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Promoting a Lower Carbon Footprint using an Enhanced Pedestrian-Friendly Model

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Abstract
Walking has significantly contributed to a lower carbon emission of a country. With the aspiration of a lesser carbon footprint zone, the initiatives of understanding the current pedestrian system are crucial. Although walking improves green mobility, it is still known as the least preferred mode. Thus, this study aims to improve pedestrian walkways and promote a higher level of usage of pedestrian walkways by analyzing the critical factors contributing to the lower carbon footprint among the urban dwellers. The results will help to improve a lower carbon footprint practice in the metropolitan area.

Keywords: Pedestrian,Friendly,Low Carbon,Satisfaction

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1.0 Introduction
Walkways are the pedestrian lanes for people to travel. The design is usually separated from roadway vehicles as to create safety a and comfortability while walking. Walkways are also known as sidewalk where its main aim is to reduce the interaction of pedestrian collisions with motor vehicles and to increase the walkability of the country. Indirectly walking could also promote a lower carbon footprint in the city centre. Every single citizen who travels from one place to the next by walking will be known as a pedestrian. These pedestrians will be as part of the road space elements. Thus main objective of this study is to determine the factors affecting the pedestrian satisfaction while walking in promoting a lower carbon footprint in urban area and to proposed a solution model for a low carbon footprint model among pedestrian through their satisfaction level.

1.1 Structure
Walking can reduce carbon emission and improve green mobility (Krishnan et al.,2013). Even after knowing the fact that walking promotes a lower carbon footprint, the decision to walk is still deficient, especially in a developing country. Kuala Lumpur is a city centre of Malaysia. The boundary starts from Jalan Yew, Jalan Tun Razak, and Jalan Sg. Besi and circling from the south-east to the north linking from Jalan Damansara down to Lebuhraya Mahameru then Jalan Istana from the north-west to the south (Figure 1.0). To enable users to walk from one point to another point in the city centre of Kuala Lumpur itself is crucial. Added with the region's tropical climate and unpredictable rainfall had further prohibits pedestrian to walk using the existing pedestrian walkways in Kuala Lumpur. Lack of

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supporting infrastructures, such as easily accessible public transport services and continuous and shaded walkways had further restraint the walking culture among urban dwellers in Malaysia, especially in the city centre.

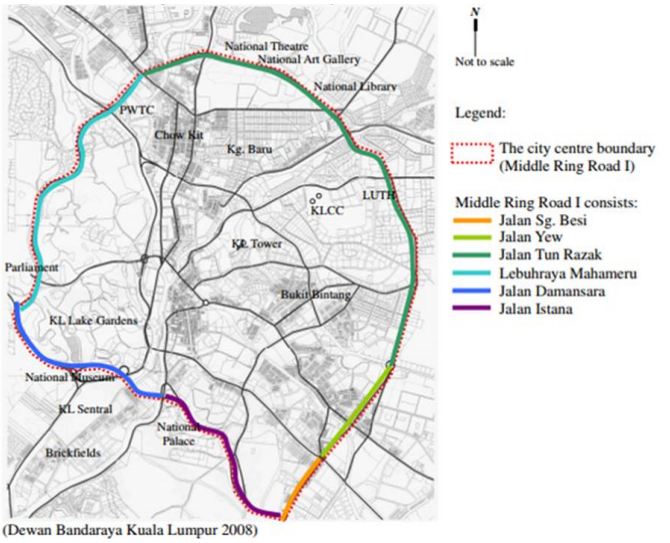

Fig. 1. (a) Kuala Lumpur Urban Area; *(Dewan Bandaraya Kuala Lumpur)*

Fig. 1. (b) Current Pedestrian Situation. *(Selva,2017)*

1.2 Problem Statement

All Humans these days are being educated on how walking as an exercise would benefit our body and at the same time, helps promote a healthier and greener lifestyle (Cao and Duncan,2019). While countries are advancing themselves, having drastic expansions and developments ongoing, modernizing and urbanizing from places to places become nations' target to achieve titles such as upgraded or developed country, people's perception towards walking has then been affected by it (Diyanah et al., 2012). To walk in a developing country, walkability in the urban has become urban designers' prioritized focus. Whether walkways are friendly for people to enjoy the benefits of walking when it has been encouraged has become pedestrians' utmost concern (Frank, 2000).

