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Spatial Pattern, Transportation and Air Quality Nexus: The Case of Iskandar Malaysia

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ABSTRACT

Spatial pattern, transportation, and air quality are three development entities which significantly affecting one another. This nexus exhibits the urbanization imprint accouter transportation generating air pollution as a reflection of spatial distribution. The integration among them is a vital part of development as it affects the societal living environment. It provides unfavorable air quality and directly cause health problems. The developing region of Iskandar Malaysia exhibits huge spatial distribution transformation accompanied by large percentage of urbanization rate, but seems less integration of land use and transportation planning which causes the exaggeration of air pollution. We carry out the research on the nexus of spatial distribution, transportation and air quality in Iskandar Malaysia by analyzing and evaluating the interconnectivity of these three entities. The spatial analysis and evaluation on the land use development pattern and spatial policy shows that the Iskandar development region are growing in the polycentric manners, where the spatial development policy drives the distributional growth of new sub-centers. We undertook a household-based travel survey that reveals the poly-centricity reflected by the de-concentration of workplaces which shifted from the single point towards multiple centers. On the other hand, this phenomenon has created a distributional traffic pattern amid the high dependency on the private vehicles of the citizens in Iskandar Malaysia. With a predominantly fossil fuel consuming vehicles, this has generated air pollution. Based on the traffic survey and the dependency of the citizens on private cars for their daily mobility, the concentration of air pollution is seemingly at risk. This research reflects that Iskandar Malaysia development region currently undergoes towards polycentric development with some new urban centers. We found that land use and transportation planning policies require serious attention as the current trend of spatial pattern development tends to reinforce high dependency on the motorized travel.

1. Introduction

Capello (2011) asserted that a region exists with a determined feature and function, which then will determine the future development of its physical and cultural landscape identity. He added that a geographical location plays a very important role towards the development of each region as this feature will determine the potential accessibility and economic advantages. This notion seems valid every where including Iskandar Malaysia. Iskandar Malaysia, the study area, is strategically situated at the southernmost tip of Peninsular Malaysia making its location a strategic point of access to Peninsular Malaysia from the southern gateway. The additional feature of economics potential of the region is good locational setting and it has stimulated the growth of the region and creating multiplier effects towards the development of its surrounding areas. The potentials of the advance economic region exposed Iskandar Malaysia to high development pressure and thus, recognized as the second fast growing economic region in Malaysia (NPP2, 2010). The existing potentials of Iskandar region have promoted the economic growth in the region with its primary urban center, which is Johor Bahru City Center, JBCC. Johor Bahru has reached over 65 percent of national urbanization rate (NPP2, 2010). The development of Johor Bahru itself is associated with the long history of Johor Bahru as the capital of the Sultanate Johor since the 18th century, and has drawn an urban dispersion pattern especially from the concentrated nucleus of the development of Johor Bahru city center (SJER CDP 2012-2025, 2012). This has partially caused a concentrated traffic movements towards the center (Gubins and Verhoef, 2013). This occurrence has drawn an imbalanced spatial distribution growth in the region with respect to job and working places, which was mostly concentrated in the single point while sprawling along the major access. As a reflection to the trends of spatial growth, new comprehensive development plan were developed to induce the imbalanced regional growth towards more balanced one. The newly developed spatial setting of Iskandar Malaysia has promoted growth of new sub-centers with promising economic potentials in each growth center.

Within an urban development context that encourages the economic growth, an environmental associated issue, which is air quality, may generate. Air quality can be reflected from the human and

environment interrelation. The daily mobility that is performed by the Iskandar Malaysia society, which is relying highly on the private vehicle, can increase the emission discharge due to the burn of fossil fuel, since most private vehicles now are depending on the fossil fuel resource. Current situation of Iskandar Malaysia in the aid of new comprehensive development strategy tend to promote the growth of a polycentric spatial pattern from sustainable transportation viewpoint, with the support of 'within walking distance' principles', maximizes the dependency on the private vehicles. The shorter distance of 'willingness to walk' of the citizens -as a result of spatial planning- in addition to insufficient public transport system –as eventual reflection of transport planning- would enhance the dependency on private vehicles, and thus amplify the air pollution. This simple example shows that the nexus of spatial pattern, transportation and air quality do exist, and it is important in the development timeline.

Land use, transportation and environmental nexus was deliberately discussed in a sequent manner through few studies advocating integration promotion throughout the planning system. Permana, Perera and Norsiah (2015a) noted that there is a linear connection between the three important development elements of land use-transport-air quality. The study took place in a developing city where a concentric characteristic is reflected. In line with it, Burgalassi et al., (2015) discussed the spatial structure and transport-generated emission that influences environmental quality. They also asserted that spatial structure can be reflected in presence of carbon emission as a result of transportation habit. This issue has also been discussed prolonged enough by, for example, Pauker (1974), Anderson, Kanaroglou and Miller (1996), Geerlings and Stead (2002), Holden and Norland (2005), Belaieff, Moy, and Rosebro (2007), Gakenheimer (2008), Manins et al. (2011) and Lee (2012). This study intends to analyze the nexus of land use -as reflected in spatial structure-, transportation and the impacts on urban air quality, which certainly will affect the living environment.

