From digital earth to digital neighbourhood: A study of subjective measures of walkability attributes in objectively assessed digital neighbourhood

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Abstract: According to IEA report (2011), about 23% of the World's CO_2 emissions result from transport and this is one of the few areas where emissions are still rapidly increasing. The use of private vehicles is one of the principle contributors to green house gas emissions from transport sector. Therefore this paper focuses on the shift to more sustainable and low carbon forms of transportation mode such as walking. Neighbourhood built environment attributes may influence walkability. For this study, the author used a modified version of the "Neighbourhood Environment Walkability Scale" to make comparison between respondents' perceptions regarding attributes of two neighborhoods of Putrajaya. The 21st Century really needs planners to use the Digital Earth Concept, to go from global to regional to national to very local issues, using integrated, advanced technologies such as earth observation, GIS, virtual reality, etc. For this research, two (2) neighborhoods of different densities (High and Low density) were selected. A sample total of 381(195 and 186) between 7 to 65 years old participants were selected For subjective measures we used 54 questions questionnaire survey where as for the objective measures we used desktop 9.3 version of Arc GIS soft ware. Our results shows that respondents who reside in high-walkable neighbourhood precinct 9 in Putrajaya rated factors such as residential density, land use mix, proximity to destination and street connectivity, consistently higher then did respondents of the low walkable neighbourhood precinct 8 in Putrajaya.

1. Introduction

It has been discussed gradually more that emissions resulting from everyday traffic should be reduced. According to International Energy Agency (IEA) report (2011)[1], transport accounts for 23% of global CO_2 emissions in 2009, and road transport accounts for about 73% of the total transport CO_2 emissions and are one of the few sectors where emissions are still growing. The use of private vehicle is one of the principle contributors to green house gas emissions from the transport sector. Pressure is growing on planners and policy makers to develop sustainable transport systems because of the issue of climate change. The second major factor contributing to the CO_2 emissions in Malaysia has been identified as

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being transportation.

Malaysia has made a conditional commitment to reduce carbon emission by 40% of the Malaysian GDP by 2020, from the 2005 baseline at the Copenhagen COP15. In his 2010 budget speech the Malaysian Prime minister announced that the government will develop Putrajaya as pioneer town ship in Green technology. As a result the Putrajaya Corporation has taken the initiative to conduct a base line study on carbon emissions. In order to achieve a Green city in Putrajaya, they have established three main components & quantitative environmental targets in Putrajaya Green City 2025 (PGC2025), namely:

1. Low carbon Putrajaya.
2. Cooler Putrajaya.
3. 3R (Reduce, Reuse, Recycle) Putrajaya.

These three components have been further divided into 12 sub action items. [2]

Table 1. A Dozen Actions Towards Green City

1.Low Carbon Putrajaya	1. Integrated City Planning & management
	2. Low Carbon Transportation
	3. Cutting edge Sustainable Buildings
	4. Low Carbon Lifestyle
	5. More and More Renewable Energy
	6. The Green Lung of Putrajaya
2. Cooler Putrajaya	7. Cooler Urban Structure & Building
	8. Community and Individual Actions to Reduce Urban Temperature
3. 3R Putrajaya	9. Use Less Consume Less
	10.Think Before You Throw
	11.Integrated Waste Treatment
4.General	12. Green Incentives and Capacity Building

Automobile-dependent development patterns, today, have come at a cost, by increasing a nation's dependence on petroleum and increasing CO_2 emissions. These contribute to global warming. If there was a more compact form of sustainable development, carbon dioxide (CO_2) emissions could be reduced, based on the principle of compact development theory [3]. The use of planning systems seems can provide a common solution for achieving major environmental improvements and particularly for achieving sustainable development [4]. Perspectives of the 'compact city' discussion have been applied in Norway to develop policies for sustainable development [5,6]. Oslo is also using such arguments to support such new inner-city development projects. The question that arises is: "Does changing urban forms tend to reduce the frequency and length of journeys, and hence energy consumption?"