There have been voices, coming on behalf of public pedestrians giving feedbacks on how unfriendly local pedestrian walkways are, expressing dissatisfaction and suggested improvements for sidewalks along Klang Valley. An article from The Star (2017) specifies that issues arisen from unfriendly pedestrian walkways were mainly distance issue; a distance of a bus-stop to a pedestrian bridge was way too far. Cars seem to be dashing across red light with no vehicle speed limit threatening crossing attempts. Lack of proper necessary infrastructures such as zebra crossing and malfunction traffic lights for crossing purposes forces pedestrians to put on uncivilised behaviour in road crossing, such as not utilising the traffic lights because of the malfunction exist on most attempts of usage (Kitamura et al., 1997)

Poor accessibility and unpleasant walking environment had disrupted the walking activities among the pedestrian and public transport users (Walton et al.,2010). Thus the main objectives are to examine the factors that affect the usage of the pedestrian walkway and to suggest a solution to the current problem faced in the urban area particularly the pedestrian satisfaction. Previous studies observed that perceived pedestrian satisfaction became tormented by a few factors. The phrase "satisfaction" has been defined as an accumulative construct to be able to affect respondents' expectations and perceptions of performances at any time (Sham et al., 2018). In this point, the pedestrian delight of pedestrian walkways is related to the notion of having safety features walkways assembly as much as humans' expectancies and opens up a possibility to crime and judging it based on how fulfilling it is closer to on walker desires in urban areas. Cervero et al. (1997) identified that pedestrians have a tendency to provide you with diverse expectations and desires; consisting of in terms of accessibility, connectivity and sense of security. Those are fundamental needs, and the opposite wishes encompass infrastructure and centres reliability, cleanliness that attracts comfort, and current pedestrian design itself.

Every pedestrian wishes that the current pedestrian design that they are using and walking is safe as this will continually lead them to another secure location. Through urban context, this gives means to stay safe and away from automobiles bounded accidents and crimes. Giles-Corti and Donovan (2002) successfully researched on the perception of traffic safety. They identified that proper sidewalks lead to a very positive impact towards walking from the pedestrian point of view. Besides, De Bourdeaudhuij et al. (2003) found out that how traffics are being perceived in the eyes of citizens dramatically depends on the walkability in a particular city and how people would take walking as a recreational exercise to travel from one place to another. Saelens et al. (2003) revealed that pedestrians' traffic safety was strongly correlated with individual walkability, which explains why crossing a road in a group is safe than passing it alone. The

satisfactory of walking experienced by pedestrians are more likely to be chosen as a habitual behaviour that is bound to be sustainable (Ettema et al., 2012).

2.0 Factors affecting the satisfaction of pedestrian walkway

Pedestrian comfort refers to walking condition provided to assist the walking from the point of origin to the end of consumption. It encompasses the standard of pedestrian options, as well as pathway conditions, walkways property, accessibility, as well as the cleanliness (Pucher et al., 2011).

2.1 Section headings

Section headings should be left justified, bold, with the first letter capitalized and numbered consecutively, starting with the Introduction. Sub-section headings should be in capital and lower-case italic letters, numbered 1.1, 1.2, etc, and left justified, with second and subsequent lines indented. All headings should have a minimum of three text lines after them before a page or column break. Ensure the text area is not blank except for the last page.

2.2 Built environment

In a study conducted by Southworth (2015), the study claims that pedestrian satisfaction relates to how the built environment can support and encourage walking. The research concluded that the built environment is an essential element to measure pedestrian satisfaction. The context refers to the things which occur naturally around the pedestrian walkway that will affect pedestrian crossing behaviour. While analysing the connections between the built environment and pedestrian behaviour, different components of the built environment create different scales of geography and a sense of satisfaction among the pedestrian.