2. Iskandar Malaysia at Glance

Iskandar Malaysia is located at the southern part of peninsular Malaysia (Figure 1) and exhibits a strategic geographical location as it possess as the major gateway into Malaysia. Dating back in the 14th century, the Straits of Tebrau which separates Johor and Singapore was well acknowledged as a fluorescent point of ship harbor coming from around the globe under the ruling of Johor Sultanate. Its prominent identity has prospered the region economically while simultaneously embark richness in physical while cultivating cultural landscape setting into the region as a whole. Looking at its potentials, Iskandar Malaysia becomes one of the major economic growth center i.e. SJER in 2006, addressing vast socio-economic growth as initiated in the Tenth Malaysia Plan (RMKe-10) along with the trust of the specially designed development plan. The region has been exposed to the pressure due to high development needs since the official ratification Iskandar Malaysia in 2006. It is also recognized as the second fast growing economic region in Malaysia after the central economic growth region of Klang Valley (NPP2, 2010).

Iskandar Malaysia exhibits a high value of land and property which grow along with the physical and economic developments guided by current spatial policy. The increase of property value is in line with the population growth and spill over of the property demand from the neighboring country Singapore. Singaporeans are allowed to own their property in Iskandar Malaysia with differentiated price to local citizens. Iskandar Malaysia, with access opportunity through Johor Bahru causeway link gateway and the Malaysia-Singapore Second Link, at the same time increases the numbers of property buyers from the developed country of Singapore. The access presents good potential interaction between the developed country of Singapore and the developing nation of Malaysia in terms of economic growth and population. Population growth in Iskandar Malaysia shows that the population in the region has reached 1.8 million in 2015 over the projected growth by 0.2 million (Khoo and Tan, 2015). The growth, on one hand has created Iskandar Malaysia as the region with highest economic growth in Peninsular Malaysia. On the other hand, it carries environmental social impacts. Environmental impact exhibited is particularly with respect to the degradation of air quality. The social impact appeared, although subject to an in-depth study, the gap between the rich and the poor. This issue must be addressed appropriately.

3. The Fundamental Principles of Spatial Structure, Transportation and Air Quality

3.1 Overview

The fundamental concept of sustainable urban development is basically to allow a controlled urban growth within the corridor of economic, environmental, social and cultural constellation. Thus, sustainable urban development requires, for example, no sprawl as sprawl may generate more waste and resources use, and no unjust eviction of urban poor as they are also human-being who have their rights. Also, closer economic gap between the rich and the poor, and respectful to other faiths, beliefs, races and other cultural backgrounds, while promoting environmental protection and minimizing pollution as a result of anthropogenic activities within acceptable limits. Urban development is visually exhibited by urbanization process as part of the development process and has drawn changes in the management and uses of land (Manins et al., 2011). Permana et al. (2015b) argued that the sprawling city, which is as a result of an uncontrolled urbanization, is also part of the development which physically appeared as spatially dispersed. In line with this notion, Aguilera et al. (2010) stated that low density urban development gradually draws on the impacts on social and environmental dynamics. The spatial distribution formed by urbanization process will build a tendency towards the elevation of transportation demand as the need of mobility increases. When the citizens with high dependency on private vehicles that consume fossil-based fuel to perform the daily commuting, then it affects the quality of living environment due to the discharge of air pollutants by the transportation activities. One of the most significant results of urban development that amplify and exacerbate air pollution is sprawl. Cheng (2003) stated that sprawl is created due to uncontrolled urbanization in the aid of economic booming and with technological influence, which also draws complexities towards the transportation system. The complexity in the process of urbanization requires strong acknowledgement of the interrelationships and interdependence of land use, transport, and energy consumption to adhere the optimization use of land, increase the efficiency of transport networks while discouraging energy consumptions. The key word in this process is the space and the process on it.

3.2 The Element of Space

Space is a prominent element of an area that must be sufficiently present in determining potential growth. It is based on the idea that spatial elements is associated with the use of space and ensuring the processes on it (Horton and Reynolds, 1971; Burgalassi and Luzzati, 2015) and the interrelation between the space and the development processes (Priemus, Najkamp and Banister, 2001). A spatial setting will lead to the flavor of development as described by Cheng (2003) in which, spatial setting involve the perspectives of space and time within a spatial arrangement. Thus a development flavor will largely depend on this setting. A development system requires strong interrelation as in the urban and regional development concept. Angel and Blei (2015) figured out that the of land uses pattern, the characteristics of the transportation system and the reactional behavior of people towards the system will determine the development process. It can be defined by the interrelation in between the residential development and land use, for example, transportation system in associated with the land use distribution (Lee, 2006; Burgalassi et. al, 2015; Angel et al., 2015; Giuliano, Agarwal and Redfearn, 2008. The spatial setting and development system will determine the spatial pattern i.e. monocentric model (Figure 2) and polycentric city model (Figure 3) of the specific region and the efficiency towards a balanced growth.

Figure 2: *Monocentric City Concept*

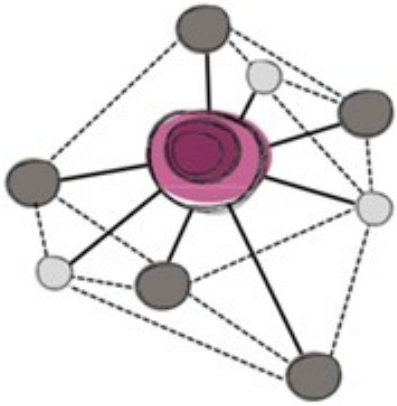

Figure 3: *Polycentric City Concept*

3.3 Transportation and Automobile Dependency

Transportation is a prominent part of a regional system. The modern development pattern increases the transportation demand due to the distributed spatial pattern. Permana and Aziz (2014) suggested that a transportation system must be a complete sets of the infrastructures, modality and the users which particularly referring to the road, vehicles and people respectively. In addition, transportation system also should consider the flows and management, because there is a distance and needs to travel and it therefore will determine the mobility habit and modal choice (Sun, Wu and Ma et al., 2013). Reflecting to the present development and modernization, modern citizens considered transportation and mobility as their way of life to fulfil their daily needs because the locational setting of residential area is separated from the other use of land i.e. commercial area. The auto mobile has become trends among them due to well developed motor vehicle as mode of transportation. Moreover, the dependency have increased over the time significantly among the developing countries allowing 6.2 billion daily automobile trips took place (Audenhove et al., 2014). The dependency is well associated with the preference of using private automobile because of inefficient public transportation system. This has caused the environmental problem generated by the transportation sector to amplify over the time.

