SPATIAL PATTERN, TRANSPORTATION, AND AIR QUALITY NEXUS IN ISKANDAR MALAYSIA

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To my beloved.

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ABSTRACT

Spatial pattern, transportation, and air quality are three development entities which affect one another thus forming a nexus. Deep understanding on the nexus between the entities provides possibility to create positive impacts on the societal living environment if the integration is well addressed. The developing region of Iskandar Malaysia shows potential to prove the nexus with the current trends of urbanisation process. The tremendous transformation in spatial distribution seemingly unintegrated with the transportation system has potential to draw impacts on the air quality. Research on the nexus of spatial pattern, transportation, and air quality was carried out in Iskandar Malaysia by analysing and evaluating the interconnectivity of the aspects. The spatial pattern study was conducted by analysing the current land use pattern and supported by the household travel survey of 400 household held in eight prominent residential zones. To confirm the traffic-induced air pollution, traffic volume survey was conducted at preselected points connecting origin and destination of the respondents. Air quality was analysed by correlating the traffic volume and air quality by using the existing model. The analysis revealed that the spatial policy of Iskandar Malaysia has driven growth towards a polycentric system with a de-concentration travel pattern for working purposes. The phenomenon exhibits a more distributed rather than concentrated and lumped traffic pattern. The travel behaviour of the citizen signified by high dependency on private automobile. This study confirms that there is nexus of spatial pattern, transportation, and air quality in Iskandar Malaysia. The nexus of the integration provide ideas to foresee the potential resolving ideas from the changes in the spatial pattern, transportation, and air quality setting in the region.

ABSTRAK

Susunatur spatial, pengangkutan, dan kualiti udara merupakan tiga entiti pembangunan yang saling memberi kesan dan membentuk hubungkait. Sekiranya integrasi antara tiga entiti pembangunan ini diberi perhatian khusus, konsep hubungkait ini mampu mendatangkan impak yang positif kepada persekitaran hidup masyarakat. Iskandar Malaysia, yang merupakan sebuah wilayah pembangunan berpotensi membuktikan kehadiran hubungkait dengan proses urbanisasi yang sedang berlaku. Walau bagaimanapun, wujud ketidaksinambungan antara tansformasi taburan ruang dengan sektor pengangkutan dan ini berpotensi memberi kesan kepada kualiti udara. Kajian hubungkait spatial, pengangkutan, dan kualiti udara ini dilaksanakan di Iskandar Malaysia dengan menganalisis dan menilai perkaitan antara tiga aspek tersebut. Analisis spatial dilakukan dengan menganalisis taburan guna tanah sedia ada dan dibantu dengan kaji selidik yang melibatkan 400 isirumah di lapan kawasan perumahan utama dalam wilayah pembangunan Iskandar. Kewujudan pencemaran udara yang disebabkan oleh aliran trafik disahkan dengan menjalankan kajian trafik beberapa jalan utama menghubungkan tempat bermula (rumah) dan destinasi (tempat kerja) responden dan seterusnya mengaplikasikan model perkaitan antara jumlah trafik dan pencemaran sedia ada. Analisis hubungkait mendapati dasar pembangunan di Iskandar Malaysia telah menjurus kepada pembentukan wilayah polisentrik. Corak perjalanan golongan bekerja tidak hanya tertumpu kepada satu pusat sahaja dan fenomena ini mempamerkan corak trafik yang bercabang dengan kebergantung kepada kenderaan persendirian yang tinggi. Kajian ini mengesahkan wujudnya hubungkait antara susunatur spatial, pengangkutan, dan kualiti udara di Iskandar Malaysia. Hubungkait yang ditunjukkan ini penting bagi penyediaan rangka perubahan susunatur ruang, pengangkutan, dan kualiti udara di wilayah ini.

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APA	-	American Planning Association
BBU	-	Bandar Baru Uda
CA.GOV	-	California Environmental Protection Agency
CBD	-	Central business district
CDPI	-	Comprehensive Development Plan I
CDPII	-	Comprehensive Development Plan II
ECER	-	East Coast economic Region
EPA	-	Environmental Protection Agency
ETP	-	Economic Transformation Programme
EU	-	European
GHG	-	Greenhouse gases
GIS	-	Geographic information system application
GTP	-	Government Transformation Programme
ICT	-	Information and Communications Technology
IMS-GT	-	Indonesia, Malaysia, Singapore Growth Triangle
IRDA	-	Iskandar Regional Development Authority
JBCC	-	Johor Bahru City Centre
JB Central	-	Johor Bahru Multimodal Station
KLIA	-	Kuala Lumpur International Airports
LPT2	-	Second East Coast highway
LPT3	-	Third East Coast highway
NCER	-	Northern Corridor economic Region
NEM	-	New Economic Model
NEP	-	New Economic Policy
NKEA	-	National Key Economic Areas

NPP	-	National Physical Plan
NSE	-	North-South Expressway
NYSDEC	-	New York State, Department of Environmental Conservation
OPP3	-	Third outline perspective plan
O-D	-	Origin-Destination
PCE	-	Passenger car equivalent
PDS3	-	Third Physical Development Strategy
PTP	-	Tanjung Pelepas Port
P3	-	Third national principle
SDT	-	Social Development Trust
SET	-	Strategic Economic Trust
SEZ	-	Special Economic Zones
SPSS	-	Statistical Package for the Social Sciences
RMKe-9	-	9th Malaysia Plan
RMKe-10	-	10th Malaysia Plan
RSN	-	State Structure Plan
RSNJ	-	Johor State Structure Plan
SJER	-	South Johor Economic Region
U.S.	-	United States
UMP	-	University Malaysia Pahang
UMT	-	University Malaysia Terengganu
UMK	-	University Malaysia Kelantan
UTM	-	University Technology Malaysia
VMT	-	Vehicle miles travelled

LIST OF SYMBOLS

CO	-	Carbon monoxide
SO_2	-	Sulphur dioxide
NO_2	-	Nitrogen dioxide
O_3	-	Ozone
$PM_{2.5}$	-	Particulate matter with average molecular size 2.5μm in diameter
PM_{10}	-	Particulate matter with average molecular size 10μm in diameter
Pb	-	Lead
NO_x	-	Nitrogen oxides
km	-	kilometer
MYR	-	Malaysian Ringgit
VOC	-	Volatile organic compound

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CHAPTER 1

INTRODUCTION

Urbanization can be explained in terms of social, physical, economic and other growth sectors which contribute to the development. The developing region, Iskandar Malaysia exhibits a transformation towards a polycentric region. Its nucleus, the Johor Bahru City Centre (JBCC) shows 69.1 percent of urbanization rate which is over the national rate by 3.7 percent (National Physical Plan-2, NPP-2). Series of development scenarios require a plan which should suggest strong integration in all development sectors to assure balanced growth and sustainable development. Within the framework of sustainable urban development, there are some most connected sectors which influenced one another at different degree of connectivity. They are spatial pattern, transportation and air quality.