Table 1.1: Dimension of the built Environment

Dimension	Definition	Examples of measures
Density and intensity	Amount of activity in a given area	Persons per acre or jobs per square mile Ratio of commercial floor space to land area
Land use mix	Promixity of different land uses	Distance from house to nearest store Share of total land area for different uses Dissimilarity index
Street connectivity	Directness and availability of alternative routes through the network	Intersections per square mile of area Ratio of straight-line distance of network distance Average block length
Street scale	Three-dimensional space along a street as bounded by buildings	Ratio of building heights to street width Average distance from street to buildings
Aesthetic qualities	Attractiveness and appeal of a place	Percent of ground in shade at noon Number of locations with graffiti per square mile
Regional structure	Distribution of activities and transportation facilities across the region	Rate of decline in density with distance from downtown Classification based on concentrations of activity and transportation network

Source: Handy et al. (2002)

Handy (2002) suggested the six dimension of the built environment in the pedestrian design. Sham et al. (2013) had further details out the urban and environmental design from the perspective of crime and safety for a vulnerable group. They concluded that a women travelling pattern differs in so many ways as compared to men; thus, their needs must first be address in enhancing their level of safety while moving to work is a concern. Their research work reflects the critical need to design proper walkways to improve the feeling of security, which indirectly measured through the level of satisfaction.

2.2 Cleanliness

The entire essential things agreed by the past study is the cleanliness of the pedestrian walkways. A decent pedestrian environment will enhance pedestrian to socialise more in public spaces (Gehl, 2004). Reasonably it is hard to see how the little details elements of the pedestrian environment would affect the choice to walk when contrasted with such factors as individual security and the time available, yet there are a few pieces of research that recommend that the condition of walkway and variance facility for pedestrian impact the choice to walk Gehl (2004)). The specific elements identified in the research are cleanliness, including the sign of litter, rubbish, pet's dirt and the quality of the sidewalk. A study by Wang et al. (2017) found that the built environment correlates with the walking distance of the pedestrian.

2.3 Infrastructure

A survey conducted by Handy (2005) further details on the factors of infrastructure and facilities that are much related to pedestrian satisfaction. An earlier study by Humpel et al. (2002) had a focus on a few variables, such as accessibility and safety. It is related to

pedestrian satisfaction. Research conducted by Leslie et al. (2005) had a focus on the bodily attributes that affect the walking activities a pedestrian. The study includes characteristics like a pathway, crosswalk, avenue furniture, safety measures, and adjoining traffic flow. The pedestrian level of carrier (LOS) method utilised by Gallin (2001) is any other approach that provides an associate standard of walking which include facility inspecting style, connectivity, and consumer elements and cleanliness.

A weighting system which further recognises that certain parts create more fabulous pedestrians activities where humans tend to walk more often with extra boost infrastructure and best side stroll centres. A right style and layout of facilities and proper placement of support around will encourage more walking activities. Thus every design needs to incorporate safety and convenience factors Tao et al., (2020). An early study was done by Khisty (1995) which had evaluated the qualitative additives of pedestrian areas from users' attitude had found subjective variables like visual splendour, comfort, gadget continuity, protection, and security plays a significant role in encouraging them to walk.