3.4 Space, Society and Air Quality

Good air quality is needed anywhere for the good life of people and environment. Thus, air quality is associated directly and particularly with the spatial distribution of the regions, the population density and the transportation system. Air quality can affect the society's way of life and health. Exposure to air pollutants can directly and biologically harm the health. Air quality can affect the lifestyle of society such as avoiding to stay outdoor for a long time. From the transportation viewpoint, it will dictate people to predominantly depend on the private cars and avoid walking and cycling as daily transportation even to travel within the walking distance zone. Fecht et al. (2016) figures out that common air pollutants which affect human health comes mostly from the vehicular traffics. The air pollutants found in the atmosphere includes Carbon Monoxide (CO), Nitrogen Dioxide (NO2), Ozone (O3), particulate matter (PM), Sulphur Dioxide (SO2) and lead (Pb) (U.S. EPA, 2016; CA.GOV, 2012; NYSDEC, 2010). Human exposure to CO can harm the health condition involving the cardiovascular system and nervous system, ground-level ozone and particulate matter infect the respiratory system while lead (Pb) can affect the sets of respiratory, cardiovascular, reproductive system, as well the immune systems (U.S. Department of Transportation, 2010). This impact shows the importance of addressing the air quality issues stem from urban development and transportation interconnectivity.

4. Spatial Pattern, Transportation and Air Quality Interconnectivity

The analysis of land use, transportation, and environmental nexus attempts to advocate the integration of these elements throughout the planning system, to ensure that the adverse impacts particularly on end results are addressed appropriately. Anderson, Kanaroglou and Miller (1996) conducted a review on urban form and energy consumption and the impacts towards the environmental biology. Their study deduced the necessity to put into consideration in particularly defined the generation of the released pollutant in the context of urbanized area to address the prevailing environmental issues. They highlighted that the policy design for transportation and land use will definitely create a form which will determine whether or not the policy is pro-environment. In the same line, Permana et al. (2008) reported that there is a strong correlation between urban form, energy consumption and air pollution. This study has confirmed the presence of nexus, and thus it can be safely said that spatial pattern, transportation and air quality are interconnected. Addressing air quality from transportation sector, must address all the elements within the nexus.

With the same idea of integration, as suggested by Anderson et al. (1996) and Burgalassi et al. (2015), also brought the evidences that uphold the spatial structure interconnection with transportation would address the emissions produced by the nexus. Considering the importance of empirical evidence as suggested by Anderson et al. (1996), they deduce that the spatial distribution which is described as the polycentric pattern comes with maximum potential of emission due to the high dependency on private vehicle. On the other hand, polycentric pattern in combination with compact and mix development have a potential to reduce the emission discharge. This is how the urban form promotes energy consumption. Permana et al. (2015a) asserted that the interlocking elements of land use, transportation and environment nexus can potentially generate co-benefits for the climate change adaptation and mitigation when all the elements were taken care. In a broader sense, U.S. EPA (2001) suggested that the interplay of land use, transportation and air quality can be assessed through emission modelling from the land use development through three sequential steps, which are estimate, forecast and model. The forecast of future land use estimation must consider the projection of the population, economic activities associated with land use development. The forecast of travel demand that involves the traditional four-step model is to acquire the traveling model of the integration of the land use and transportation economic activities of the distinct population in determined zone. The emission model is generated from the estimation of the emitted pollutant from the transportation process. Attention on the land use induced transportation system and the emission discharged can potentially promote better plan towards sustainability while reducing environmental impacts generated by the anthropogenic activities (Anderson et al., 1996).

Wagner and Wegener (2007) agreed that the modelling of the integration of land use, transportation and environment requires s microsimulation process to dig up further deep solution. The model describe microscopic submodule to each of land use, transport and the environment. The microscopic model of land use should account for prominent elements of population, firms, residential mobility, firm location/relocation, residential buildings and non-residential buildings to understand the trip process between origin and destination. The transportation model characterizes the people's travel behavior to track down the travel demand as reflected in the traffic flow, the traffic links loads and the pick time of travelling. The micro module for environment modelling relies on the forecast of transportation cost towards the environment. By this arrangement, the microsimulation can provide the possibility towards the developments of better transportation system, improving societal behavior on their mobility and provide clear image of land use-transportation integration to improve the environmental quality. Considering the above arguments, we conducted the study by employing known methodology towards the accomplishment of the objectives.

