

# SIDEWALK DESIGN DECISION SUPPORT TOOL: TO MEASURE BUILT ENVIRONMENT VARIABLES INFLUENCING RESIDENT WALKING BEHAVIOUR

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**Abstract:** The association between built environment and human physical activity is a controversial issue to the discipline of urban design, specially, to the other disciplines, including, urban planning, transportation planning, landscape architecture, architecture. Indeed, the association between built environment and physical activity has mostly been mostly considered in the community macro-scale rather than the individual micro-scale. Direct assessment of the association between built environment and individual's walking activity as it derives from personal reactions and perceptions are still rare in urban design field of research. To date, the urban design body of knowledge grown to subtler 'physical and environmental qualities' that may influence personal walking behaviour. Indeed, the physical and environmental qualities as 'perceptual qualities' reflects basic attributes of urban design which is needed to be considered as the concept of 'walkability'. To implement the concept of 'walkability' that covers both 'perceptual qualities' and 'personal reactions' for residents living in a local neighbourhood, essentially, it needs to develop a 'Decision Support Tool'. Indeed, this tool aids to collect and integrate professionals' various alternative solutions and preferences. This tool contributes them to achieve more accurately the final decision regarding future sidewalk development in a targeted neighbourhood. The current research used

'Grounded Group Decision Making' (GGDM) method. In fact, the output of GGDM will contribute the professionals interfere making decision for future development of a local neighbourhood based on the concept of walkability and personal reactions. The reliable and valid output of this tool contributes local government authority professionals, practitioners, and also academic researchers to measure and evaluate the association between a targeted local neighbourhood environment and its residents' walking behaviour in Malaysia. In contrast with previous assessment models, this model can be applied in other countries if they follow this system design procedure and convert and adopt it with their neighbourhood urban contexts.

**Keywords:** Walkability, Built Environment, Walking Behaviour, Group Decision Making, Decision Support Tool

## INTRODUCTION

This paper presents the research model on development of the pedestrian responsible path assessment tool. The research was conducted in multi-disciplinary approach, employing methodologies from urban design, urban planning, transportation planning, landscape architecture, public health, decision making, and system development to form a wide-range detailed analysis of the subject matter. The research was in the

hypothesis that “A design decision support tool aids local governments of Malaysia towards enhancing pedestrian responsible walkway environment design process”. As such, the research agenda structured to address this hypothesis is on that:

- Facilitate making decision of all participating stakeholders regarding design a responsible and walkable path environment.
- Provides a systematically mechanism that often complex residents’ perception and local government decisions can be considered in a more compatible manner with the Malaysian targeted neighborhood context.

The research has been planned in a series of main linked phases and involved steps. To develop this decision support system, the overall package of the research has been followed as below;

- A review of both existing path walkability variables and walkability assessment tolls/instruments
- A details discussion with Malaysian stakeholder infer in path design and planning
- A neighborhood environmental value and ranking assessment regarding responsible path walkability performance
- The Decision Support System development for responsible walkable path design

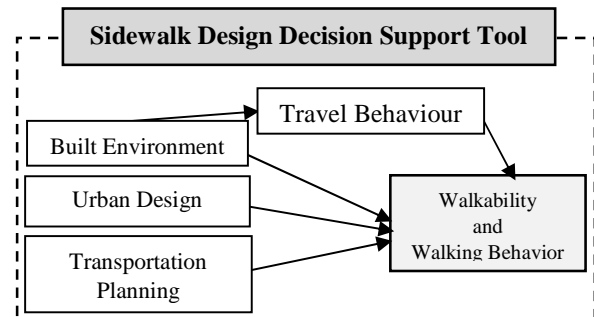
The output of research will provide an understanding and evaluating better path environment characteristics which fulfills almost entire users’ different needs and demands by high level of performance. Also, the research results will address the issue of path walkability from urban-wide perspective, by aiming to focus on neighbourhood micro-scale.

