landscape fragmentation and those issues that particularly address how fragmentation affects people directly and indirectly, including normative dimensions of the problem.

1.7 Scope and Delimitation of the Study

The present study focusses on human dimensions of landscape fragmentation. This scope implies that the study is investigating how human development activities trigger environmental change and subsequently how these changes affect humans and the environment. In view of the nested and complicated links between globalisation, urbanisation and landscape change, this study also pays considerable attention to the links between these processes and sustainability implications that arise from such interactions. Furthermore, the scope also takes into consideration some attention on the urban and peri-urban landscapes as spaces of contestation between aspirations for sustainability, economic development and population. It is within the scope of the study to link the sustainability challenges of landscape change to the ongoing debates on the Anthropocene and the wider changes to planetary systems in the context of human impacts. This is important in view of

the very short time span within which unprecedented landscape change can take place in the emerging economies.

1.8 Significance of the Study

The present study has the potential to make significant contributions to streamlining and mainstreaming urban sustainability discourse among the urban research community, planners and policymakers, businesses and society. For the urban sustainability research community, this study has painted the picture of multiple sustainability challenges in a low-density area undergoing rapid and urban and economic development. The study presents landscape change in urban and semi urban areas as an overwhelming problem that breeds multiple sustainability implications.

SEZs are new vehicles for urban and economic transformation in many emerging economies. It is widely assumed that SEZs are good models for sustainability. In contrast, this study reveals that SEZs may well represent a new layer of sustainability crises with multiple social and ecological dimensions. Hence, this study could be relevant to planners, policymakers, and stakeholders who must pay attention to how landscape change can be a source of additional pressure on ecosystem health as well as how the unfolding changes affect public welfare and access to landscape services.

By focussing on human dimensions of landscape fragmentation, the study reveals a picture of the interconnections between landscape change and the social and ecological dimensions of rapid urbanisation. In other words, this study shines the spotlight on how landscape change affects environmental quality and its relations with people's welfare and rights to use and experience a wide range of landscape services. Thus, the study tries to recognise the voices of the locals belonging to different locations, ages and genders. The study also helps our understanding of the role of science and policy dialogue in addressing sustainability challenges in the emerging economies, particularly with regard to sharing the ideas of experts, locals

and public officers in respect of dealing with present and future challenges arising from landscape change.

Recent years have seen public policies and pressures from civil groups put businesses under increased scrutiny with regards to how they affect environmental sustainability. At the same time, businesses also seek a better means of profit making through innovative and environmentally benign procedures. The findings of this study can be helpful to businesses in understanding how their land development projects can affect landscape sustainability through increased emissions, disturbing habitats of biodiversity or interrupting people's rights to enjoy landscape services.

1.9 Structure of the Thesis

This thesis is comprised of seven chapters, each of which contains multiple sections and subsections. The present chapter (1) comprises ten sections that set the scene for the whole research storyline. It sets the research background by raising issues and gaps relating to landscape fragmentation and urban sustainability. The chapter also outlines the aim, objectives and research questions raised to facilitate the investigation of the problems and gaps while also highlighting the significance of this study.

Chapter 2 reviews relevant literature in its 10 sections and essentially evaluates the most common concepts related to landscape. The chapter offers a critique of a wide range of literature to explain and situate terms and concepts such as landscape fragmentation, urban landscape, *desakota* landscape, methods and tools of measuring landscape fragmentation, as well as some existing landscape theories. This chapter provides the author with a chance to develop a critical storyline of concepts and how they are applied in the context of the study objectives and research questions. Chapter 3 is also another encounter with literature, and essentially focusses on critiquing other terms related to urban landscape change in the context of globalisation and urbanisation. It also explains the common terms used in this study and offers constructive criticism of concepts and theories relating to urban planning,

globalisation, sustainability, and methods with which to measure and manage landscape fragmentation. This chapter overlaps with Chapter 2 in the section where the study's conceptual framework and research variables are shown graphically.

Chapter 4 adds to the research framework outlined in Chapter 3 and essentially sets out the details of the study approach design. This study applied 11 landscape metrics in order to analyse different aspects of landscape composition and configuration parameters. The computations of the landscape metrics was supported by FRAGSTATS and GIS. In addition, field observations complemented some of the inadequacies of spatially explicit analysis of fragmentation. For an effective understanding of how fragmentation affects local communities, a Rasch Model supported questionnaire measured public perceptions on how fragmentation of landscapes affects people and their local environment. Finally, a Delphi technique combined with Analytic Hierarchy Process (AHP) was used to evaluate the existing sustainability and identify strategies for supporting sustainability. The chapter also explains relevant geographic features of Iskandar Malaysia. Understanding the geographical background is fundamental to understanding and explaining the human-landscape interactions.

The results of the study are presented in Chapter 5, which puts forth the patterns of landscape structure change highlighting the extent of changes to landscape configuration in Iskandar Malaysia between 2006 and 2010. Secondly, field observations revealed some problems of fragmentation by roads, which include changing morphology, wildlife roadkill, barrier effects of widened roads and public safety hazards, as well as dwindling chances for experiencing landscapes. Thirdly, the chapter also reports on analysis of public perceptions on fragmentation of landscapes, and reveals that local investments played a dominant role in landscape fragmentation compared with their foreign counterparts. Some of the opinions expressed by aspects re-echoed concerns voiced by local communities.

Discussion of the study's findings is presented in Chapter 6. The chapter explains multiple implications of the study findings in the context of research questions and the established knowledge experiences and contexts from relevant examples around the world.

Chapter 7 concludes this thesis by synthesising the research questions, literature review, methodology, findings and discussions in light of the quest for sustainable urbanisation. One of the major conclusions reveals the need to redefine landscape fragmentation so that it accommodates the realities of the contemporary global-urban landscape change. The chapter also identifies the contributions of the study to science and policy whilst highlighting the areas for further study based on the findings of the present thesis.

1.10 Summary

This chapter underlines the importance of investigating the effects of rapid fragmentation of landscapes in special economic regions of Southeast Asia. It shows that landscape change in the context of rapid urbanisation is a complex sustainability problem that must be explained systematically using appropriate concepts and modes of analysis. The chapter reveals that landscape fragmentation can create a myriad of social, policy, and ecological implications. The next chapter explains the problem of landscape fragmentation and its relations with urbanisation.

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