Of Land Use Mix, Location and Travel Carbon Emission: State of The Relationship in Neighbourhoods of Iskandar Malaysia

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ABSTRACT: Climate has been changing due to increasing level of greenhouse (GHG) emission from human activities and land use has been identified as one of the major factors. The increasing rate of urbanisation with its sprawl consequences has long been a concern in terms of major source of CO_2 emission. Land uses in terms of types, amount and location do have direct and indirect effects on CO_2 emission. Aim of this research is to identify the optimal mix and siting of land uses in neighborhoods in Iskandar Malaysia based on the physical layouts of existing neighborhoods. In line with the goal of Iskandar Malaysia to be the first Low Carbon City in Malaysia, this research might help by providing the information needed in order to achieve it. Iskandar Malaysia is chosen for this research because in Iskandar Malaysia it already have three types of mixed uses category but yet no one have measure the level of this mixed use development. This research have selected for about ten neighborhoods developed from 1980s to 2000s ranging from 100-1000 acres as it sample. Assessment and analysis are carried out on several metrics to investigate the relationship between land use mixing, location of land uses and travel carbon emission. CommunityViz an ArcGIS based on scenario planning softwares, is used to compare the impact of various real and hypothetical land use mix scenarios on internal travel and eventually travel carbon emission. The findings seem to indicate that the mixing as well as the location of land uses do affect travel carbon emission greatly. Travel carbon emission is worse in exclusive neighborhoods that cater only for residential uses.

Keywords: Travel carbon emission, land use mix, CommunityViz, Iskandar Malaysia, CO_2 emission

1. INTRODUCTION

Mix of land uses is one of the principles promoted by Smart Growth Network as a measure that can help in overcoming excessive CO_2 emissions. The term ‘mixed-use’ is usually used for a development comprises of residential land uses combined with office, commercial, entertainment, childcare or civic uses such as schools, libraries or government services. At the neighborhood level, mix of land uses is believed to be an essential solution in trying to solve environmental problems that include greenhouse gas emission. Maleki & Zain (2011), for instance, believe that mixed-use design with properly arranged neighborhoods and site components can lead towards reduced distance to facilities and reduction in motorized travel thus promoting non-motorized travelling. Meanwhile according to Harris (2000), mixed uses not only increase the density but also give choices through diversity of land uses. It is also supported by Aurand (2010) who observed that mixed-use development means the combination of commercial, residential and industrial uses within one geographical area and no separation of residential and non-residential land uses.

Based on The Comprehensive Development Plan of Iskandar Malaysia (2006-2025) by Khazanah Nasional (2006), the current development in Iskandar Malaysia is concentrated along the highways and major roads as well as at the city center. The increasing practice of exclusive zoning can lead to separation of land uses that result in isolation of land use activities. This means increased level of CO_2 emission from longer travel time and distance as well as more traffic congestion and air pollution. Mix of land uses can be assessed using an index called diversity index, borrowed from a concept used in ecology. There are various types of diversity indices that have been discussed by various authors such as Alberti and Cohen (2001) and Xi and Cho (2007). Applied to neighborhoods in Iskandar Malaysia by Kassim (2012), the indices showed that land use diversity in the neighborhoods has been on the decline since the first planned neighborhoods were built (Figure 1.0).