The paper outlines the phases and involved steps taken in developing the assessment tool which supports decisions on future neighbourhood development and relative corrective actions to manage path and sidewalk environment to be used more for walking activity.

### BACKGROUND OF RESEARCH: Walkability and Sidewalk Design on Different Fields of Research

An extensive review on literatures in different relevant fields of research will aid to achieve a more comprehensive ‘Walkability Decision Support Tool’. Figure 1 illustrates that there are different fields of research challenging with the issues of walkability and walking behaviour based on their views. These research fields include Built Environment, Transportation Planning, and Urban Design,

Methodologies. The following describes in depth the empirical investigations of each mentioned research fields.



**Figure1:** Framework of different fields of researches dealing with walkability and walking behaviour issues to develop walkability indexes.

#### A) Association Between Built Environment and Travel Behavior

Regarding purview literatures, study on relationship between built environment and travel behaviour started in the late 1970s; while, there are some unexplored detailed researches at the interface of relationship between urban form and travel behaviour in general. It was supposed that urban form, land use and design impact on travel demand [1]; however, Boarnet and Crane [2] express that land use characteristics affect on travel behaviour through entirely complex relationships. Actually, there are few built environment characteristics have been determined that positively deal with physical activity specially for adults; such as, safety from traffic [3], residential density, land use mix, and street connectivity [4.5.6], street lighting [7].

Besides, Handy [5] states that socio-economic, attitude and preference towards travel and neighbourhood characteristics, and specifically residential self-selection bring some changes in travel behaviour. However, the studies that have investigated on the neighbourhood land-use characteristic result that land-use play no critical role in explaining residents’ travel behaviour and choice decisions [8, 9, 10, 2, 11].

#### B) Association Between Built Environment And Walking Behavior

There is ever-growing recognition of built environment influences on physical activities (i.e. walking behaviour). Many studies have been focused to regional macro-scale of built environment that cannot provide the detailed information about neighbourhoods or roads and streets within them for policy-makers [12, 13, 14]. Thus, it is necessary to considerer micro-scale built environment as well to capture better physical activity within

neighbourhoods. To date, neighbourhood micro-scale studies, besides of socio-psychological and socio-demographic factors, variables have identified many environmental variables which impact on walking [15, 16, 17, 18, 19, 7, 20, 21, 12, 8].

Furthermore, the recent studies show that spatial structure of the neighbourhood has substantial influence on walkability, walking mode choice, walking route choice, and other relevant dimensions of walking behaviour [5, 11]. Also, few built environment characteristics have been identified that positively associated with physical activity specially for adults; including, aesthetics [22], well maintained footpaths [23, 3, 20], the presence of facilities that function as destinations, e.g. shops [23, 3, 20, 7], access to facilities for physical activity, e.g. parks and recreation centers [23, 3, 22], accessible, safe green spaces [24, 19, 25].

### **C) Association Between Transportation And Walking Behavior**

In the field of transportation planning, study on walking environment produced engineering road design manuals and guidelines that creates effective traffic flow [26], but with low attention to pedestrian walking behaviour and walkability. The early empirical investigations have been considered on walking speed, pedestrian space along highways, unobstructed pedestrian walkway, traffic safety, estimation on pedestrian demand and infrastructure supply [27]. The preliminary series of transportation studies conducted to measure micro-level pedestrian walking environment [28, 29, 30], such as quantifying the total number of lanes, average width of sidewalk, and types of traffic control device. However, the recent studies focus on social and psychological measurement to identify the influences on walking behaviour. Transportation researchers rarely overlooked the qualitative aspect of walking behaviour such as pedestrian perception, comfort, safety and security, and visual attractiveness; while, the manuals have been improved by just qualitative knowledge [31]. Obviously, transportation researches associate to determine walking environment indicators, but they have not conducted in a systematic and scientific way.