5. Methodology

5.1 Definition of the Nexus

The idea of Wagner et al. (2007) on the importance of critical research on each elements of the nexus to address on individual issues of the element gives rise of the evidence in the urban development timeline involving the nexus. The configuration of the nexus can be equally determined as each development sectors and they are confirmed co-related to one another. This study encompasses three urban and regional planning prominent sectors accommodating spatial growth and distribution, urban mobility and transportation and environmental air quality generated by the traffic flow (Anderson et al., 1996). It can also generate energy consumptions from transportation sector. To assess and understand all of them can be acquired through empirical study. The prominent part of the research acquires the nexus of these three sectors in accomplishing the sustainable growth as envisioned by the national spatial setting of Malaysia through regional comprehensive plan of Iskandar Malaysia. To empirically conduct this research, each individual sector was analyzed by a specific method underlying the technical and social measures to address as the objectives.

5.2 Research Organization

We undertook the study by analyzing the current spatial configuration of Iskandar Malaysia. The spatial configuration of the region was determined through identifying the clustered residential areas and understanding the centers of economic, which are usually formed the

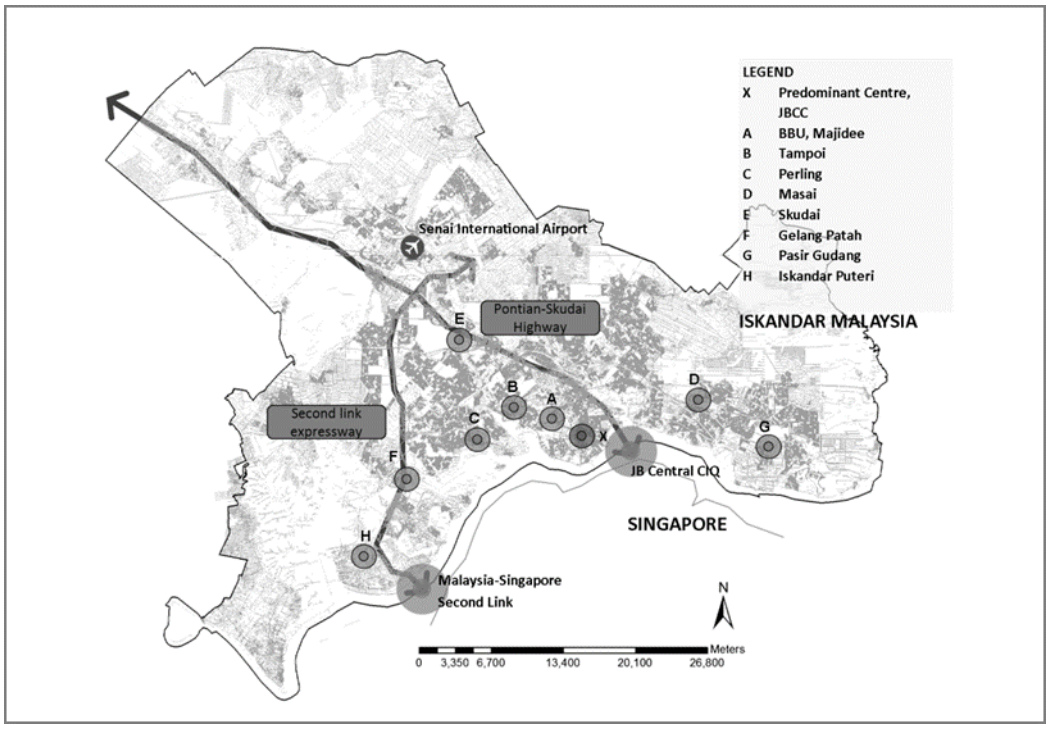

Figure 4: *Predefined Origin (Residents of Respondents)*

concentration of working places. Origin and destination survey of the commuters was conducted. The identification was based on the idea of quantifying spatial structure as suggested by Lee (2006). He focused on the population distribution and employment agglomeration. The interaction of between residential distribution and the primary job centers would depict the spatial pattern. The identification of spatial pattern could also be established through the identification of land use pattern by assessing working places (the destination) and commuter's living quarters (the origin) that is conducted through questionnaire survey and with the aid of review on spatial policy for the Iskandar development region.

The primary data was collected via a questionnaire survey. We organized a random sampling survey method by considering the population size of Iskandar Malaysia. An estimated population was 1.7 million, and with an error of 2.5%, the respondents were determined and selected randomly. The household travel survey was conducted by acquiring 400 randomly selected respondents to distinguish and understand the origin and destination sectors in the city. Some city sectors were predefined to easily recognize the origin and destination and for further analysis to define the spatial pattern of Iskandar Malaysia. The predefined sectors of residential areas shown in Figure 4.

The household travel survey provides information of the prominent linkages connecting the origin and destination of respondents. Based on this, we selected some important points that most probably the connecting points of origin and destination of the commuters. The traffic volumes were estimated at the selected points as shown in Figure 5. On site traffic volume counts to further estimate the air pollution by using the correlation model of traffic and air pollution. The of air pollutants i.e. SO2, CO, and PM10 were estimated based on the existing traffic volume and air pollutant correlation model. The model was derived from a study in a developing city with obvious mono-centricity. The application of the model was decided by considering the similarity on the dependency on private cars, traffic flows as the major source of air pollution and all particulate matters are dominantly generated from the vehicles.