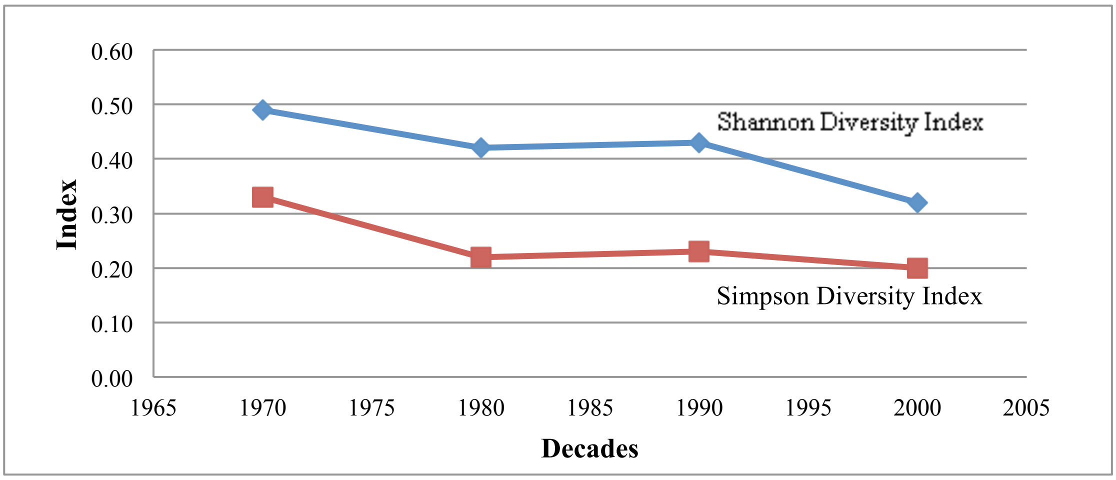


Figure 1.0: Land Use Diversity in Iskandar Malaysia from pre 1980's to 2000's

Since the mid 1990's, the economy of Malaysia has been dominated by the manufacturing industry. The new changes of economic structure cause rapid urbanization especially in Klang Valley, Penang and Johor Bahru. Conversion of agriculture areas into new townships resulted in expansion of urban areas and also urban sprawls. As the economy grows, the number of private vehicles grows along resulting in increase in the vehicle miles travelled (VMT) due to inefficient public transportation system. It becomes worst by in efficient and inappropriate design of neighborhoods that promotes separation of land uses and along distance travels. Thus, a sufficient mix of land uses is seen as crucial as one the steps to arrest spiraling increase of household vehicle miles travelled.

An ArcGIS-based scenario planning software, CommunityViz, is used for this study to compare several planning scenarios, both existing and hypothetical future scenarios. This study being carried out by taking into account of three important aspects which are walking distance, land use distribution and level of CO_2 emission that will be the end result and main purpose of this research. The whole discussion is based on an assessment carried out on selected neighborhoods in Iskandar Malaysia, Johor.

2. MATERIALS AND METHOD

2.1 Study Area

The study area is Iskandar Malaysia, Johor as shown in Figure 2.0 and it has 394 neighborhoods, defined as planned residential subdivisions in this study. Iskandar Malaysia is the main development corridor in Johor and development is governed by five local authorities which are Majlis Perbandaran Johor Bahru Tengah (MPJBT), Majlis Bandaraya Johor Bahru (MBJB), Majlis Perbandaran Kulai (MPKu), Majlis Perbandaran Pasir Gudang (MPPG) and Majlis Daerah Pontian (MDP). The size of study area is 2,217 square kilometers. For the purpose of this paper, only a few neighborhoods were chosen with sizes ranging from 100-1000 acres. Smaller developments normally support only one type of land use while bigger ones are yet to be a hundred-percent completed at the time of the study. All the neighborhoods are planned residential areas and other than those such as villages are excluded.