### **D) Association between Urban Design And Walking Behavior**

In the field of urban Design, the studies on walking lunched since early 1960s by Jane Jacobs's seminal work on urban design theories [32]. Urban design researchers unlike transportation researchers investigate on non-functional aspects of walking, such as sense of safety, sense of security and visual interests. Indeed, urban design researchers interpret these functional factors of urban environment - transportation researcher emphasize on them- to

human behaviour especially on pedestrian behaviour. Referring to existing literatures, they interested to walking travel, interaction between pedestrian and street and relative subjects to them. Urban design theorist are investigated on diverse dimensions of pedestrian behaviour; such as, Jacobs [32] 'eyes upon the street' regarding the issue of 'sense of security', Lynch [33] 'path quality', Gehl [34] 'soft edge', Jacobs [35] 'green buffer zone', Southworth [26] inclusive design in residential streets. While the findings of mentioned urban design theorist have been very useful, the researchers have not performed them in a scientific and systematic way, as same as transportation research field.

### **PROBLEM STATEMENT**

Although empirical evidences investigated in background of study makes a theoretical framework of positive association between walkability and walking behaviour in different fields of research, it could not find any definitive globally answer to relation between local neighbourhood design and human walking activity. Besides, the result of this evidence study on empirical researches in different disciplines of urban planning, transportation planning, urban design, and urban management shows inconsistencies in built environment perceptual qualities and qualitative attribute measurements. Indeed, the perceptual qualities and qualitative attribute of built environment highlighted that interpretation of these attributes into quantifiable variables was a very difficult work in different disciplines. However, these discussed evidences construct firmly the foundation to emerging to the research on understanding precisely association between local neighbourhood design and its residents' preferences and perceptions to use sidewalks to walk more.

Indeed, most of the reviewed statically-driven studied have not interpreted these built environmental qualities into measurable variety. Specially, empirical research conducted by Ewing et al. [36] and Sealans et al. [6] developed previous research by indicating a critical relationship between perceptual qualities and personal reactions with walking behaviour within a local neighbourhood. It is while sidewalk design within a local neighbourhood has been rarely considered from the perspective of urban design. Only, Ewing et al. [36] proposed measurement protocols for such perceptual qualities and personal reactions as urban design attributes which yet were not practically used in most of empirical studies.

Traditionally, a group of professionals in urban design and other professionals in different disciplines of urban management are following general and

unique series of guidelines, codes, and standards to neighbourhood development. In fact, the decision made by this group of professionals has been similarly applied in different neighbourhood development with different environmental and demographic characteristic. In that manner, urban designers could not act independently to suggest local neighbourhood development based on its demographic and residential characteristic. Besides, according to Mokhtarian and Cao [37] changing urban form cannot change people behaviour and attitude, but changing urban areas based on people attitude, perception, and self-selection would ameliorate people behaviour in travel and walking behaviour.

Badland and Schofield [38], state that researchers need more detailed knowledge and information regarding global perspective in leading the current trends in built environment and walking behaviour research. Referring to Badland and Schofield [38], the majority of walking behaviour studies is based on country-specific, self-report cross-sectional designs, which intensively need to inherent current certain and faults, through consisting between studies, and making inter-study comparison. Furthermore, Badland and Schofield [38] state that there is a crucial need to enhance systematically existing assessment tools regarding the inclusive-user approach.

In this regards, the current research proposes a 'Decision Support Tool' which aids urban designers for future neighbourhood development. Juxtaposing the output of the tool helps urban designers to convince other professionals participate, specially, in neighbourhood's sidewalk development through implying much more adaptability between local neighbourhood sidewalk environment characteristics and its residents' needs, preferences, and perceptions. In other word, although researchers found that neighbourhood environment is related to walking activity [39, 22, 7, 40, 41, 42] using this tool contributes urban designers to propose the specific guidelines and codes compatible with the targeted neighbourhood's sidewalk environment characteristics and its own users.