6. The Nexus Configuration in Iskandar Malaysia

6.1 Spatial Setting of Iskandar Malaysia

Under the statutory plan of Peninsular Malaysia, Iskandar region is ruled by the spatial policy setting through the National Planning Policy 2, Five -Year Malaysian Plan, Iskandar Malaysia CDP-I (2012) and further Iskandar Malaysia CDP-II (2014). The serial development plans set up a system in coordinating and controlling the spatial growth in Peninsular Malaysia in particular. The Iskandar Malaysia development region covers the total areas ruled by five local government authorities, with approximately 2,216.3 sq. km (Iskandar Malaysia CDP-I, 2012), and with the total of 1.7 million population residing within (Iskandar Malaysia CDP II, 2014). The growth was formally guided by a comprehensive development plan, CDP for Iskandar Malaysia under the regulation of Khazanah Malaysia with the monitors of Iskandar Region Development Authority, IRDA. Since the first comprehensive plan, most developments in Iskandar Malaysia have been translated into vast economically and socially catalytic projects to deliver the vision of developing a strong, sustainable conurbation of international standing as stated in the Iskandar Malaysia CDP-I (2012).

Spatial development of Iskandar Malaysia before the new development concept was introduced counteract the imbalanced growth pattern that was existed with a single economic center (see Figure 6). As the single economic center was the major concentration point, it has become a densely populated center holding the highest capacity of job

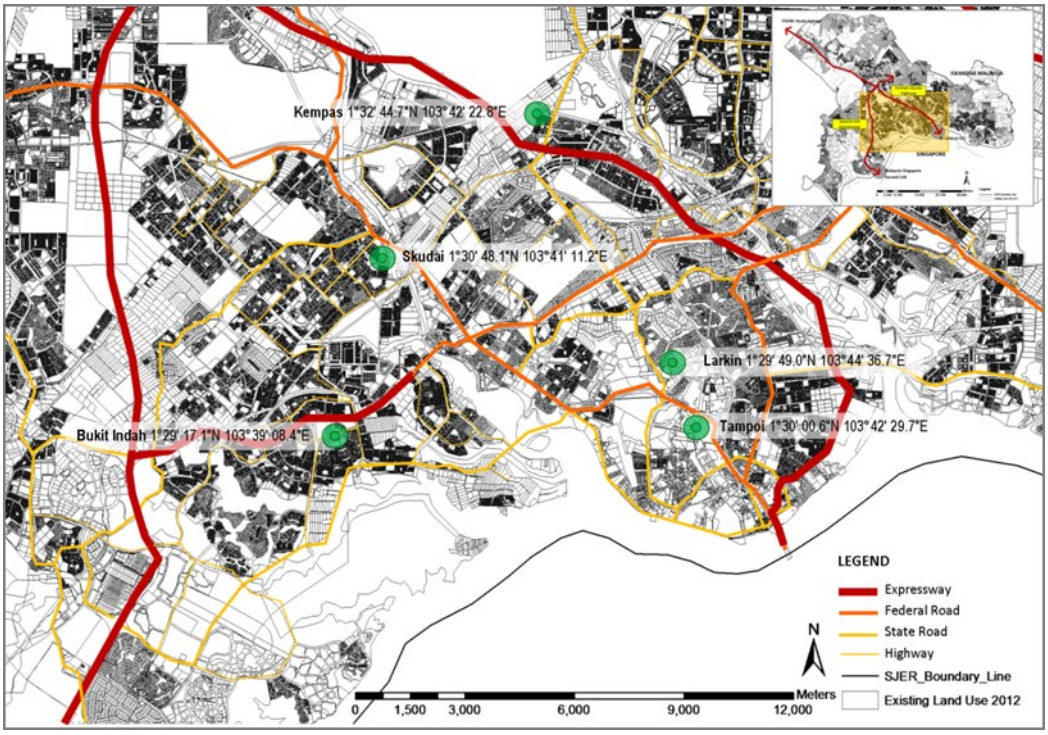

Figure 5: *Predefined Prominent Traffic Points Connecting Origin and Destination*

agglomeration. This has caused development pressure in the single center. On the other hand a sprawl takes place along the major access towards the center (Iskandar Malaysia CDP-I, 2012). The sprawl shows an extrapolation that is originated from the major center which promotes separation of land uses causing most population to live away from the center but highly accessible to the center because of the strong transportation network (Anderson et al., 1996). This is causing the less concentration in the center from time to time. The spatial distribution of Iskandar Malaysia as exhibited in Figure 6 shows that the JBCC is connected by major expressways towards the center.

The comprehensive development plan which was specifically design to guide the development in Iskandar Malaysia was projected to that development in the region meets the national 2020 vision as a fully developed nation by 2020, by delivering the vision of developing a strong, sustainable conurbation of international standing as stated in the Iskandar Malaysia CDP-I 2012. Stimulated by existing spatial growth,