Understanding the spatial pattern, transportation and air quality nexus can help in ensuring the provisional of good environmental quality through integration of spatial and transportation planning. In addition to that, the environmental quality improvement has been set out as one of the Malaysia government transformation agenda to be a major priority to the people (GTP 2014, 2015). While, the development of Iskandar Malaysia is undergoing at a very rapid manner, the region will face constraint for long-term urban development because of less interaction between the development sectors which most cities are experiencing (Fedra, 2004). Thus, the region becomes an interesting study area to prove the presence of nexus.

1.1 Iskandar Malaysia at Glance

Iskandar Malaysia is located within the state of Johor and strategically situated at the southernmost tip of peninsular Malaysia (refer Figure 1.1). The region also particularly classified into the Southern Economic Development Region (SJER). It is disaggregated by the Straits of Tebrau, emerging Singapore from the Johor Sultanate and discovered as an economically advanced region since its recognition dating back in the 14th century.

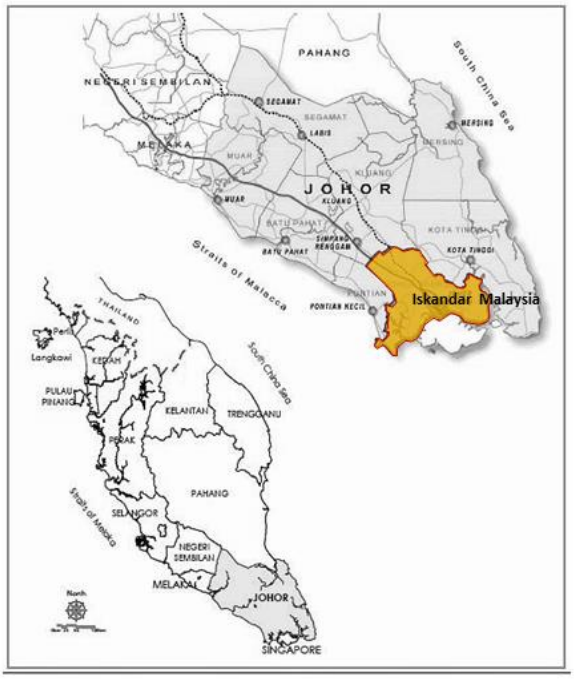

Figure 1.1: National Locational Setting of Iskandar Malaysia

Its focal centre used to be a favourable ships harbour among the traders and merchants from all over the globe. This prominent identity has prospered the region economically then, cultivating cultural landscape setting in the region. Descending the prosperity of traditional events and figures developed throughout the history, Iskandar Malaysia upholds a strong identity of economically potential region possess by its strategic locational setting.

The emerging potential aspects of Iskandar Malaysia have recommended Iskandar Malaysia southern economic development region in 2006. The recommendation is believed to address vast socioeconomic growth as initiated in the tenth Malaysia Plan (10th MP). Currently, Iskandar Malaysia accommodates land with high value due the current development trends. Its location as the major southern gateway from Singapore into the Peninsular Malaysia has set the region as an important access point. There are good access opportunities between Malaysia and Singapore through the Johor Bahru causeway link gateway and the Malaysia-Singapore Second Link (refer Figure 1.2).

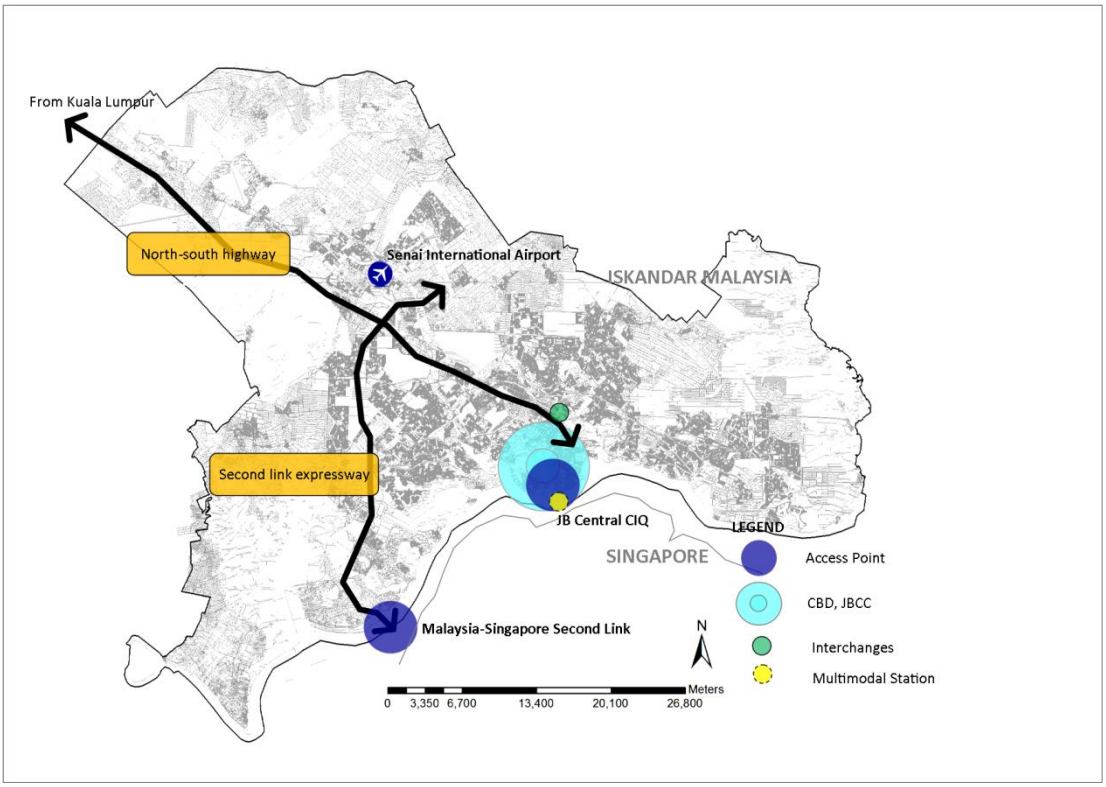

Figure 1.2: Existing Provisional Access to Iskandar Malaysia

These accesses present good potential interaction between the developed country of Singapore and the developing nation of Malaysia. There is high connectivity towards all other parts of Malaysia through direct links with the Malaysian North-South Expressway. The linkages perform a better connection with accessibility to the Senai International Airports which serves for the people and freight transportation with

dual function of both domestic and international connections. Current performance of transportation infrastructure and services provides potential growth for the region as a whole. It is possible as Iskandar Malaysia will be developed in accordance with the National 2020 Vision. Practically it is a notable stopping centre between Singapore and Malaysia.