There are a number of other parameters for central, high-density development that support favorable sustainable energy use, such as;

- Low energy use for housing and everyday travel
- Efficient remote heating systems
- Proximity to a variety of workplaces
- Public and private services
- a highly developed public transport system [7]

Vehicle Mile Travel (VMT) and CO_2 emissions can also be reduced by compact mixed use development [8]. Through planning and controlling land use, the need for automobile transport can be effectively decreased [9]

According to IPCC's fourth Assessment Report [10], dependence on automobiles has been increasing almost everywhere in the world, and land use planning and different policies could assist in slowing the growth in vehicle use.

2. Methods

Potential participants were selected from one high walkable neighborhood precinct 9 and other one low walkable neighborhood precinct 8.Selected neighbourhoods are highlighted in figure 1. The two areas were chosen having a different gross densities precinct 8 having a gross density 7.54 dwelling units per acre and income ranging between 6000-9000RM precinct 9 having a density of 21.8 dwelling units per acre. Precinct 9 participants monthly income was ranging from 1200-2100RM. The high walkable area Precinct 9 is near to the Putrajaya central transportation hub, generally flat with many intersections. Precinct 9 has a high population density with a mixture of dwelling style comprising of apartments, small living units and multiple storey complexes. It is one of the bigger precincts in Putrajaya. Most facilities are provided within 800 meter walking distance A GIS map figure 2 is showing great proximity to most facilities. It is planned as a medium-high to high density residential area to optimize its location adjacent to the main ERL/LRT station in precinct 7 and its proximity to major routes. Along the primary access road within the precinct are located all the public facilities. The main character of the precinct is defined by the high-rise high density residential blocks. There are many community facilities such as Health Centre, a School complex, a post office, a Mosque, a Surau, a Public Market, a Community Hall, and a bus depot, open spaces are in form of linear Park, Neighborhood parks, and other landscaped reserves.

The low-walkable area Precinct 8 is located at the western boundary of Putrajaya. A GIS map image of the neighbourhood is provided in figure 3 Due to its water front location, Residential area in this precinct is maintained as low density. There are many community facilities such as School complex, two post offices, a police station, a mosque, a Surau, a Branch library, a public market, a Multi-purpose community hall, an information Centre and a Putrajaya Service Centre.

Initially A modified Version of the Neighbourhood Environment Walkability Scale (NEWS) was used to asses neighbourhood environment attributes with known relationship to walking behavior [11] Environment attributes assessed in the survey included: residential density; proximity to and ease of access to non- residential land uses such as restaurants and retail stores (land-use mix diversity and land use mix access); street connectivity; walking facilities (e.g., footpaths, walking paths); aesthetics; traffic safety; and safety from crime [12]. Data were coded, entered and checked using SPSS version 19 for Windows.

GIS data for street intersection land use mix were analyzed to form:

(1) Intersection density (a measure of street connectivity based on the 3 and 4-way intersections within a 400 and 800 meter buffer) fifty five 3 and 4-way intersection were found in precinct 8 whereas 93 3 and 4-way intersection were found in precinct 9.
(2) Dwelling density (a number of dwelling units divided by the land area).
(3) Land use mix measurements were done based on the distribution of development across seven different uses (Residential uses, commercial uses, government uses, Park and open spaces, Public Amenities, Public utilities, transportation) for each neighbourhood.
(4) Proximity (400 and 800 meter buffer are drawn around the centroid), these buffer are used for Ped Shed analysis also known as walkable catchments.