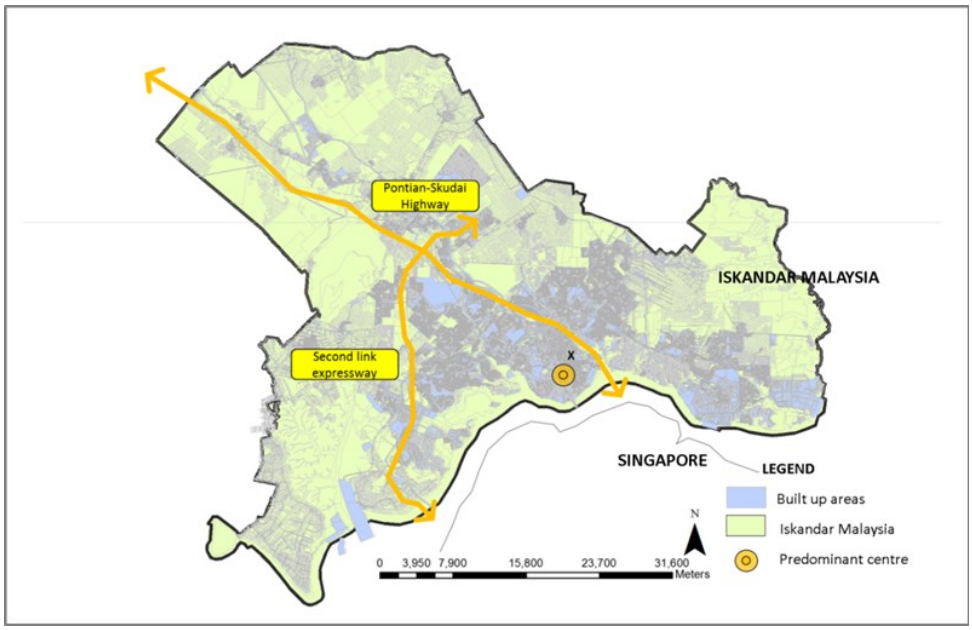

Figure 6: *Spatial Distribution of Iskandar Malaysia (2012)*

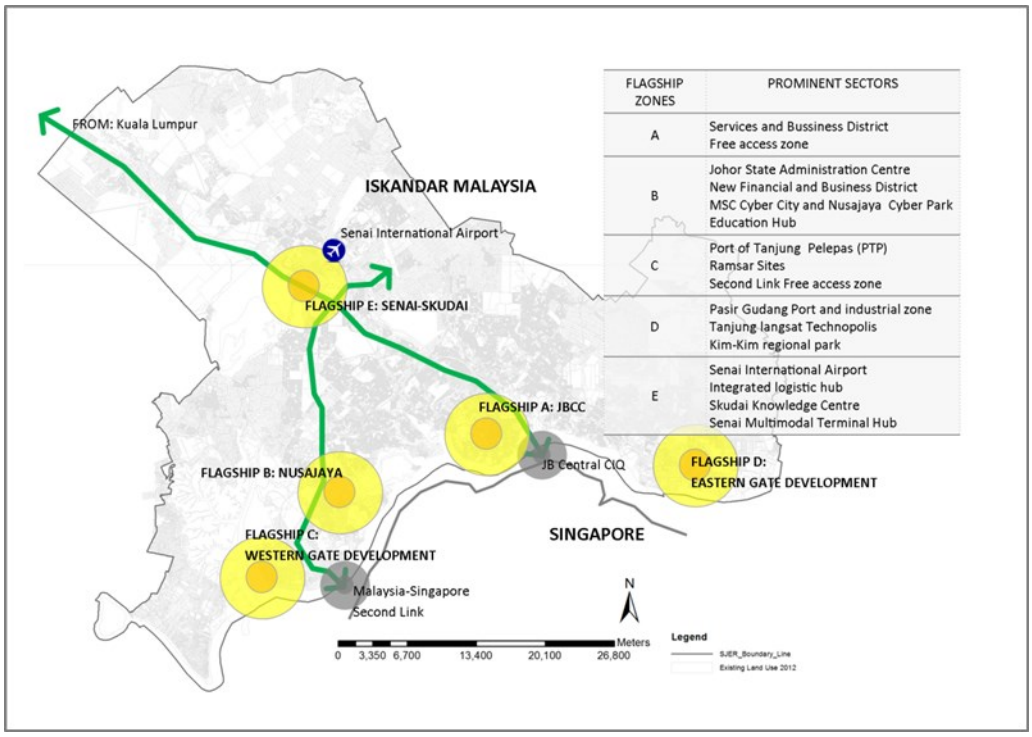

Figure 7: *New Sub-nucleus Promotion*

the new development sets up the promotional growth of sub-centers to advocate balanced growth. To nurture a balanced growth towards a polycentric system, the spatial setting for the development timeline of 2005-2012 was designed with the recognition of new centers (Figure 7). Based on the economic potential of each new center, the overall objectives is to spur the growth of the region as a whole entity of Iskandar Malaysia Region. This is as a long-term spatial planning in promoting less dependency on the private cars trough well design transportation system in line with overall development of Iskandar Malaysia.

Based on a study by Burgalassi et al. (2015), the poly-centricity will not reduce the air pollution generation from the transportation sector but the system is viable to reduce automobile dependency for a long-term development. In the perspective of Iskandar Malaysia, the region was determined as the monocentric regional system with concentrated development at the primary commercial center of JBCC. The sole commercial center of Johor Bahru, the presence of JBSS has driven the high traffic concentration towards the center and generated air pollution do exist. However, later on as Iskandar development region was formally established in 2006 and recognized as the southern economic growth region, the traditional concentric development was shifted towards a development of multiple growth center. This has cultivated new spatial pattern as polycentric regional system decelerating the sprawling process that may create imbalanced regional growth. The traffic concentration generated by a monocentric city has shifted accordingly towards more distributed traffic pattern along with the polycentric system, and thus reducing the concentration of emission. However, this is not improving the air quality rather distributing the concentration of air pollutants towards lesser concentration. Moreover, the travel behavior of citizens in Iskandar Malaysian shows major dependency on the private cars would definitely exacerbates the air pollution.