### **SIGNIFICANCE OF RESEARCH**

Figure 2 illustrate the theoretical framework of the research which includes two parts. The up-side part of theoretical model refers to current practice which presents Ewing et al. [36] study. In fact, the study by Ewing et al. [36] is the available study which proposed measurement protocols for such perceptual qualities and personal reactions as urban design attributes. It has not been yet used practically in empirical studies, specifically, in multi criteria

decision making (MCDM) studies. The bottom-side part of theoretical model proposes a novel idea on developing a 'Decision Support Tool' which helps urban designers to measure more accurately the association between a local neighbourhood path environment with its residents' walking behaviour. In fact, the result of the 'Decision Support Tool' would be very useful for both professionals and practitioners for making decision to future path development and corrective actions.

### **DECISION MAKING THEORY**

Decision making theory on travel behavior mostly focuses on the process and hierarchy of deciding during daily trips. The research on decision behavior is an empirical approach for exploring and recognizing human decisions. The good decisions are those able to fulfill the decision maker's purposes. Understanding decision making is directly relevant to the study of walking behavior, travel choice and route choice, as human behavior in real experiences, is often the main focus in both research and practice. According to theory of decision making on human travel behavior, it covers two descriptive focuses which include how people actually make decisions, and how a normative vision should be made base on their decision [43].

Essentially, qualitative predictions created behavioral modeling related to individuals' travel patterns, which is based more on quantitative estimating and forecasting. Adding up qualitative measures is supported with the theoretical practice of Simon, who established the rules and regulations of qualitative structure as well as quantities attributes [44]. Decision behavior theory includes many approaches that are useful in studying travel behavior, such as subjective utility theory, the related multi-attribute utility theory (with weighted utilities and estimated probabilities related to risk or uncertainty), and Simon's satisfying concept of adjusting goals and values to the environment [45]. Sequential decision-making, commonly associated in structural models [43] is relevant to the hierarchy that link residential location and auto ownership to short-term travel decisions made in active and environments. Sequential linking occurs through 1) formation of strategy or routine; 2) similar problems that appear in sequence; or 3) early decisions that dictate conditions for later decisions and help form choice sets [24].