Iskandar Malaysia Development Region covers the total areas of approximately 2,216.3 sq. km. (Iskandar Malaysia Comprehensive Development Plan I, CDPI, 2012) with 1.74 million total populations (Iskandar Malaysia Comprehensive Development Plan II, CDPII, 2014). The development of this economic region guided by the formation of Iskandar Special Regional Plan established as Iskandar Malaysia Comprehensive Development Plan (CDP) to accomplish an economically developed region by 2025. The first CDP has promoted translation of most developments in Iskandar into economic and social catalytic projects to deliver the vision of developing a strong, sustainable conurbation of international standing as stated in the Iskandar Malaysia CDPI (2012).

To be recognised as a sustainably developed region under the sustainable developments trust which was set up by the NPP-2, Iskandar development authority tends to further advocate good association of the economic prosperity, environmental resiliency, and social vibrancy integration. The specially designed CDP for Iskandar Malaysia is bonded to series of structured governance aligned from the federal government authority i.e. National Physical Planning (NPP), state planning authority i.e. State Structure Plan (RSN) and Iskandar Regional Development Authority (IRDA) in line with national spatial policy framework.

At the national level, an integrated national transformation network connecting national economic development regions was set up according to the sustainable development agenda which first initiated dating back from the Eight Malaysian Plan (2001-2005)(RMKe-8) of the five years national plan as a commitments to the Local Agenda 21 representing global partnerships. The Johor State Structure Plan (RSNJ) provides translation to the NPP-2 setting in delivering sustainable development to the state of Johor as a whole.

Iskandar Malaysia was categorized into specific economic development of southern region in the five national economic corridors of Peninsular Malaysia as stated under the national Economic Transformation Programmes (ETP). The southern region of Johor Bahru conurbation extended from Tanjung Pelepas in west and Pasir Gudang in the east part of Johor (NPP-2, 2010). In line with the 12 National Key Economic Areas (NKEA) stated in the national ETP, under the tenth Malaysia Plan (RMKe-10, 2010), Iskandar Malaysia comes with value added potential to form a new economic landscape. The economic development proposal in the first Iskandar Malaysia, CDPI focusing on the macroeconomic development strategies focusing on the services and manufacturing sectors as the key economic drivers while optimizing the use of resources availability within the economic region. The strategic economic trust (SET) developed accordingly in diversifying economic development while addressing national transformation agenda.

1.2 Research Background

Physical development and urbanisation promote changes in the spatial distribution, transportation system, and environmental quality. Spatial system depends among others, on the distribution of urban centres. The urban centres which refer to the centres of economics are the key elements in the regional spatial structure and its development (Burgalassi and Luzzati, 2015). They exist as the engine of the economic activities. The mobility of people to the urban centre develops a certain urban mobility pattern. Their commuting behaviour is based on the provided transportation system i.e. roads, streets, footpaths and public transport routes; also, the service utilities (Davis, 2000). This is because, the performance of transportation facilities will determine how mobility can be done, using which route and with what mode of transport. Further the commuting behaviour will determine the quality of our environment through emission released which describe a simple interconnection forming a nexus.

A good plan of a city or region should consider a scenario of spatial, transportation and air quality nexus especially in policy development for a sustainable development (Geerlings and Stead, 2003). There are researches integrating land use and transportation which have been discussed by Acheampong and Silva (2015), Su et al. (2014), Gubins and Verhoef (2014), Holden (2006), Bartholomew (2005) and Pauker (1974).

Directly, the spatial pattern and transportation has been found discussed by Lin et al. (2013), Olomedo (2008), Lee (2006), Bertaud (2002), Cirilli and Veneri (2001) and Premius et al. (2001). Then, Burgalassi and Luzzati (2015) have reviewed on the urban spatial pattern and emission to the urban air. The United States Environmental Protection Agency, U.S. EPA (2001) also critically discuss on the impacts of land use planning towards the air quality. Few researchers in addition has been promoting the vitality of integrating the transportation and air quality such as Permana et al. (2015b), Apkan et al. (2014), Che Puan et al. (2014), Ong et al. (2011) and Xia and Shao (2005). However, it is hard to find the discussion of the relationship among the spatial pattern, transportation, and air quality at once. This shows that it is importance to understand the nexus at once, and thus becomes an important research arena.

Environmentally, the total understanding on the nexus of land use, transportation, and air quality, if addressed properly, can potentially promote sustainability while reducing environmental impacts generated from the development activities (U.S. EPA, 2001). In addition to that, Wagner and Wegener (2007) also agreed that modelling the nexus would provide a possibility towards the developments of better transportation system, improving travel behaviour while improving the air quality. By the above arguments, the nexus of land use or spatial pattern, transportation and air quality is an important arena of research. Therefore, the research on the nexus in Iskandar Malaysia is essential. It is also expected that the research can contribute to the emergence of knowledge and develop deep understanding on the concept and further promote implementation in the urban development.

1.3 Problem Statement

Developing countries are struggling in attaining sustainable development amid constantly arising issues and at the same time provoking environmental problems as experienced among the Asian cities such as Bandung, Indonesia (Permana et al. 2015a; Permana et al.,2015b), China cities (Su et al., 2014) and Bangkok, Thailand (Gakenheimer, 2008). The developing region, Iskandar Malaysia as initiated in the national spatial policy is believed to spur growth throughout the southern region. Sembiring and Ewing (2014) believed that the promotional growth will consequently come with potential environmental problems. As discussed by Baklanov et al. (2016), rapid urbanization affects the quality of urban air.

The current spatial distribution pattern in Iskandar Malaysia seemingly exhibits growth of new-centres towards a polycentric system. As aligned in the spatial development growth plan, the development of new sub-centres will help to counteract the unbalanced growth pattern in the region. This scenario at the same time creates possibility of a de-concentration mobility pattern towards the predominant central business district (CBD), JBCC which holds high capacity of job opportunities and clustering of economic activities.

Based on Permana, et al. (2015b) the development of transportation network would be expanded along with the spatial growth distribution. Thus, growth of new spatial distribution has a characteristic to be interactively connected with the transportation system. Thereby, the traffic flow concentration towards the single centre becomes less. Based on McMillen (2001), the polycentric system imposes good impacts in adjusting the travel behaviour of the citizen if jobs are agglomerated and distributed in some centres. It is based on the decision made by the citizen to be living as close as possible to their workplace to reduce their trip distance. In line with this, Casello (2007) believed that the principles of non-walking distance would create high dependency on private automobile which is not good for the environment. If the distance can be adjust from the planning of spatial setting through good integration of land use and transportation then, the causes towards environment can possibly be reduced.

The environment provides the most important surrounding effects to the society i.e. living environment, societal behaviour, and health. The degradation of the environmental quality through air pollution for example may contribute to substantial increases in rates of all major public health problems (The European Environment, 2010) based on the European countries i.e. developed region. The anthropogenic activities in urban areas may generate pollutants such as the Nitrogen Dioxide (NO_2), Carbon Monoxide (*CO*), Sulphur Dioxide (SO_2), Ozone (O_3), Particulate Matter both with average molecular size 2.5μm ($PM_{2.5}$) or 10μm (PM_{10}) in diameter and Lead (*Pb*) (Buckley and Mitchell, 2010). However, transportation process itself found to be releasing emissions such as Oxide of Nitrogen (NO_X), CO, Volatile Organic Compounds (*VOC*) and *PM* (Xia and Shao, 2005) which was generated due to the combustions of fuel. A research on transport generated emission in urban areas illustrates that the emission of CO_2 accounted for about 90 percent of the total burning of fossil fuels in the transport process (Solomon et al., 2007).