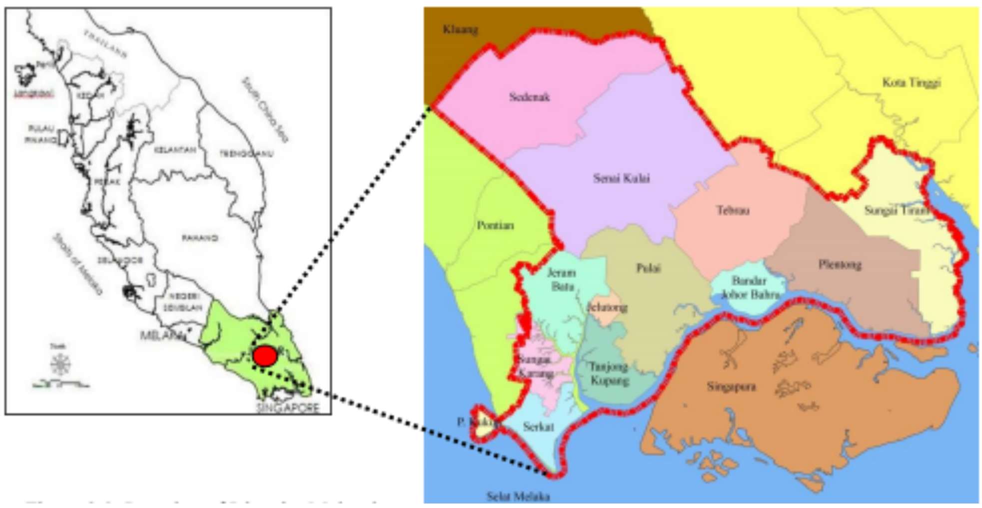


Figure 2.0: Location of Iskandar Malaysia

2.2 Data Collection

Data for the study came from both primary and secondary sources. Data on VMT and accessibility in terms of road network were gathered through a series of questionnaire survey within the selected neighborhoods. Diversity indices of every neighborhood also gathered from primary source by applying Simpsons Diversity Index and Shannon Diversity Index. Meanwhile, secondary data, such digital maps of the neighborhoods and types of land uses were sourced from the Iskandar Regional Development Authority (IRDA) office. Using the travel data gathered and the CommunityViz software, with certain assumptions adopted, the current level of travel-induced CO_2 emissions was calculated for each neighborhood. Five indicators were used to estimate the current level of CO_2 emission; 1) Average vehicle miles travelled in kilometers, 2) Household vehicle trips per day (from home to shop), 3) Persons per household (4.2 per house-based on 2010 census), 4) CO_2 emission (14.00 lbs/gallon or 1.68 kg/liter – based on Euro emission standard), and 5) passenger-car fuel efficiency, assumed at 39.0 miles/gallon or approximately 16 kilometers/liter.

3. RESULTS AND DISCUSSION

Table 1.0 shows ten selected neighborhoods together with the size and unit of each land uses.

Table 1.0: Unit of land uses and the size of every neighborhoods

Neighborhoods	Size (Acres)	Type of Land Uses (unit)				
		Industrial	Commercial	Institution and Public Facilities	Open Space	Residential
Kota Puteri	126.06	0	97	2	16	2150
Taman Senai Utama	183.13	0	221	8	17	1623
Taman Pelangi	445.95	0	309	15	11	3353
Taman Pulai Utama	347.51	0	227	4	17	4241
Taman Tampoi	153.41	21	48	8	3	105
Taman Megah Ria	465.78	0	219	10	17	2371
Taman Johor Jaya	937.89	109	689	0	11	1181
Taman Sentosa	251.87	0	353	4	10	1960
Taman Abad	250.25	0	315	4	10	2086
Bandar Baru Uda	398.39	0	232	14	7	3354

According to neighborhood profile in Table 1.0, Taman Johor Jaya is the largest neighborhood and the smallest among all is Kota Puteri. Certain neighborhoods contain zero industrial area and only few of neighborhoods such as Taman Tampoi and Taman Johor Jaya include industrial zone within its neighborhoods.

Table 2.0 shows the ten neighborhoods with diversity index, vehicle mile travel and level of carbon emission for current condition. In Table 2.0, it is shown that the lower the diversity index, the higher the VMT and CO_2 emission being released to the atmosphere. There are three neighborhoods that release CO_2 on average more than 5000 metric tons/year per household, which are Kota Puteri (5,954 metric tons), Taman Megah Ria (5,906 metric tons) and Bandar Baru Uda (5,893 metric tons).

However, for the purpose of discussion, only five neighborhoods are discussed based on walking distance, land use distribution and level of CO_2 emission. The five neighbourhoods are Taman Senai Utama, Taman Pulai Utama, Taman Abad, Taman Kota Puteri and Bandar Baru Uda. For land use distribution, the amount of every land use and its location become the main concern when it comes to the amount travel carbon emission in neighborhoods. This is supported by Grant & Perrott (2011) who said that location always become a matter when it comes to mix of uses in neighborhoods. When people choose to drive their own vehicles everyday to commute instead of using public transit or by walking, more travel carbon emission being released to the atmosphere. Figure 3.0 and Figure 4.0 show samples of existing layout for Taman Abad and Bandar Baru Uda.

Table 2.0: The ten neighborhoods with diversity index, VMT and level of carbon emission for current condition

	Neighborhoods	Diversity Index	VMT/miles	CO_2 Emission (metric tons/year)
i.	Kota Puteri	0.10	40.03	5954
ii.	Taman Senai Utama	0.23	24.72	3710
iii.	Taman Pelangi	0.40	45.15	3052
iv.	Taman Pulai Utama	0.23	43.79	3813
v.	Taman Tampoi	0.60	16.26	1233
vi.	Taman Megah Ria	0.17	33.55	5906
vii.	Taman Johor Jaya	0.44	21.88	3119
viii.	Taman Sentosa	0.47	19.06	2799
ix.	Taman Abad	0.39	19.81	3082
x.	Bandar Baru Uda	0.38	28.38	5893