### **RESEARCH AIM AND OBJECTIVES**

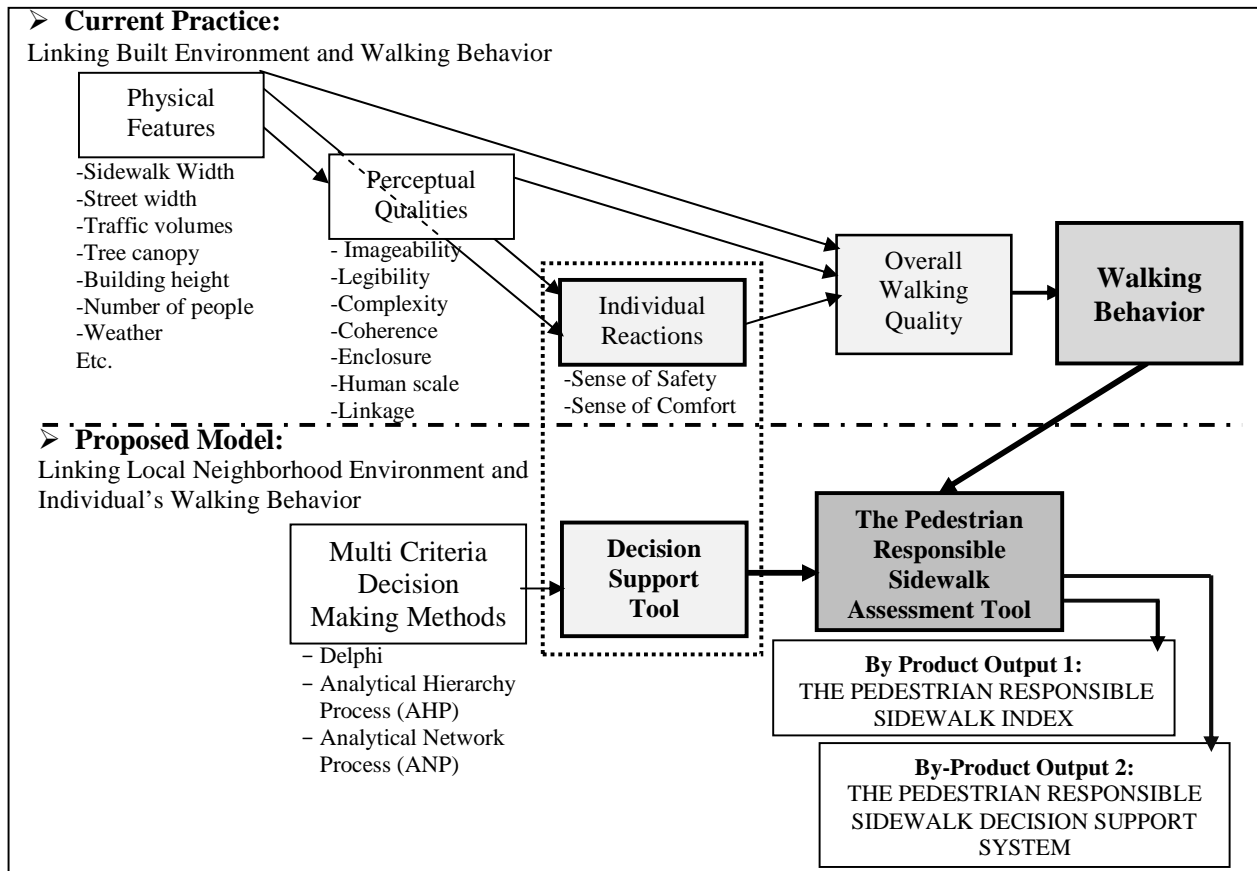
In this regard, the research planed to develop a design decision support tool towards enhancing pedestrian responsible walkway environment in Malaysia walkway infrastructure design process. To come up

with the expected research output the following objectives were identified;

- **Objective 1:** To review walkway infrastructure design process in Malaysia
- **Objective 2:** To identify pedestrian responsible walkway environmental indicators in Malaysia urban context
- **Objective 3:** To establish requirement of walkway design decision support tool compatible for pedestrian responsible walkway design

- **Objective 4:** To develop the pedestrian responsible walkway design decision support tool

Figure 3 shows the research methodology flowchart which was structured in four (4) phases involved fifteen (15) steps to conduct the research.



**Figure2:** Proposed Model on the Pedestrian Responsible Sidewalk Assessment Tool, the Current Practice adopted and modified from Ewing et al., (2005)