Based on the above discussion, there is potential that the environmental quality for the society can be improved if the transportation can be improved towards a more sustainable way. The idea of nexus among spatial, transportation and air quality exhibits association to the discussed problem above incorporating societal living environment. This is also in line with the national policy promotion of providing good environmental living for the society through initiatives enlisted in national government transformation programme (GTP 2014, 2015). It is therefore important to study the nexus of spatial, transportation and air quality nexus in the case of developing region, Iskandar Malaysia.

1.4 Objectives of the Study

This aims of this research is to analyse and evaluate the interconnectivity among the three development entities namely spatial structure, transportation, and air quality in Iskandar Malaysia. With the determined problem statement, the objectives of the study was predefined and listed as follows:

i) To identify the current spatial structure and development pattern in Iskandar development region based on the spatial policy setting and land use distribution.
ii) To evaluate the mobility pattern and behaviour in association with the spatial distribution in Iskandar Region with the aid of the household-travel survey.
iii) To estimate the air pollution generated from the transportation sector by using the existing correlation model of air pollution and traffic volume.
iv) To critically discuss and understand the interplay of spatial structure, mobility and the air quality nexus in Iskandar Region.

1.4 Research Questions

A development process requires strong integration among the associated and relevant sectors contributes to the development. Spatial pattern, transportation, and air quality are three development entities which directly or indirectly affects one another. Belaieff et al. (2007) asserted that the land use, transport, and energy nexus create causes which affect the ecosystems. The important element of connectivity between energy, environment, and urban form is the urban transportation, where abundant evidences have linked the spatial density of economic activities to the demand for vehicle use (Safirova et al.,2007). Mismatch of land use and

transportation network will disintegrate the whole spatial system then muddle up with the urban environment.

Thus, to accomplish the objectives of the research, the following research questions are offered:

i) What is the current spatial structure in Iskandar Region?
ii) How does the current spatial structure reflect the transportation system in the region?
iii) What is the quality of urban air in relation with the mobility pattern and travel behaviour in Iskandar Region?
iv) How does the interplay of spatial structure and urban mobility in Iskandar Region affect the air quality?

1.6 Scope and limitation of the Study

This study addresses the spatial pattern, transportation, and air quality nexus in the developing region which is presently figured with a high urbanisation rate. By realizing the broad scope of the nexus, this study is limited and focuses on certain areas only within Iskandar Malaysia and proves that the nexus do exist in the area given current spatial policies and development in the region. As indicated in the Low Carbon Society (LCS) Blueprint for Iskandar Malaysia (2013), the quantification of GHGs in Iskandar Malaysia was based on the regional's features which as includes the land use and transportation structure. Dominantly, industrial activities contribute highest percentage in the generation of GHGs. At the same time, transportation sector exhibit huge potential reduction if proper mitigation plan and countermeasure were takes place in the promotion of GHGs reduction emission.

Therefore, the research was carried out on the following manners:

i) Spatial analysis is certainly covering the whole Iskandar Malaysia.
ii) The transportation system is analysed for the whole Iskandar Malaysia but the traffic volume analysis is done for certain linkages only.
iii) The content of air pollutants stem from the transportation sector is estimated based on existing traffic volume and air quality model.
iv) The traffic is estimated at certain important linkages only by using manual traffic counting to understand daily and weekly pattern of the traffic flow.

1.7 Research Methodology

There are few researches on the interconnectivity of land use, transportation, and environmental nexus have been done, for example by Anderson et al. (1996) and Burgalassi and luzzati (2015). Anderson et al. (1996) highlighted the necessity of the policy design for transportation and land use integration to improve the environmental quality. Burgalassi and Luzzati (2015) considered using empirical evidence to deduce the integration between spatial pattern, transportation modal choice, and emission to the ambient air quality. Based on the U.S. EPA (2001) the nexus can be traced by using a model through simplified into stages of (1) estimation, (2) forecast and finally (3) modelling. Wagner and Wegener (2007) also agreed with the concept of modelling. However, microsimulation process is a necessity in creating the nexus. It is necessary to conduct a study to cope with essential issues that contribute to development.

Deep understanding on the urban growth factors is a necessity when analysing how spatial pattern can reflect the transportation emission (Lee, 2012). To answer the research question, well defined and broader understanding of the nexus concept between the development entities which contributes to growth is important. Based on Wagner and Wegener (2007), critical research on each development sectors is important to derive solution based on the issues tackled. This study cover three prominent sectors of developments includes spatial pattern, transportation, and air quality.

The core of this research is the nexus interconnection among the three entities of land use, transportation and air quality. The final outcome is a concept of nexus with the support of evidence to help improving the development pattern towards sustainable manner. To empirically conduct this research, each of significant sectors requires specific method underlying technical and social measures. The following methods were used in undertaking this study and briefly described here. Further description on the methodology is explained in Chapter 3.

1.7.1 Review on the Existing Studies

Reviews on the precedent studies, academic journals, and articles help in the developments of the research questions and construction of the research objectives while developing knowledge and understanding of land use, transportation, and environment nexus in the development basis. In addressing the spatial structure, mobility and air quality nexus, a series of linked stages ranging from the understanding of issues to the analysis of data was determined, plan and implemented (refer Figure 1.3). Table 1.1 presents the details classification of data required, methods of data collection and instruments needed to conduct the primary data collection in order to attain the spatial, transportation and air quality nexus.