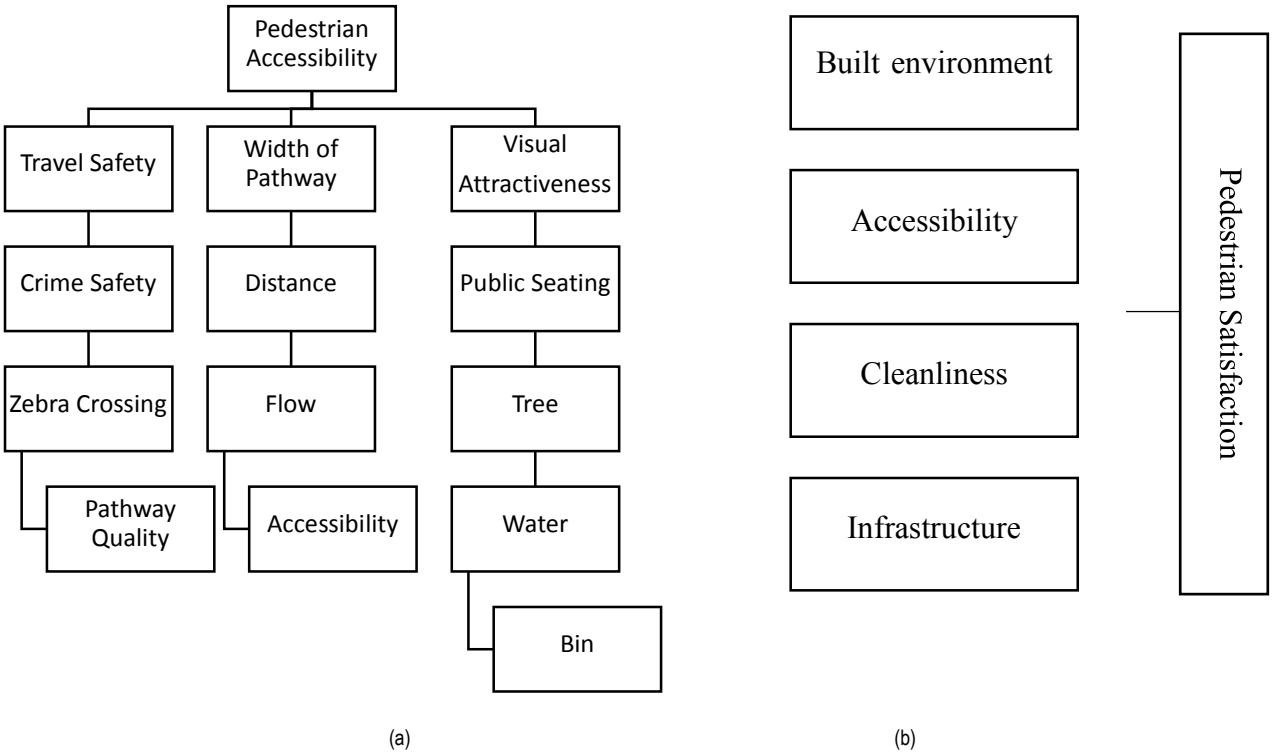

Fig. 2: (a) Elements of Pedestrian Accessibility; (b) Theoretical Framework.
(Andidi et al., 2015)

Connectivity and accessibility are known to be crucial criteria for pedestrian design in encouraging the walking activities (Hutabarat Lo, 2009; Vojnovic, 2006). The discussion was further supported by Tsukaguchi et al., (2007) who concludes that connectivity is the crucial factor influencing the pedestrian direction desire. The street networks should be connected with right sidewalks to different destinations to inspire citizens to walk in the metropolitan area where the carbon release is high. Thus it is agreed that a well-planned street network is crucial so that streets can nicely link to various modes of transportation (Southworth, 2005). He further added that the roads must conjointly give a variety of uses for the surrounding buildings and areas, sensible first-rate of paths, adequate width of walkways and display clear signage for the ease of the pedestrian while walking or taking their step.

3.0 Research Design

This study embarks into a quantitative method where a set of questionnaire used to collect the data through a stated preference survey. The primary respondents of the investigation are among daily active working people who live and work in the city centre of Kuala Lumpur. Data on respondent residential area was verified. Using a Krejcie & Morgan (1970) table, around 384 sample sizes were chosen as the target sample for the study. These individuals will be those who have experienced as a pedestrian walking in the walkways in Kuala Lumpur to ensure that they fairly answer provided questionnaire through knowledge and skills they have previously had as a pedestrian in Kuala Lumpur.

4.0 Findings and Discussion

4.1 Means Score Analysis on Built Environment

Table 1.2 presents the mean score analysis on the current attributes of the built environment surrounding the pedestrian walkways. The most striking results indicate that the majority of the pedestrian indicates a higher satisfaction towards the contemporary design of walkways which include separation from the current traffic (3.31). Most of the pedestrian feel safer using the segregated pedestrian walkways. The current user indicates a higher number of comfort using the existing pedestrian (3.27).