6.2 Poly-centricity as a Reflection of Distributional Travel Pattern

Development of multiple centers in Iskandar Malaysia would influence the sub-centers and its surrounding areas to sequentially grow as well in terms of physical and economic sectors. This arrangement in return can promote a balanced population distribution throughout the region rather than concentration at only one point as previously happen. The promotion of polycentric system with multiple numbers of centers has potential to adjust the transportation system when the working populations tend to wisely determine their residential and locational setting of their workplace (McMillen, 2001). Based on Ding and Zhao (2013), the job decentralization, to some extents, will determine its efficiency with respect to energy and environment. The commuting habit will therefore change as the working population would probably prefer to live nearby their workplace (McMillen, 2011). It is because, they are no longer dominantly depending on the major center to be their workplace and possibly choose to live as close proximity to their workplace. Further, this situation will create a less travel distance to work place and at the same time reduce the automobile dependency as proved by Burgalassi et al. (2015). The poly-centricity is therefore has a long-term potential to reduce the automobile dependency.

The household travel survey based on the origin-destination in eight predefined residential and economic centers reveals that the predominant center i.e. JBCC (Figure 8) is no longer exist as the major destination of working place. Based on the travel survey, as shown in Table 1, there is a significant numbers of concentrations towards zone G (11.25%) followed by zone E (11.00%) and zone H (8.75%). However, the highest numbers of concentration towards JBCC is only 5.75% and in average, and only 3.00% of working population is still travelling towards the center. The figure as shown in Figure 8 reveals the emergence of zone G, E and H as the new sub-nucleus in Iskandar Malaysia which holding high capacity of job agglomeration. The

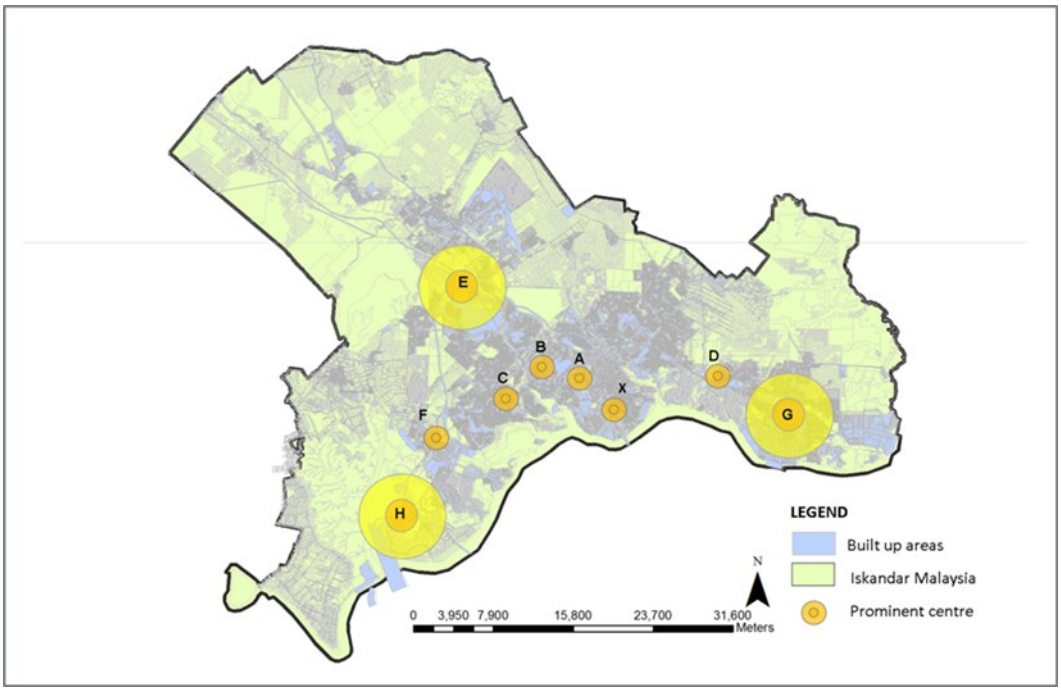

Figure 8: *New Sub-nucleus Promotion*

phenomenon shows that the development of spatial distribution in Iskandar Malaysia is going in coordination with the setting of spatial policy towards the development of polycentric region system.

The prevailing concept of development setting has as well promoted a balanced job-housing distribution through self-contained sub-nucleus. Evidently, zones G and E accommodate more than 10% of working population who travel within the same zones to their workplace (Table 1). The figure then followed by zones H and F with concentration of 8.75% and 6.50% respectively. The development of economic centers in the new-sub nucleus has advocates the growth of residential as well as other facilities and infrastructure development within and surrounding the zone of development to accommodate the working population. There is significant numbers of working population who travelling from zone F (5.75%) to JBCC with 0.75% different to the figures of population of working and living within the zone. This figure explains the situation where the populations of zone F dependency on the zone X (JBCC), as the major center of job agglomeration, is still high. This is because, zone F used to be an under developed zone before zone H was promoted into a new center accommodating the state administration center. This development has strong influence on the concentration of air pollutants resulting from transportation sector.

6.3 Traffic Generated Air Pollution

Fossil-fuel-consuming automobiles those emit pollutants to the atmosphere show a tendency to be increasing and become prevailing figure in Iskandar Malaysia. Based on our survey, the citizens of Iskandar Malaysia have very high dependency on the private vehicles for travelling thus contributed to high emission into the urban atmosphere. In relation to this, we have subscribed a model of traffic and air quality correlation. Since the study also analyzed the traffic volume at some selected points, and by using the existing model of traffic volume and air quality, the quantity of pollutants have then been derived from the model. The model was based on the study of Permana and Aziz (2014), as shown in the following correlations:
The correlation between traffic volume and CO resulting in the following regression equations. Regression equations can be calculated by using Excel or SPSS.