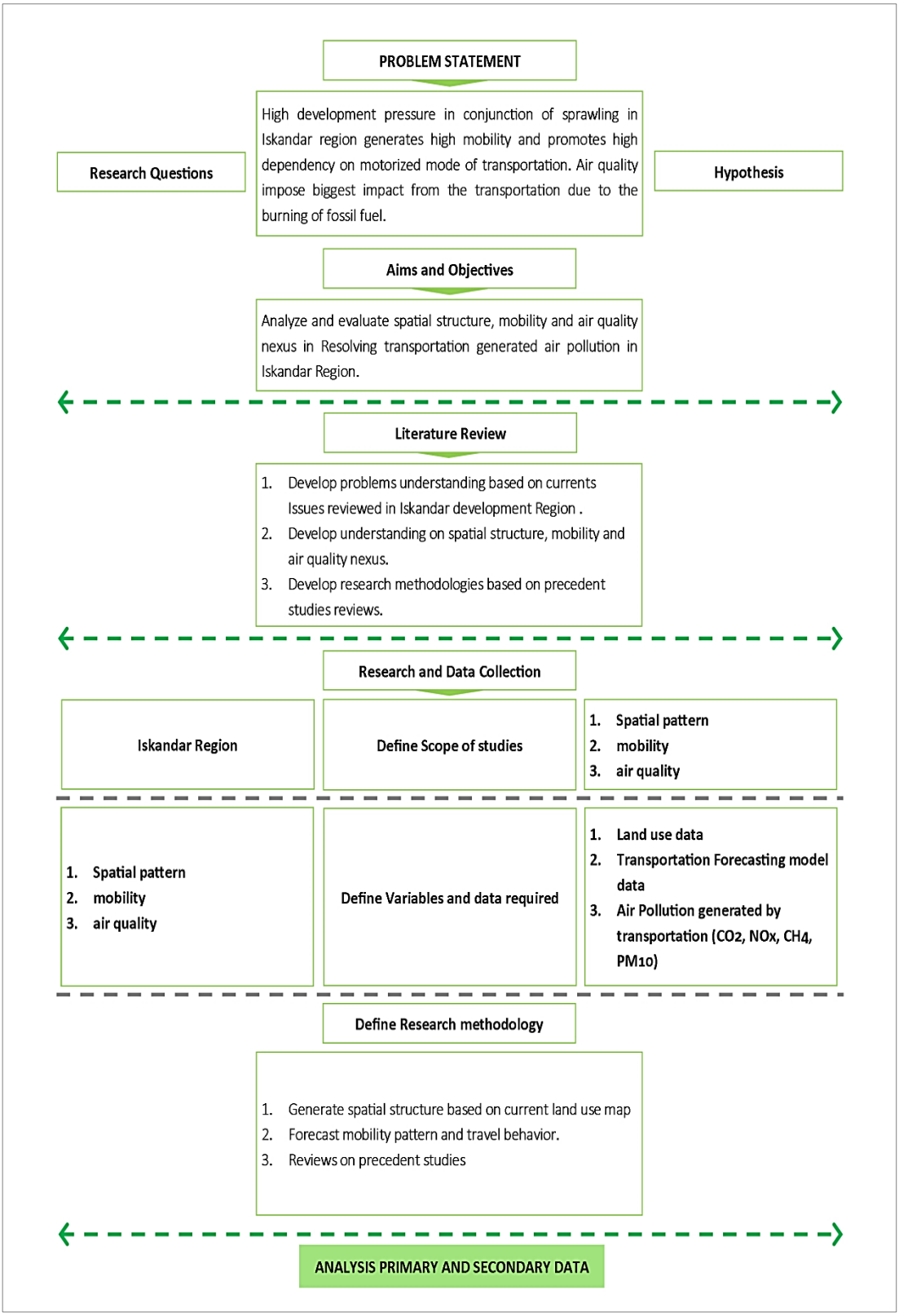

Figure 1.3: Research outline

Table 1.1: Research Data Required

RESEARCH OBJECTIVES	DATA REQUIRED	RESEARCH METHODOLOGY	RESEARCH INSTRUMENT
To identify the current spatial structure and development pattern in Iskandar development region based on the spatial policy setting and land use distribution.	land use data	Reviews on spatial planning policies integrated to the development of Iskandar Malaysia. Identify and descriptively analyze the current land use map. Identify significant Origin and Destination.	Sets of Spatial Policies as the basis which respect to the development of Iskandar Malaysia GIS application to assist the analysis
To evaluate the mobility pattern and behaviour in association with the spatial distribution in Iskandar Region with the aid of the household-travel survey	Household-travel data	Conduct a Household-travel survey. Develop trip table of origin-destination. Mapping out the spatial pattern using origin-destination data	Questionnaire. SPSS application. GIS application. Correlation model of traffic-air pollution
To estimate the air pollution generated from the transportation sector by using the existing correlation model of air pollution and traffic volume.	Traffic Volume	Conduct traffic Volume Survey at prominent points connecting origin and destinations. Estimate air pollutants by using the existing traffic-volume-air pollutants correlation model	SPSS application Traffic count form
To critically discuss and understand on the interplay of spatial structure, mobility and the air quality nexus in Iskandar Region.	Current data on conducted research and precedent studies	Reviews the precedent studies and best practices. Analyze the findings	

The spatial evaluation is a process towards understanding the regional structure of Iskandar Malaysia through reviews on the spatial policy. Current spatial pattern can be determined through analysis on land use pattern. Determination of small area to define the origin is based on the distribution of centres and residential land use. The origin-destination study provides figures of the current spatial system and further determines the integration of mobility pattern and land use connectivity. There are few centres of economic allocates job agglomeration however, the determination of major centres is important to clearly describe how the city was radiated from the origin and forming the new spatial pattern.

1.7.2 Research Tool Development

This research requires primary data which should be acquire from the primary survey. To accomplish this, a set of questionnaire of household-travel survey was developed. This questionnaire set is categorized into the personal demographic profile of the respondents and their travel behaviour. These respective questions are prominent to show the interaction between the spatial pattern in Iskandar Malaysia and the transportation behaviour of the population. The questions classified into closed-ended, open-ended, and open-response-option to fulfil the needs of respective research objective.

1.7.3 Data Analysis

Data analysis involves both primary and secondary data. Current land use data provides spatial pattern from the existing land use pattern and zoning of activities in Iskandar Region. Spatial policies reviews and studies integrated to the development in Iskandar Malaysia give a clear picture of spatial structure in the region. The second stage of data analysis integrate the spatial system with the household travel primary data survey which conducted at the selected neighbourhood

with high impact from the prevailing spatial growth trend as exhibit from the early study. The third stage uncovers air pollution particulate matter from the analysis of traffic load survey. Finally, critical discussions on the spatial pattern, mobility, and air quality nexus based on the findings and precedent studies justify the statement made.

1.8 Expected Findings and Contribution of Research

The research is expected to deliver the research questions which prominently focussing for the developing region, Iskandar Malaysia. The expected outcomes of the research are:

i) Iskandar Malaysia current spatial growth trends and the present trend of development is identified.
ii) Mobility pattern and travel behaviour of the Iskandar Malaysian's population as reflected by the spatial setting of Iskandar Malaysia region is analysed.
iii) The estimation of air pollution based on the traffic volume is determined.
iv) A descriptive concept of spatial structure, mobility, and air quality nexus is developed.

In the case of Iskandar Region, this study is important in providing the ideas to resolve land use transportation and generated air pollution problems. This is necessary in order to see whether changes to transport and land-use patterns are beneficial or not to the society, and to identify those changes with the greatest potential impacts (Anderson et al., 1996).

1.9 Summary of the Research

Iskandar Region reclaimed specific features in its development timeline to prove the exhibition of nexus between spatial pattern, transportation, and air quality in urban development. Since the establishment of its first CDP, Iskandar Malaysia land uses percentage has grown to almost 50% from the total built up areas of 31,463 hectares in 2005 to 61,786 hectares in 2013 within the development period (Iskandar Malaysia CDPII, 2014). It is also notable in the second Iskandar Malaysia CDP (2014) that the determined population in Iskandar Malaysia also has increased to 1.74 million populations with net density of 2,600 persons per square kilometres. At circumstance, its rapid development has been notable in the NPP-2 (2010) with urbanization rate over the national urbanization rate.