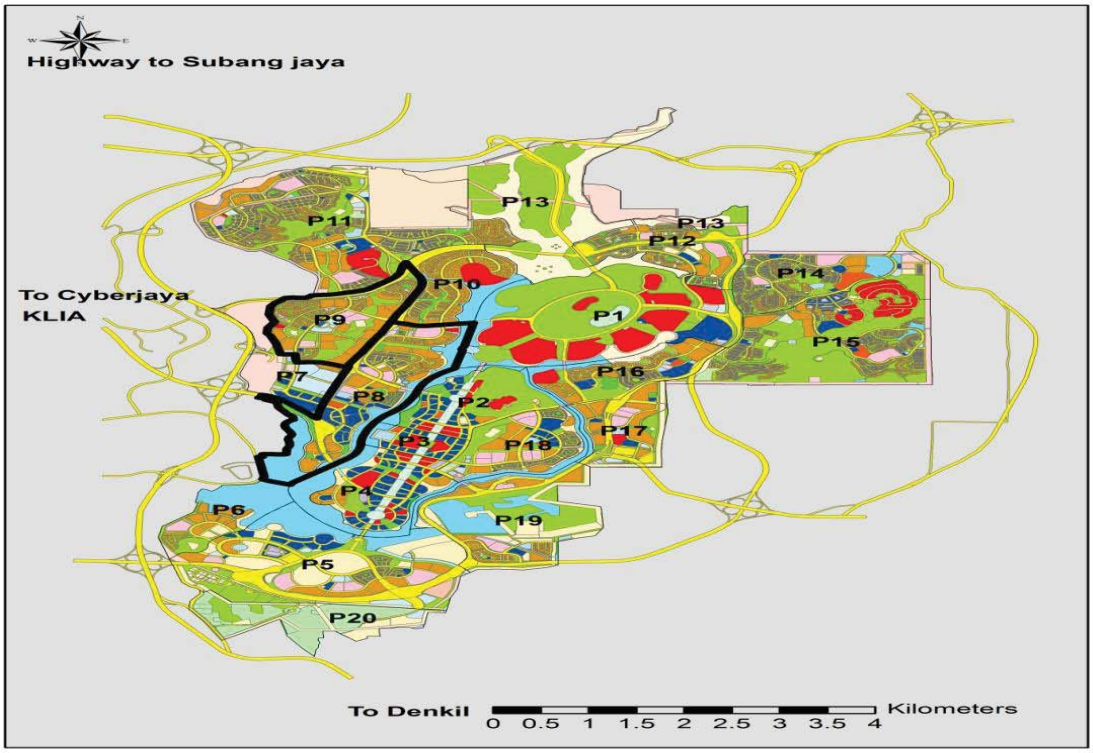

Figure 1. Map with the study area highlighted

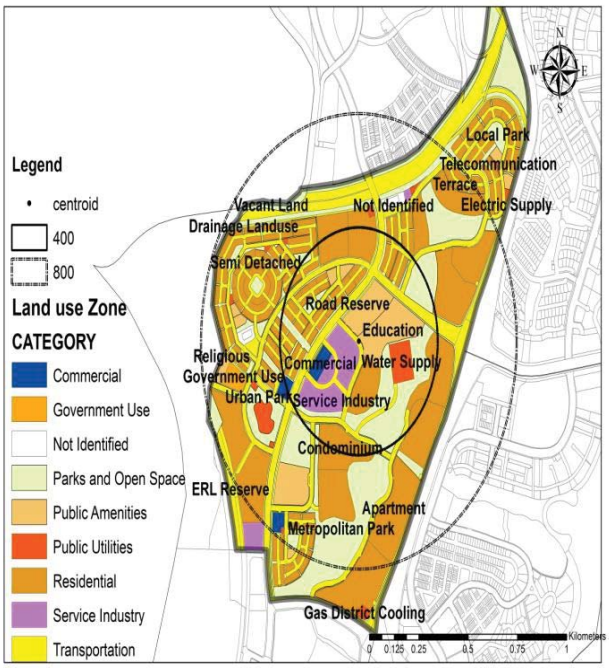

Figure 2. High walkable Precinct 9

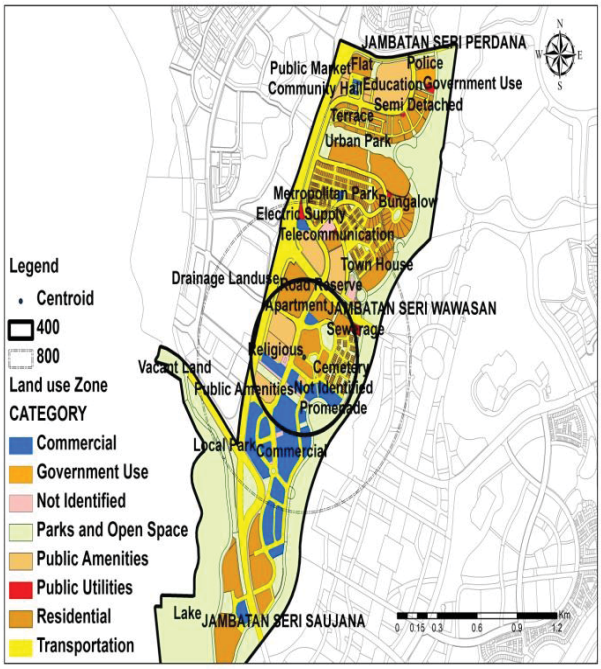

Figure 3. Low walkable Precinct 8

3. Results

Total numbers of 381 participants 195 participants from precinct 9 and 186 participants from precinct 8 were selected between the age 7-65. Comparison of mean scores on Neighbourhood Environment Walkability subscale score are in Table 2. Respondents residing in the high walkable neighbourhood precinct 9 provided ratings indicative of higher residential density, Land use mix, connectivity, infrastructure for walking, safety from traffic and safety from crime than did respondents from low walkable neighbourhood. However, residents of the low walkable neighbourhood had higher ratings of aesthetics of their neighbourhood than did residents of the high walkable neighbourhood. Car ownership was high among participants (85%) from precinct 8. In precinct 9 (62%) respondents has car owner ship.

Table 2. Mean (standard deviation) subscale scores for high and low walkable neighbourhood

Perceived Neighbourhood Built Environment Attributes (No. items)	**High Density[a] (Precinct 9) Residents (N=195) mean (SD) Low income**	**Low Density[b] (Precinct 8) Residents (N=186) mean (SD) High income**
Residential Density (6)	3.0896 (.32748)	2.3376 (.27880)
Land use Mix (23)	3.5168 (.20279)	2.1701 (.09908)
Access to services (3)	3.5502 (.40291)	2.0718 (.34759)
Street Connectivity (2)	3.2177 (.50901)	2.3385 (.61410)