Figure 3.0: Taman Abad

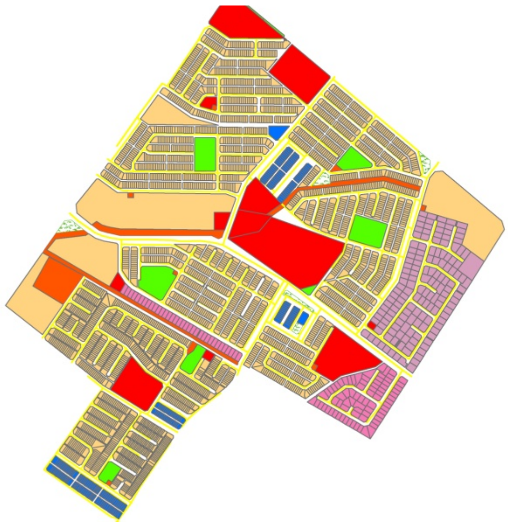


Figure 4.0: Bandar Baru Uda

In terms of accessibility, the walking distance to the nearest services and facilities according to human scale that is five to ten minutes walking was being emphasized in this research as well. The distances considered were 400-meter and 800-meter radius from a house to commercial area. Total unit of existing commercial areas that can be accessed by the residents before reallocation of land uses is important so a comparison can be made. Table 3.0 shows the total unit of houses that can access commercial areas within walking distance after reallocation of commercial land uses. The accessibility is measured by using Network Analysis tools in ArcGIS.

Table 3.0: Number of houses within various walking distances after reallocation of commercial land use

Neighborhoods	Walking Distance				
	0-200 meter	201-400 meter	401-600 meter	601-800 meter	801-1000 meter
Taman Senai Utama	384	218	118	73	78
Taman Pulai Utama	655	243	496	555	347
Taman Abad	123	200	143	143	174
Kota Puteri	259	375	318	154	50
Bandar Baru Uda	86	218	199	154	201

After the reallocation of commercial areas (see Figures 5 & 6 for an example), there is a great amount of increase in unit of houses that have access to shops and decrease in vehicle miles travelled. As shown in Table 4.0, there is a substantial decrease in the average vehicle miles travelled in each neighbourhood compared to the original figures (Table 2.0). This could mean the residents tend to walk due to all services and facilities are located within walking distance. In term of accessibility, it is proven that if neighborhoods can provide diverse land uses that are connected to one and another, the residents would have a choice whether to walk or use their cars.

Table 4.0: Vehicle miles travelled after reallocation of commercial land use

Neighborhoods	Vehicle miles travelled (kilometers)
Kota Puteri	1.32
Taman Senai Utama	0.84
Taman Pulai Utama	1.13
Taman Abad	3.44
Bandar Baru Uda	2.62

Figure 5.0: Taman Senai Utama

Figure 6.0: Taman Pulai Utama

When commercial land uses have been dispersed, the final result that we are interested in will be the level of CO_2 emission. Figure 7.0 shows the level of CO_2 emission before commercial land use being reallocated.