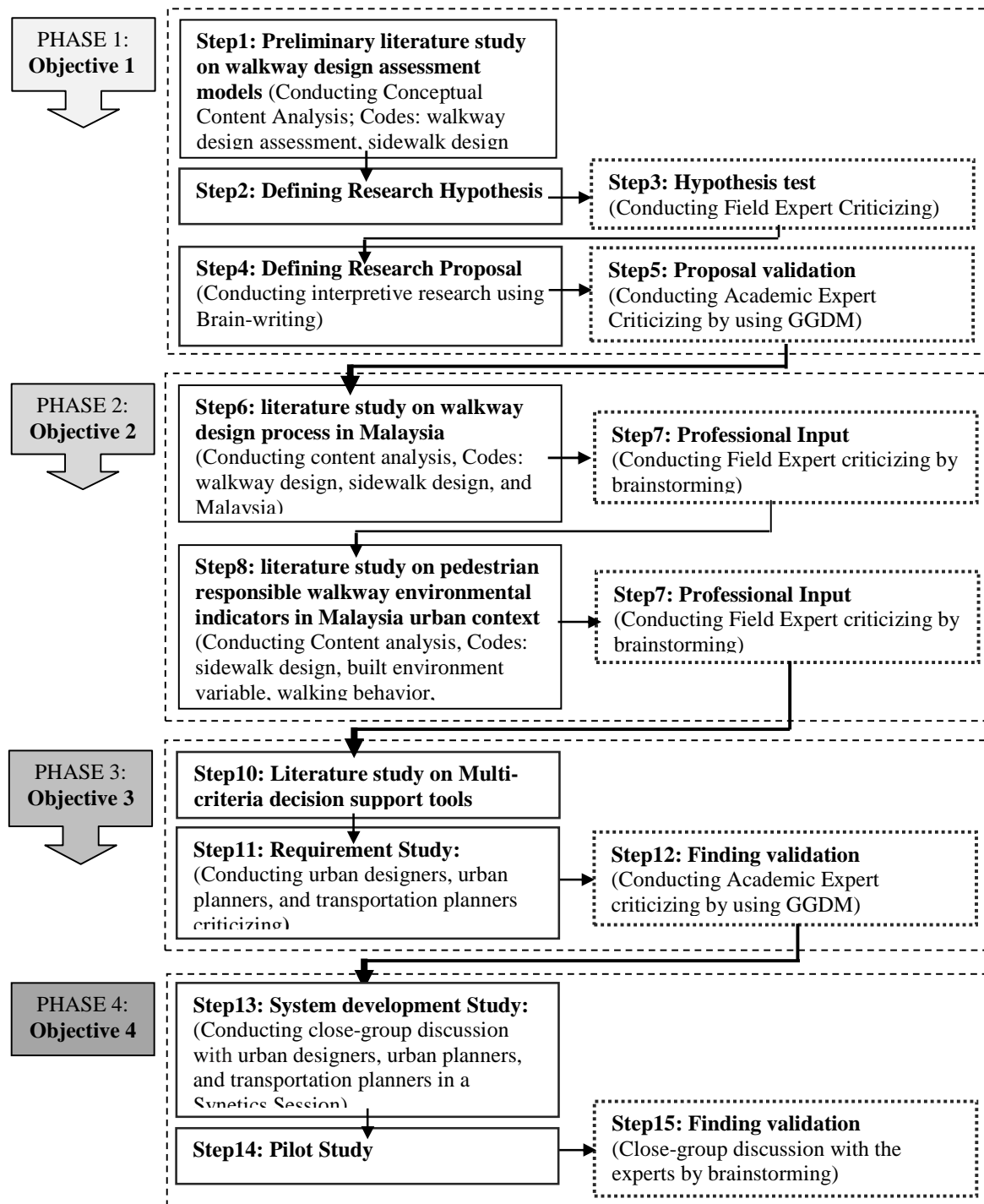


Figure 3: Research Methodology Flow to Develop Sidewalk Design Decision Support Tool

## CONCLUSION

The current research developed previous studies by Ewing et al. (2005) and Sealans et al. (2003) that applying 'perceptual qualities' and 'personal reaction' attributes in neighbourhood environment design causes incensement in residents' walking.

This paper is presented the rational and structure research proposal to do so.