Based on the determination of current development trend in Iskandar Malaysia, this research aims to analyse and evaluate the nexus of spatial structure, transportation, and air quality in the case of Iskandar Malaysia. The research questions accomplish the determination of spatial pattern, transportation, and air quality nexus in Iskandar Malaysia. Methodologically, reviews on spatial setting for Iskandar Malaysia and collection of primary data through a household-travel survey and traffic volume counts address and delivers the research questions and objectives.

Exploring the idea of spatial structure, mobility, and air quality nexus may provoke the policy makers in putting the matters into consideration to generate an integrated planning system (Geerlings et al., 2003). Studies have proved that the policy setting plays vital role in addressing sustainable development through promotion of integrated development. It is where each development sectors such as land use, transportation, environment, and other prominent sector meets up. Therefore, research on the nexus between spatial pattern, transportation and air quality nexus in the developing region, Iskandar Malaysia is important.

REFFERENCES

Acheampong, R.A., Silva, E. A. (2015). Land use–transport interaction modeling: A review of the literature and future research directions. *The Journal of Transport and Land Use*. Vol 8, No.3, (1-28).

Abdullah, J., Yahaya, M.Z., Mohd Yunus, M.Z., and Md Ali Saifudin, M.S. (2009). Urban Sprawl in Malaysia: Evidences from Three Largest Metropolitan Areas. *Journal of the Malaysian Institute of Planners.*VII (69-82).

Afroz, R., Hassan, M.N., Ibrahim, N.A. (2003). Review of Air Pollution and Health Impacts in Malaysia. *Environmental Research.* 92 (71–77).

Ahmad, B. (2012). The Traditional Four Steps Transportation Modeling Using Simplified Transport Network: A Case Study of Dhaka City, Bangladesh. *IJASETR.*1(1)(03).

Akta Perancangan Bandar dan Desa 1976 (Akta 172) Pindaan 2006 (2006). Cited as Town and Country Planning Act of 1976 (Act 172) amendment 2006 (2006). Pesuruhjaya Penyemak Undang-Undang, Malaysia. Percetakan Nasional Malaysia Bhd.

Anas, A., Arnott, R., and Small, K.A. (1998). Urban Spatial Structure. American Economic Association. *Journal of Economic Literature,* Vol. 36, No. 3 (1426-1464).

Anderson, W.P., Kanaroglou, P.S., and Miller, E.J. (1996). Urban Form, Energy, and the Environment: A Review of Issues, Evidence, and Policy. *Urban Studies.* 33 (1)(7-35).

Angel, S. and Blei, A.M. (2015) The spatial structure of American cities: The great majority of workplaces are no longer in CBDs, employment sub-centers, or live-work communities. *Cities*. 51 (21-35).

Apkan, P. E., Usip, E. E., Jeremiah, U. O. (2014). Impacts of Traffic Volumes on Air Quality in Uyo Urban, Akwa Ibom State, Nigeria. *Journal of Environment and Earth Science.*Vol.4, No.21.

Audenhove, F. J., Komiichuk, O., Dauby, L., and Pourbaix, J. (2014). *The Future of Urban Mobility. Imperatives to Shape Extended Mobility Ecosystems of Tomorrow*. Vol (2). Arthur D. little, Future Lab.

Baklanov, A., Molina, L. T. and Gauss, M. (2016). Megacities, Air Quality and Climate. *Atmospheric Environment.* 126 (235-249).

Bartholomew (2005). *Integrating Land Use Issues into Transportation Planning: Scenario Planning*. College of Architecture and Planning, University of Utah.

Bart, I.L. (2010). Urban Sprawl and Climate Change: A Statistical Exploration of Cause and Effect, With Policy Options for the EU. *Land Use Policy*. 27 (283–292).

Beevers, S., Carslaw, D., Westmoreland, E. and Mittal, H. (2009). *Air Pollution and Emission Trends in London.* King's College London, environmental research Group Leeds university, institute for Transport Studies.

Belaieff, A., Moy, G. and Rosebro, J. (2007). *Planning for a Sustainable Nexus of Urban Land Use, Transport and Energy*. School of Engineering Blekinge Institute of Technology Karlskrona, Sweden.

Bertaud, A. (2002). Note on Transportation and Urban Spatial Structure. *Washington, ABCDE Conference.*

Bera,S. and Krishna Rao, K.V. (2011). Estimation of Origin-Destination Matrix from Traffic Counts: The State of the Art. *European Transport.* 49 (3-23).

Both, C.V., Schwarz, J.O., and Hewitt, R. (2013). Allianz Risk Pulse, Focus: *The Future of Individual Mobility*. May 2013. Allianz SE, Munich, Germany.

Buckley, S.M., Mitchell, M.J. (2010). Improvements in Urban Air Quality: Case Studies from New York State, USA. *Water Air Soil Pollutant.*

Burgalassi, D. and Luzzati, T. (2015). *Urban Spatial Structure and Environmental Emissions: A Survey of the Literature and Some Empirical Evidence for Italian NUTS 3 Regions.* An IRPET (Regional Institute for Economic Planning of Tuscany),University of Pisa, Department of Economics and Management, Italy.

Burger, M.J., de Goei, B., van der Laan, L., and Huisman, F.J.M. (2011). Heterogeneous Development of Metropolitan Spatial Structure: Evidence from Commuting Patterns in English and Welsh City-Regions, 1981–2001. *Cities.* 28 (160-170).

Brown, M. (2013). *National Transport Authority National Household Travel Survey 2012.* National Transport Authority, Dublin.

California Environmental Protection Agency. (2012). Ambient Air Quality Standards. Retrieved from http://www.arb.ca.gov/research/aaqs/aaqs.htm on July 21st, 2016.

Cambridge Systematics, Inc. (1996). *Travel Survey Manual.* U.S. Department of Transportation, U.S. Environmental Protection Agency.

Carey, M., Hendrickson, C. and Siddharthan, K. (1981).A Method for Direct Estimation of Origin/Destination Trip Matrices. Carnegie, Mellon University, Pittsburgh, Pennsylvania. *Transportation Science.* Vol. 15, No.1.

Casello, J.M. (2007). Transit competitiveness in polycentric Metropolitan regions. School of Planning and Department of Civil Engineering, University of Waterloo, Canada. *Transportation Research.* Part A (41) (19–40).

Chan, P. and Kasipillai, J. (2008). Travel Demand Management; lesson for Malaysia. *Journal of Public Transportation*. 11(3).

Chang, S.C. (2015). Effects of Financial Developments and Income on Energy Consumption. *International Review of Economics and Finance*. 35 (28–44).

Che Puan, O., Nabay, M. M., and Ibrahim, M.N. (2014). Effect of Vehicular Traffic Volume and Composition on Carbon Emission. *Jurnal Teknologi*. Penerbit Utm Press.