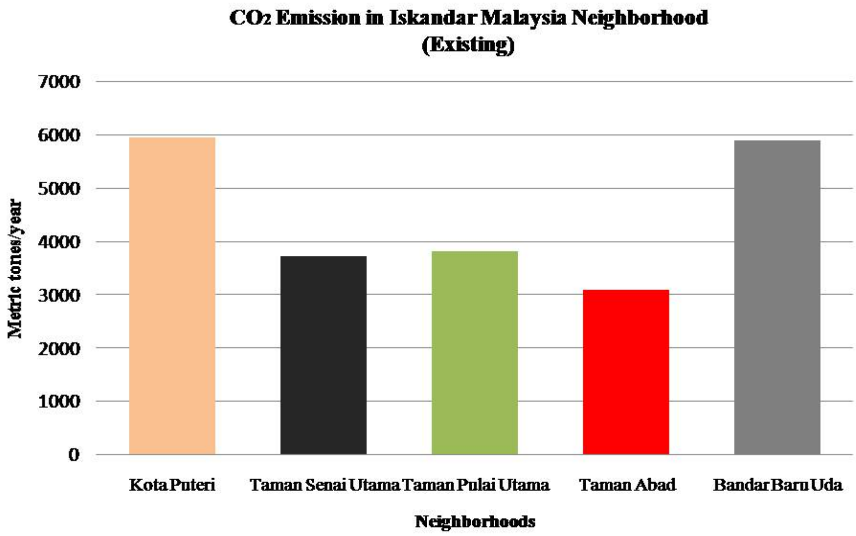


Figure 7.0: Existing level of CO_2 emission per household in five neighborhoods

It can be said that Bandar Baru Uda and Kota Puteri have the highest level CO_2 followed by Taman Pulai Utama then Taman Senai Utama and the last is Taman Abad. Mostly the locations of commercial areas are concentrated at one part of neighborhoods only and it is not even at the center of the neighborhoods itself. All of the matters that have been discussed before in terms of land use distribution (location), accessibility (walking distance) does affect the carbon emission induced by travel. The existing neighborhoods design shows that the location of land uses is not well located and also the imbalance between commercial and housing unit have caused the level of CO_2 being released to the atmosphere to increase.

Figure 8.0 shows the predicted level of CO_2 emission produced by CommunityViz after a simulation has been done on the amended layouts where commercial areas are allocated throughout the neighborhoods within walking distance of the houses (Figure 9). Figure 8.0 shows that the level of CO_2 emission after the reallocation is decreased compared to before. In order to get this kind of result where less travel carbon emission is released, the commercial areas have to be dispersed. Obviously the location of commercial area is important as it influences the level of CO_2 emission. If there is no commercial area within the neighborhoods or little commercial units, more outbound travel has to be done, increasing travel carbon emission. Figure 9.0 shows an example of how the commercial areas can be dispersed while Figure 10.0 shows the resulting accessibility to commercial areas after the simulation.

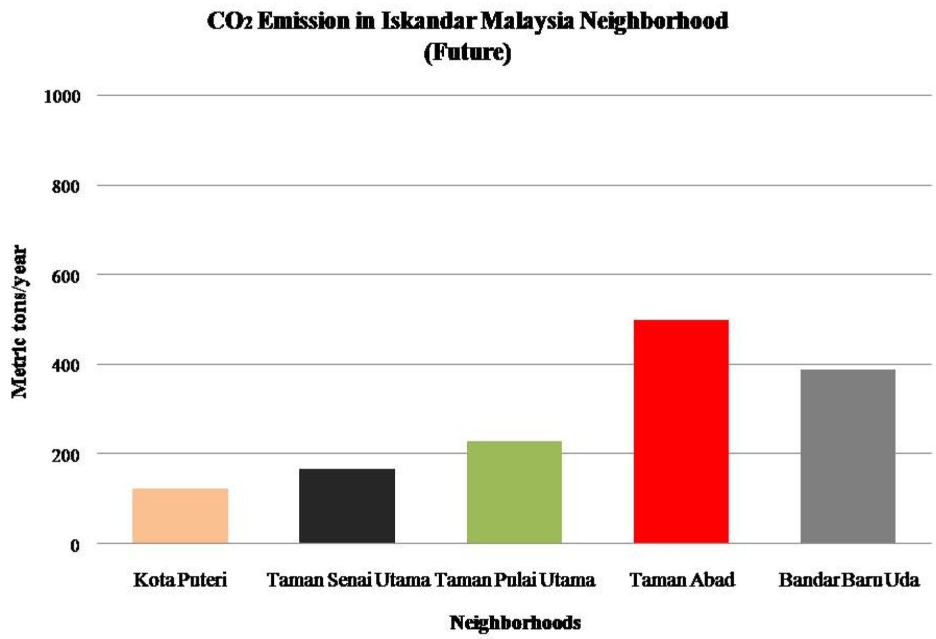
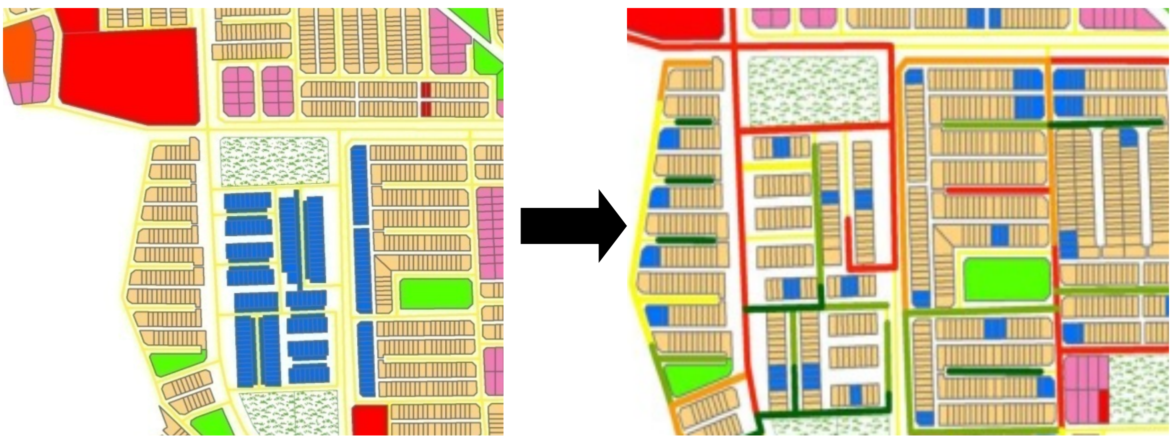
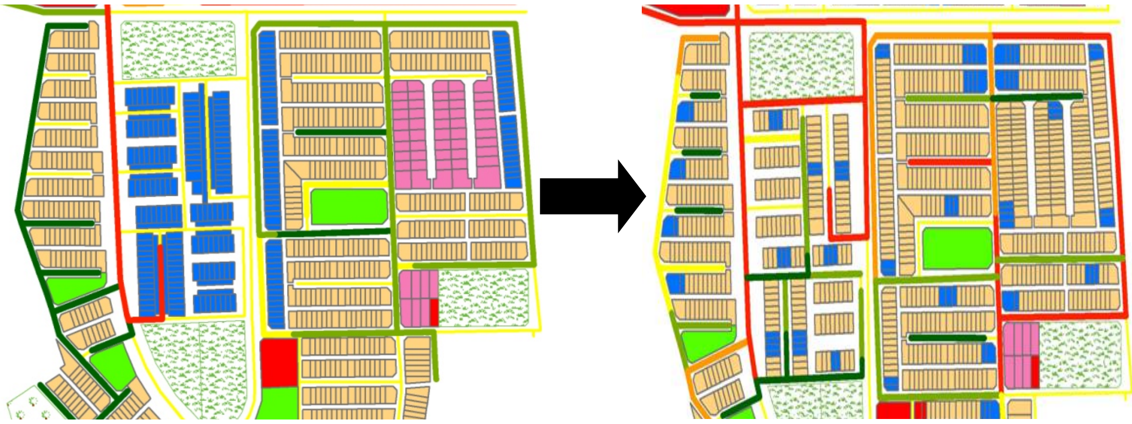