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## REFERENCES

- [1] Cervero, R. and Kockelman., K., 1997, "Travel Demand and the 3Ds: Density, Diversity, and Design." *Transportation Research Part D* 2(3): 199-219
- [2] Boarnet, M.G. and Crane, R., 2001, *Travel by Design; the influence of urban form on travel*. New York, Oxford University Press
- [3] Duncan, M., Spence, J., Mummery, W., 2005. Perceived environmental and physical activity: a meta-analysis of selected environmental characteristics. *International Journal of Behavioral Nutrition and Physical Activity* 2.
- [4] Frank LD, Engelke PO, Schmid TL. 2003, *Health and community design: the impact of the built environment on physical activity*. Washington, DC: Island Press.
- [5] Handy, S., 2005, "Critical Assessment of the Literature on the Relationships Among Transportation, Land Use, and Physical Activity." *TRB Special Report 282: Does the Built Environment Influence Physical Activity? Examining the Evidence*. Accessible at <http://trb.org/downloads/sr282papers/sr282Handy.pdf>
- [6] Saelens BE, Sallis JF, Frank LD. Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. *Ann Behav Med* 2003;25:80-91.
- [7] Saelens, B.E., Sallis, J.F., Black, J.B., and Chen, D., 2003a. Neighborhood-Based differences in physical activity: an environment scale evaluation. *American Journal of Public Health*, 93(9), 1552-58
- [8] Kitamura, R., Mokhtarian, P.L., and Laidet, L., 1997. A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay area. *Transportation*, 24, 125- 58
- [9] Stead, D., 2001, "Relationships between land use, socio-economic factors, and travel patterns." *Environment and Planning B: Planning and Design* 28: 499-528.
- [10] Dieleman, F.M., Dijst, M. and Burghouwt, G., 2002, "Urban form and travel behaviour: Micro-level household attributes and residential context." *Urban Studies* 39(3):507-527.
- [11] Bhat, C.R. and Guo, J.Y., 2007, "A comprehensive analysis of built environment characteristics on household residential choice and auto ownership levels." *Transportation Research Part B* 41: 506-526.
- [12] Frank, L.D., and Pivo, G., 1994. Impacts of mixed use and density on utilization of three modes of travel: Single-occupant vehicle, transit, and walking. *Transportation Research Record*, 1466, 44-52.
- [13] Bauman A, Armstrong T, Davies J, et al. , 2003, Trends in physical activity participation and the impact of integrated campaign among Australian adults, 1997-99. *Aust N Z J Public Health*;27: 76-9.
- [14] Saelens, Brian E.; Sallis, James F.; Black, Jennifer B.; Chen, Diana.; 2003, Neighborhood-Based Differences in Physical Activity: An Environment Scale Evaluation, *American Journal of Public Health* , Vol 93, No. 9
- [15] Sallis, J.F., Johnson, M.F., Calfas, K.J., Caparosa, S., and Nicholas, J.F., 1997. Assessing perceived physical environmental variables that may influence physical activity. *Res Q Exercise Sport*, 68, 345-351.
- [16] Sallis, J.F., Prochaska, J.J., and Taylor, W.C., 1999. A review of correlates of physical activity of children and adolescent. *Medicine and Science in Sports and Exercise*, 963-975.
- [17] Giles-Corti, B., and Donovan, R.J., 2002a. Socioeconomic status differences in recreational physical activity levels and real and perceived access to a supportive physical environment. *Preventive Medicine*, 35, 601-611.
- [18] Brownson, R.C., Baker, E.A., Housemann, R.A., Brennan, L.K., and Bacak, S.J., 2001. Environmental and Policy Determinants of Physical Activity in the United States. *American Journal of Public Health*, 91, 1995-2003.
- [19] Giles-Corti, B., and Donovan, R.J., 2002b. The relative influence of individual, social and physical environmental determinants of physical activity. *Soc Sci Med.*, 54(12), 1793- 1812.
- [20] Pikora, T., Giles-Corti, B., Bull, F., Jamrozik, K., and Donovan, R., 2003. Developing a framework for assessment of the environmental determinants of walking and cycling. *Social Science and Medicine*, 56(8), 1693-1703.
- [21] Kockelman, K.M., 1997. Travel behavior as function of accessibility, land-use mixing, and land use balance: Evidence from San Francisco Bay area. *Transportation Research Record*, 1607, 116-125
- [22] Humpel N, Owen N, Leslie E. Environmental factors associated with adults' participation in physical activity: a review. *Am J Prev Med* 2002;22:188-99.