Cheng. J, 2003. *Modelling Spatial and Temporal Urban Growth*. Faculty of Geographical Science, Utrecht University, Netherlands.

Cirilli, A. and Veneri, P. (2001). *Spatial Structure and Mobility Patterns: Towards a Taxonomy of the Italian Urban Systems*. Università Politecnica delle Marche (Ancona - Italy).

Davis, L. (2000). *Urban Design Compendium*. The Housing Corporation.

Ding, C. and Zhao, X. (2014). Land market, land development and urban spatial structure in Beijing. Urban Studies and Planning Program, University of Maryland, United States. *Land Use Policy.* 40 (83–90).

Engelfriet, L. (2015). *The impact of urban density on car dependency and related energy consumption.* Vrije Universiteit, Amsterdam, The Netherlands.

EU Comission of Climate Action. (2016). *Reducing Emissions from Transport.* Retrieved on July 24th 2016 from http://ec.europa.eu/clima/policies/transport/index_en.htm.

Fecht, D., Hansell, A. L., Morley, D., Dajnak, D., Vienneau, D., Beevers, S., Toledano, M.B., Kelly, F. J., Anderson, H.R, and Gulliver, J. (2016). Spatial and temporal associations of road traffic noise and air pollution in London: Implications for epidemiological studies. *Environmental Studies.* 88 (235-242).

Fedra, K. (2004). *Sustainable Urban Transportation: A Model-based Approach*. Gumpoldskirchen, AUSTRIA.

Gakenheimer, R. (2008). Land Use and Environment in Transportation Planning as an Option among Others in Rapidly Growing and Motorizing Cities. *International Transport Forum: Transport and Energy: The Challenge of Climate Change*. Massachusetts institute of technology.

Geerlings, H. and Stead, D. (2003). Integrating Transport, Land-Use Planning and Environment Policy in European Countries. *EJTIR, **2** (3/4) (215-232).*

Glaeser, E.L. (2010). Agglomeration Economics. National Bureau of Economic Research (1).

Government Transformation Programme (GTP) Annual Report, 2014. (2015). Jabatan Perdana Menteri, Malaysia. Retrieved on February 6th 2016 from http://etp.pemandu.gov.my

Gubins, S. and Verhoef, E. T. (2014). Dynamic bottleneck congestion and residential land use in the monocentric city. Amsterdam, The Netherlands. *Journal of Urban Economics* 80 (51–61).

Gupta, J. and Shah, N.H. (2012). Origin Destination Transportation Models: Methods. Department of Mathematics, Gujarat University, Ahmedabad, Gujarat, India. *Int Jr. of Mathematical Sciences & Applications.*Vol. 2, No. 2.

Guy, B.P. and Fricker, J.D. (2005). *Guidelines for Data Collection Techniques and Methods for Roadside Station Origin-Destination Studies.* Purdue University, West Lafayette, Indiana.

Hock, S.S. (2015). The Population of Malaysia, Second Edition. Retreived from https://books.google.com.my/books?id=33FpBgAAQBAJ&printsec=frontcover#v=onepage&q&f=false on Nov, 11th 2016.

Holden, D. (2006). The Relationship Between Land Use and Car Dependence and its Application for Land Use Planning Policy in Sydney. *29th Australasian Transport Research Forum.*

Hsueh, Y.H, and Lin, Y.S, (2014). Exploring the Spatial Structure of a Destination Zone Based on Travel Nodes. *International Journal of Current Research and Academic Review.* 2(7)(1-10).

Iskandar Malaysia Comprehensive Development Plan for South Johor Economic Region 2006-2025 (Iskandar Malaysia CDPI) (2012).

Iskandar Malaysia Comprehensive Development Plan for South Johor Economic Region 2012-2025 (Iskandar Malaysia CDPII) (2014).

Johor Public Transport Masterplan (2015-2045). (2016). Perbadanan Pengangkutan Awam Johor.

Kinfu, Y. (2005). Spatial Mobility Among Indigenous Australians: Patterns and Determinants. *Working Papers in Demography No. 97.*

Klaff, V.Z. and Schnore, L.F. (1972). The Applicability of the Burgess Zonal Hypothesis to 75 Cities in the United States. *Working Paper.* (72-78).

Knaap, E., Ding, C., Niu, Y., and Mishra, S. (2014). Polycentrism as a Sustainable Development Strategy: Empirical Analysis from the State of Maryland. Forth coming in the *Journal of Urbanism.*

Lee, B. (2006). *Urban Spatial Structure, Commuting, and Growth in Us Metropolitan Areas.* Faculty of the Graduate School University of Southern California.

Lee, J.C. (2012). *The Effects of Urban Form on Vehicle Emissions - Focusing on Urban Form Factors and three Conventional Air Pollutions and Carbon Dioxide*. The Ohio State University.

Lefevre, B. (2008). Long-term energy consumptions of urban transportation: A prospective simulation of ‘‘transport–land uses’’ policies in Bangalore. *Energy Policy*.

Lesage, J. P. and Pace, R. K. (2005). Spatial Econometric Modeling of Origin-Destination Flows. *Regional Science.* 48 (941-967).

Lin, D., Allan, A., Cui, J. and McLaughlin, R. (2012). *The Effects of Polycentric Development on Commuting Patterns in Metropolitan Areas.* University of South Australia, Adelaide.

Lin, D., Allan, A., and Cui, J. (2013). Does Polycentric Urban Spatial Development Lead to Less Commuting: A Perspective of Jobs-housing Balance. *Polycentric city and urban commuting.* 49th ISOCARP Congress 2013.

Low Carbon Society (LCS) Blueprint for Iskandar Malaysia 2025. (2013). UTM-Low Carbon Asia Research Centre.

Madrid City Council. (2012). *Madrid’s Air Quality Plan 2011-2015*. Government Division of Environment, Safety and Mobility, Madrid City Council.

Maistrou, H. (1998). Analysis of Urban Patterns in Historic Settlements, As Basis for Their Conservation and Planning. *Nahoum Cohen in “Urban Conservation” 1998.*

McMillen, D.P. (2001). *Polycentric Urban Structure*. Federal Reserve Bank of Chicago. (15-27).

Meurs, H. and Haaijer, R. (2001). Spatial Structure and Mobility. *Transportation Research Part D.* 6 (429-446).

Mohd Shariff, N. (2012). Vehicle Ownership and Transportation Planning in *Malaysia. International conference on Traffic and Transportation Engineering 2012*. 26

National Physical Plan 2 (NPP-2). (2010). Federal Department of Town and Country Planning, Ministry of Housing and Local Government, Malaysia.

New Economic Model for Malaysia Part 1 (2009) (NEM 1, 2009). National Economic Advisory Council. Putrajaya Malaysia.

New York State, Department of Environmental Conservation (NYSDEC). (2010). National Ambient Air Quality Standards. Retrieved from http://www.dec.ny.gov/chemical/8542.html on July 21st, 2016.