Table 1.2: Means Score Analysis of Built Environment

Built Environment	Mean	Std. Deviation
I am comfortable walking on the current pedestrian walkway.	3.27	1.053
I am satisfied with the current walkways surrounding.	3.15	1.070
I am satisfied with the design of the current walkway.	3.12	1.087
I am satisfied with the current tree plantation along the walkways.	3.19	1.117
I am satisfied when the walkways separated from the traffic.	3.31	1.064

4.2 Means Score Analysis on Cleanliness

Table 1.3 shows the results obtained from the mean score analysis on the attributes of cleanliness. Poorly maintained walkways scored the highest mean score (3.74). Followed by the second highest mean score (3.69), which represent walkways that have unpleasant smell will affect pedestrians' satisfaction. Whereby, pedestrians who satisfied with the cleanliness of the current pedestrian walkway score the lowest mean with 2.16 as most of the respondents disagree with this statement. It shows that cleanliness will always affect their satisfaction towards it.

Table 1.3: Mean score analysis for Cleanliness

Cleanliness	Mean	Std. Deviation
Cleanliness of pedestrian walkway will affect my satisfaction.	3.68	1.219
Cleanliness of the current pedestrian walkways satisfy me.	2.16	1.161
Walkways full of rubbish will affect my satisfaction towards the sidewalk.	3.63	1.282
Walkways that have unpleasant smell will affect my satisfaction towards it.	3.69	1.200
Poorly maintained walkways will affect my decision to use it.	3.74	1.251
Cleanliness of the pedestrian walkways is not crucial to me.	2.33	1.363

4.3 Means Score Analysis on Infrastructure

It is apparent from the mean score result that it shows that pedestrians are most satisfied when the walkways are covered as it has the highest score of the mean (3.61) among all. Followed by the second-highest of the mean score (3.54), pedestrians are satisfied when there are guide rail along the walkways and when there are guard rails along with it. Besides, pedestrians are least confident with the current CCTV provision along the sidewalks as it has the lowest mean with 1.60.

Table 1.4: Mean Score Analysis on Infrastructure

Infrastructure	Mean	Std. Deviation
I am satisfied when the walkways are covered.	3.61	1.233
I am satisfied when there are benches along the walkways.	3.41	1.040
I am satisfied when there are guard rails along the walkways.	3.54	1.018
I am satisfied with the current walkway design.	3.19	1.112
I am satisfied with the current lighting provision along the walkways.	3.13	1.114
I am satisfied with the current CCTV provision along the walkways.	1.60	1.234

4.4 Means Score Analysis on Accessibility

Data present in this table shows the means score analysis on the attributes if accessibility. The results show that covered walkways (3.89) recorded the highest mean score. Indirectly if more pedestrian is satisfied, then more often they will walk and used the sidewalks provided to them and thus promoting a lower carbon footprint in a city centre. The second highest means score is on the accessibility of the paths (3.41). The current pedestrian walkways possess good accessibility from one node to another. Attributes of accessibility scores the least (2.99). The results show that majority of the respondents felt that the infrastructure provider for the disabled is still not sufficient.

Table 1.5: Mean Score Analysis for Accessibility of Current Walkways

Accessibility	Mean	Std. Deviation
I am satisfied when the walkways are easily accessible.	3.41	1.129
I am satisfied with the current pedestrian walkways accessibility.	3.17	0.949
I am satisfied with the accessibility for disabled people on current walkways.	2.99	1.081
I am satisfied with the current pedestrian walkways connection to public transports.	3.17	1.120
The high connectivity of covered walkways affects my satisfaction.	3.89	1.172

4.5 Analysis of the Multiple Regression

A multiple regression analysis refers to a statistical process for estimating the relationships among variables. It helps to predict one or more than one variables (predictor) influence on others variable (dependent variable).