Linear:	$y = 0.0004x + 1.1379$ $(r2=0.5977)$
Logarithmic:	$y = 0.810\ln(x) - 3.9863$ $(r2=0.5604)$
Polynomial:	$y = -3E\text{-}08x2 + 0.0006x + 0.9009$ $(r2=0.6127)$
Power:	$y = 0.553x0.4671$ $(r2=0.4683)$
Exponential:	$y = 1.0753e0.0002x$ $(r2=0.4274)$

Based on the model and data acquired from the survey on traffic volume, the generated air pollution is shown in Table 2 and it reveals that there is high concentration pollutant in Skudai area, although the concentration is still below the National Air Quality Standard of Malaysia. The selection of the measuring points was to justify the linkages between resident (origin) and working place (destination). Table 2 confirms the function of the trunk road of Skudai as the main linkage connecting the residential areas and economic centers where the job agglomeration takes place. Atmospheric pollution due to traffic generation embraces three types of pollutants, which are SO2, CO and PM10, and estimated by using the correlation between air pollutant and traffic volume as based on the above model.

The nexus of land use as reflected in spatial structure, transport and environment have been reflected in the above discussion and confirmed that the nexus does exist. Addressing air quality in Iskandar Malaysia stems from transportation sector should not be undertaken with silo-effect manner, rather simultaneously organized within all the elements of nexus. Fail to address all the elements in the nexus, there will be a significant tendency of the increase of air pollution issue in Iskandar Malaysia, with primary factor of high dependency of the citizens of Iskandar Malaysia on private vehicles. This is an inconvenient truth and serve as a warning for the authority to cope with the issue.

Table 1: *Origin-Destination Matrix Table*

ORIGIN ZONES	DESTINATION ZONES										
	X, JBCC	A	B	C	D	E	F	G	H	Y	Y1
A	4.00%	0.75%	1.00%	0.00%	0.50%	0.50%	0.00%	0.00%	0.00%	0.00%	0.25%
B	1.75%	2.25%	0.25%	0.00%	0.75%	1.00%	0.25%	0.75%	0.25%	0.25%	0.75%
C	2.75%	0.00%	1.00%	0.00%	0.00%	0.50%	0.00%	0.50%	0.00%	0.25%	0.25%
D	1.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	0.00%	0.00%	0.00%
E	5.25%	0.75%	1.00%	0.50%	0.25%	11.00%	0.00%	0.75%	0.25%	0.25%	0.25%
F	5.75%	0.75%	1.25%	0.25%	0.75%	1.25%	6.50%	0.50%	1.25%	2.25%	4.50%
G	3.00%	0.25%	1.00%	0.00%	1.00%	0.25%	0.50%	11.25%	0.00%	0.75%	0.25%
H	0.50%	0.00%	0.25%	0.00%	0.00%	0.00%	1.75%	0.00%	8.75%	0.25%	0.75%

Notes

X	Predominant Center
Y	Outside the region, within Malaysia
Y1	Singapore
	Working and living within the same area
	Highest concentration towards an area

7. Concluding Remarks

As a concluding remark, it is obvious that Iskandar Malaysia was a monocentric region of single concentration towards the single center of JBCC as Central Business District. However, with the current spatial policy and development of Iskandar Malaysia, the mono-centricity has gradually shifted to poly-centricity in combination with mixed development. This has promoted development of the region to spatially grow in polycentric manners. The poly-centricity has been confirmed through spatial assessment through the analysis of the travel pattern of the citizens in Iskandar Malaysian. This pattern resulting in the dispersal traffic pattern within Iskandar Malaysia and helps to reduce the pressure of traffics in certain links, as well as the concentration of carbon generated by traffics. However, the polycentric development does not well integrated with the development of transportation system to be in line with the spatial growth as stated in the comprehensive development plans.

The poly-centricity is believed reducing the pressure of traffics in certain links, as well as the concentration of carbon generated by traffics towards the predominant CBD, JBCC. However, the dispersal of GHG over vast areas within Iskandar Malaysia will also be remarkable. Thus, without noteworthy reduction of carbon emission generated by traffic through, for instance, the notable shift of the commuters from private transport to public transport, Iskandar Malaysia will suffer from

Table 2: *Quantity of air pollutants at some selected points*

POINTS	SO_2 Concentration *=0.0183×ln(traffic volume)-0.0993*	*CO* Concentration =1.3193×ln(traffic volume)-7.4258	PM_{10} Content =0.013×ln(traffic volume)+81.331
Skudai Coordinate: 1°30' 48.1"N 103°41' 11.2"E	0.064 (1 hour)	4.377 (1 hour)	81.447 (1 hour)
Kempas Coordinate: 1°32' 44.7"N 103°42' 22.8"E,	0.050 (1 hour)	3.359 (1 hour)	81.437 (1 hour)
Tampoi Coordinate: 1°30' 00.6"N 103°42' 29.7"E	0.048 (1 hour)	3.166 (1 hour)	81.415 (1 hour)
Bukit Indah Coordinate: 1°29' 17.1"N 103°39' 08.4"E	0.055 (1 hour)	3.672 (1 hour)	81.421 (1 hour)
Larkin Coordinate: 1°29' 49.0"N 103°44' 36.7"E	0.036 (1 hour)	2.348 (1 hour)	81.407 (1 hour)
Malaysian Standard Pollution Content			
SO2 (ppm)	0.04 (1 hour)		
CO (ppm)	9.00 (1 hour)		
PM10 (ppm)	260 (24 hour)		

noticeable degradation of air quality. This is what we would like to warn, if not to offer, through this study.

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