Nielsen (2014). Car Ownership in M'sia Third Highest in the World. The Star Online. Retrieved from http://www.thestar.com.my/business/business-news/2014/04/16/car-ownership-in-msia-third-highest-in-the-world/ on July 24th, 2016.

Novacko, L., Simunovic, L.J., and Krasic, D. (2014). Estimation of Origin-Destination Trip Matrices for Small Cities. Traffic and Transportation. Vol. 26 (5), (419-428).

Ong, H.C., Mahlia, T.M.I., and Masjuki, H.H. (2011). A Review on Emissions and Mitigation Strategies for Road Transport in Malaysia. *Renewable and Sustainable Energy Reviews.* 15 (3516–3522).

Olmedo, H.S. (2008). *Spatial and Transport Planning Integrated Policies: Guidelines for Northwest Spain.* Transport Studies Unit Oxford University Centre for the Environment.

Pauker, G.J. (1974). Can Land Use Management Reduce Energy Consumption? *Caltech Seminar Series Energy Consumption in Private Transportation.* Santa Monica, California.

Permana, A.S., and Abdul Aziz, N. (2014). Land Use, Urban Mobility and Environment Nexus: Evidence from a Developing City. (Imprint Penerbit UTM).

Permana, A.S., Perera, R., Abd. Aziz, N. and Ho, C.S. (2015)(a). Creating the Synergy of Land Use, Transport, Energy and Environment Elements towards Climate Change Co-benefits. *IJBES* 2(1), (17-28).

Permana, A.S., Perera, R., Abd. Aziz, N. and Ho, C.S. (2015)(b). Corroborating the Land Use Change as Primary Determinant of Air Quality Degradation in a Concentric City. *IJBES* 2(2), (75-84).

Permana, A.S., Mohd Yusop, A., Towolie, S. and Dyachia, Z.S. (2016). Spatial Structure, Transport Energy and Air Quality Nexus; Evidence from Iskandar Malaysia. (imprint Penerbit UTM).

Peterson, A. (2007). The Origin–*Destination Matrix Estimation Problem — Analysis and Computations.* Sweden.

Priemus, H., Najkamp, P., and Banister, D. (2001). Mobility and Spatial Dynamics : An Uneasy Relationship. Research Institute for Housing, Urban and Mobility Studies, GA Delft, Netherlands. *Journal of Transport Geography* (9)(167-171).

Rancangan Malaysia Ke-8, 2001-2005 (RMKe-8). (2001). Unit Perancangan Ekonomi, Jabatan Perdana Menteri, Putrajaya, Malaysia.

Safirova, E., Houde, S. and Harrington, W. (2007). Spatial Development and Energy Consumption. Discussion Paper. *Resource for the Future.* (07-51).

Sembiring, M. and Ewing, J.J. (2014). Examining Economic Development, Environmental Policy, and Transboundary Pollution: The Case of Iskandar Malaysia and Air Quality. Centre for Non-Traditional Security (NTS) Studies S. Rajaratnam School of International Studies (RSIS), Singapore. no. IN1402, March 2014.

Siniscalco, M.T and Auriat, N. (2005). *Quantitative Research Methods in Educational Planning.* UNESCO International Institute for Educational Planning.

Sivakumar, A. (2007). *Modelling Transport: a Synthesis of Transport Modelling Methodologies.* Imperial College London.

Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller. (2007). IPCC, 2007: Climate Change 2007: *The Physical Science*

Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Statistik Pengangkutan Malaysia. (2009). Ministry of Transport, Malaysia.

Statistik Pengangkutan Malaysia. (2010). Ministry of Transport, Malaysia.

Statistik Pengangkutan Malaysia. (2011). Ministry of Transport, Malaysia.

Statistik Pengangkutan Malaysia. (2012). Ministry of Transport, Malaysia.

Statistik Pengangkutan Malaysia. (2013). Ministry of Transport, Malaysia.

Statistik Pengangkutan Malaysia. (2014). Ministry of Transport, Malaysia.

Su, H., Wu, J.H., Tan, Y., Bao. Y., Song, B. and He, X. (2014). A Land Use and Transportation Integration Method for Land Use Allocation and Transportation Strategies in China. *Transportation Research*. Part A (69) (329–353).

Sun, H., Wu, J., Ma, D., and Long, J. (2014). Spatial Distribution Complexities of Traffic Congestions and Bottlenecks in Different Network Topologies. *Applied Mathematical Modelling.* 38 (496-505).

Taib, M.S. and Siong, H.C. (2008). Planning System in Malaysia. *Joint TUT-UTM Seminar of Sustainable development and Governance.*

Tasic, I. and Porter, R.J. (2016). Modeling Spatial Relationships between Multimodal Transportation Infrastructure and Traffic Safety Outcomes in Urban Environments. *Safety Science*. 82 (325–337).

The European Environment, State and Outlook (2010). *Environment, Health, and Quality of Life.*

Teddlie, C. and Yu, F. (2007). Mixed Methods Sampling: a Typology with Examples. *Journal of Mixed Methods Research*. Vol 1, No. 1 (77-100).

Tenth Malaysia Plan, 2011-2015 (RMKe-10). (2010). The Economic Planning Unit, Prime Minister Department, Putrajaya, Malaysia.

United States, U.S. Department of Transportation. (2010). *Frieght and Air Quality handbook.*

United States Environmental Ptotection Agency (U.S. EPA). (2001*). Improving Air Quality Through land Use Activity.* Transportation and Regional Programs

Division Office of Transportation and Air Quality U.S. Environmental Protection Agency.

U.S. EPA (2016). Sources of Greenhouse Gas Emissions. Retrieved from https://www3.epa.gov/climatechange/ghgemissions/sources/transportation.html on July 24th, 2016.

U.S. EPA (2016). National Ambient Air Quality Standards Table. Retrieved from https://www.epa.gov/criteria-air-pollutants/naaqs-table on July 21st, 2016.

United State Federal Highway Administration (FHWA) Retrieved on July 24th 2016 from http://www.fhwa.dot.gov

Wagner, P. and Weneger, M. (2007). Urban Land Use, Transport and Environment Models. *Experiences with an Integrated Microscopic Approach.* disp 170.3 (45-55).

Wats, A. (2010). A study: The temperature rise has caused the CO2 Increase, not the other way around. Retrieved from https://wattsupwiththat.com/2010/06/09/a-study-the-temperature-rise-has-caused-the-co2-increase-not-the-other-way-around/ on Nov 20th 2016.

Xia, L. and Shao, Y. (2005). Modelling of Traffic Flow and Air Pollution Emission with Application to Hong Kong Island. *Environmental Modelling & Software*. 20 (1175–1188).

Yaldi, G., Taylor, M.A.P. and Yue, W.L. (2011). Forecasting Origin-Destination Matrices by Using Neural Network Approach: A Comparison of Testing Performance Between Back Propagation, Variable Learning Rate and Levenberg-Marquardt Algorithms. *Australasian Transport Research Forum 2011*.