Figure 8.0: Expected level of CO_2 emission in five neighborhoods after simulation



Before **After**

Figure 9.0: Distribution of commercial areas before and after being dispersed in Taman Senai Utama



Before **After**

Figure 10.0: Accessibility before and after commercial areas being dispersed in Taman Senai Utama

4.0 CONCLUSIONS

The results of this study show that after comparison being made between the existing layout and the hypothetical layout where commercial areas had been dispersed, there is a great amount of decrease in internal travel carbon emission. Therefore it can be concluded that the greater the mixture of land uses in a neighbourhood, the lower the level of travel-induced CO_2 emission in that neighbourhood. Thus, practicing the right mixed-use development could help Iskandar Malaysia achieve its goal of becoming the first Low Carbon City in Malaysia. In relation to that, Iskandar Malaysia is also taking it very serious on mixed use development where there are three types of mixed-use categories suggested; business center and jobs located in transit planning zone, either mixed use development within city center and transit planning zone, and the third is within the area of residential zoning (Khazanah Nasional, 2006). As Katz (1994) said countries that applied mixed-use development tend to make either commercial or public space as the center or focal point of development.

Moreover, mixed-use development does not encourage zoning nor standalone land uses without support from any land uses. Coupland (1997) stated that government usually supports mixed-use development because of the benefits that they will gain. Besides, mixed-use development makes the residents less dependent on private vehicles, more dependent on walking and public transport. Therefore, mixed-use development should be a norm instead of an exception so that developers and investors realize the benefits together raising awareness of how important for a neighborhood or city to implement mixed-use development.

5.0 ACKNOWLEDGEMENT

The authors would like to acknowledge the funding support for this research which was provided by Universiti Teknologi Malaysia under the Research University Grant Programme (GUP) - Grant No. 00H59.

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