- [23] De Bourdeaudhuij, I., Sallis, J., Saelens, B., 2003. Environmental correlates of physical activity in a sample of Belgian adults. *American Journal of Health Promotion* 18, 83–92.
- [24] Croucher, K., Myers, L., Bretherton, J., 2007. The links between green-space and health: a critical literature review, University of York, 2007.
- [25] Sugiyama, T., Ward Thompson, C., 2008. Associations between characteristics of neighborhood open space and older people's walking. *Urban Forestry & Urban Greening* 7, 41–51.
- [26] Southworth, M., 2005, Designing the Walkable City, *Journal of Urban Planning and Development*, 131 (4)
- [27] Pushkarev, B., Zupan, J.M., 1975, *Urban Space for Pedestrian*, MIT Press: Cambridge, Massachusetts
- [28] Gallin, N. ,2001, Quantifying Pedestrian friendliness- Guidelines for Assessing Pedestrian level of Service, *Journal Road and Transport research*, 10 (1)
- [29] Emrey, J., 2003, The WABSA Project: Assessing and Improving Your Community's Walkability and Bikeability, Working Paper, the University of North Carolina at Chapel Hill
- [30] Emrey, J., Crumo, C., Bors, .., 2003, Reliability and Validity of Two instruments Designed to Access the Walking and Bicycling Sustainability of Sidewalks and Roads, *American Journal of Health Promotion*, 18 (1):34-46
- [31] American Association of State Highway and Transportation Officials (AASHTO), 2004, *Guide for the Planning, Design, and Operation of Pedestrian facilities*, AASHTO: Washington, DC.
- [32] Jacobs, Jane, 1961, *Life and Death of Great American Cities*, New York: Vintage Books
- [33] Lynch, K., Soutworth, M., 1974, *Designing and Managing the Strip*, in *City Sense and City Design*; writing and Projects of Kevin Lynch, Cambridge, mass: MIT Press
- [34] Gehl, J., 1987, *Life Between Buildings: Using Public Space*, New York; Van Nostrand Reinhold
- [35] Jacobs, Allan, 1993, *great Street*, Cambridge, Massachusetts: MIT Press
- [36] Ewing, Reid; Handy, Susan; Brownson, Ross C.; Clemente, Otto; Winston, Emily; 2006, Identifying and Measuring Urban Design Qualities Related to Walkability, *Journal of Physical Activity and Health*, Vol. 3, Suppl 1, S223-S240
- [37] Mokhtarian, Patricia L. Cao, Xinyu; 2008, Examining the impacts of residential self-selection on travel behavior: A focus on methodologies, *Transportation Research Part B*, Vol. 42, pp. 204–228
- [38] Badland, H., Schofield, G. (2005). Transport, urban design, and physical activity: an evidence-based update. *Transportation Research Part D: Transport and Environment*, 10(3), 177–96.
- [39] Heath GW, Brownson RC, Kruger J, et al. The effectiveness of urban design and land use and transport policies and practices to increase physical activity: a systematic review. *J Phys Act Health* 2006;3(1S):S55–S76.
- [40] Owen N, Humpel N, Leslie E, Bauman A, Sallis JF. Understanding environmental influences on walking: review and research agenda. *Am J Prev Med* 2004;27:67–76.
- [41] Gebel K, Bauman AE, Pettecrew M. The physical environment and physical activity: a critical appraisal of review articles. *Am J Prev Med* 2007;32:361–9.
- [42] Transportation Research Board-Institute of Medicine. Does the built environment influence physical activity? Examining the evidence. Washington DC: National Academies Press, 2005.
- [43] Svenson, O. ; 1998; The perspective from behavioral decision theory. In: Garling, T., Laitila, T., & Westin, K. (Eds.), *Theoretical Foundations of Travel Choice Modeling*; Amsterdam: Elsevier
- [44] Garling, T., Laitila, T., & Westin, K. (Eds.) ;1998; *Theoretical foundations of travel choice modeling*; Amsterdam: Elsevier.
- [45] Shay, E., Fan, Y. L., Rodriguez, D. A., Khattak, A.J.; 2006; Drive or walk? Utilitarian trips within a neo-traditional neighborhood; *Transportation Research Record*, No. 1983; Transportation Research Board, Washington DC

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