Table 1.6: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.886 [a]	0.784	0.782	2.65538

a. Predictors: (Constant), Built Environment, Cleanliness, Infrastructure, Accessibility
b. Dependent Variable: Pedestrian Satisfaction

Table 1.7: Coefficients of Regression Analysis

Model	Unstandardised Coefficients		Standardised Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	1.145	.527		2.173	.030
Built Environment	.091	.048	.093	1.879	.061
Cleanliness	-.235	.040	-.247	-5.888	.000
Infrastructure	.688	.050	.691	13.783	.000
Accessibility	.316	.037	.367	8.478	.000

a.Dependent Variable: Pedestrian Satisfaction

Table 1.6 and Table 1.7 illustrates the model summary for the regression analysis and the coefficient of regression analysis. It shows that R-value is 0.886, which is nearly 1. The relationship between pedestrian's satisfaction (DV) and the independent variables which

consist of the built environment, cleanliness, infrastructure and accessibility (predictors) is stable. The R square shows the value of 0.784, which represent 78.4% of the variable that is pedestrian satisfaction depends on the four independent variables, namely build environment, cleanliness, infrastructure and accessibility. The remaining 21.6% of change cannot be predicted. Among the other possibility could be personal or other related factors of the surrounding environment at that particular spot. Based on the multiple regression result, all the independent variable, which include cleanliness, infrastructure and accessibility shows a significant value that affect the dependent variable except built environment which shows an insignificant value. One of the possible reason for this might be due to the highest satisfaction of pedestrian walkways and distance between walking and the bus stop location in Kuala Lumpur urban area recently.

4.6 Multiple Regression Final Equation

Based on the coefficient value of the multiple regression , thus this is the final multiple regression equation for promoting a lower carbon footprint using an enhance pedestrian satisfaction model approach. Since $\boldsymbol{X_1}$(build environment) has insignificant value; thus, the following is the final regression model for the study which take into account cleanliness, infrastructure and accessibility.

Model of multiple linear regression equation:

$$\boldsymbol{\gamma = \alpha + B_2 X_2 + B_3 X_3 + B_4 X_4 + \varepsilon} \qquad \textbf{(1)}$$

$\boldsymbol{\gamma}$ = Pedestrian Satisfaction
$\boldsymbol{\alpha}$ = Constant
$\boldsymbol{B_1}$ - $\boldsymbol{B_4}$ = Regression coefficients computed by the model
$\boldsymbol{X_1}$ =Build environment
$\boldsymbol{X_2}$ =Cleanliness
$\boldsymbol{X_3}$ =Infrastructure
$\boldsymbol{X_4}$ =Accessibility
$\boldsymbol{\varepsilon}$ =error does not capture by model

$\boldsymbol{\gamma}$ (pedestrian satisfaction) = $\boldsymbol{\alpha}$ (1.145) + $\boldsymbol{B_2}$ (-0.235) $\boldsymbol{X_2}$ (Cleanliness) + $\boldsymbol{B_3}$ (0.688)$\boldsymbol{X_3}$ (Infrastructure) + $\boldsymbol{B_4}$ (0.316) $\boldsymbol{X_4}$ (Accessibility) + $\boldsymbol{\varepsilon}$ (0.527)

Equation 1 shows the final equation derived from the regression model summary. This model predict the satisfaction level of the current pedestrian users while using pedestrian walkways in the metropolitan area. To run the simulation model to measure the level of satisfaction of the existing pedestrian, the X_1, X_2, X_3, and X_4, the value could be replaced from 1 to 5 depending on the amount of satisfaction indication (1 = Very dissatisfied, 5= Very satisfied)

5.0 Conclusion

The present study of promoting a lower carbon footprint using an enhance pedestrian satisfaction model have highlighted several attributes that affect the pedestrian satisfaction which include cleanliness, infrastructure and accessibility. Thus a successful of promoting a lower carbon footprint or in another words promoting walking among the urban dwellers could be possible by enhancing the 3 attributes mention above. This model explained that the independent variable influence the dependent variable (pedestrian satisfaction) by 78 %. Thus it can be concluded that in promoting a lower carbon footprint in an urban area, all these attributes are relevant for a town planners consideration.

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