Infrastructure for walking (6)	3.0681 (.33979)	2.3188 (.28101)
Aesthetics (4)	2.9368 (.28659)	3.0205 (.30391)
Safety from traffic (3)	3.5269 (.25147)	2.1180 (.45949)
Safety from Crime (3)	2.5824 (.24644)	1.9504 (.24014)
Parking is difficult in local shopping area (single item)	3.3710 (.65514)	1.7436 (.43777)
Street in my neighbourhood do not have many cul de sac (single item)	3.2634(.55063)	1.1846 (.52442)
Street are hilly (single item)	2.6057 (.69106)	1.6154 (.52834)
major barrier to walking like freeways, railway lines, rivers (single item)	3.0538 (.60387)	1.9590 (.28422)

[a]High density = 21.8 DU/A [b]Low density=7.54 DU/A

Conclusions

Built environment attributes perceived by participant were related to objectively assessed neighbourhood Walkability. Statistically significant differences were found in participant's ratings of environment attributes between those residing in objectively high and low walkable neighbourhood for residential density, land use mix diversity, connectivity, walking Infrastructure, showing that respondents from neighbourhood with different built environment attributes do perceived these attributes differently. These two neighbourhoods were chosen to differ objectively on dwelling densities, mix land use, street connectivity and Proximity and in fact respondents perceived these differences according to their self report hence compact, mixed-use development reduce vehicle mile travel therefore such development must be implemented to reduce CO_2 emissions.

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