PATH WALKABILITY ASSESSMENT FRAMEWORK BASED ON DECISION TREE ANALYSIS OF PEDESTRIAN TRAVELERS' RETAIL WALKING

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To whom teach me since I was born

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ABSTRACT

Better understanding of the association between built environment, walkability, and human physical activity is a research issue for urban designers, urban planners, transportation planners, and landscape architects. However, direct association between built environment and individual's walking behavior which derives from personal reaction and perception was not yet studied in urban design that integrate with multi-criteria decision making methods. To date, three models have been developed to assess urban walkability using decision making methods, namely, Pedestrian Infrastructure Prioritization Decision System, Pedestrian Safety Guide and Countermeasure Selection System, and Pedestrian Performance Measure System. These models are applicable in urban planning and transportation planning, but not useful for urban design. Thus, this research aims to develop the path walkability assessment framework based on decision tree analysis of pedestrians which is usable for urban designers. Six objectives were identified to achieve the aim. Firstly, the study investigated walkability issues and problematic causes in sustainable neighborhood development. This objective resulted with seventeen problematic issues needed to be considered in the walkability assessment framework development. Second objective was to establish the walkability assessment principles. The third objective was to indicate the walkability assessment variables, including, walkability features, criteria, and sub-criteria compatible with retail pedestrians. Fourth objective was to determine the most appropriate decision making method and the system development process model for capturing retail pedestrians' sequential route choice patterns. To address second, third, and fourth objectives, literature reviews and expert inputs were conducted to validate the findings of the literature reviews. The expert input sessions involved professionals, including, urban designers, urban planners, transportation planners, landscape architects, and architects who are knowledgeable and have experiences in urban assessment framework development. The Grounded Group Decision Making method and Weighted Sum Method were applied to analyze the collected data from the experts' inputs. In result, fourteen urban walkability principles corresponding to the second objective were identified. Besides, five walkability features, eleven walkability criteria, and fifty six walkability sub-criteria corresponding to the third objective were determined. Corresponding to the fourth objective, the decision tree analysis model and the prototyping system development process model have been approved by the aforementioned group of experts. The fifth objective was to develop the Path Walkability Index (PAWDEX) assessment framework. The framework was developed using Synectics method. The preliminary framework validation was conducted in an expert input session engaging experts in urban design who have extensive knowledge in using decision making methods and decision support tools. Finally, the sixth objective was to validate the developed framework through pilot study within a selected neighborhood area. The neighborhood area was selected based on suggestion by the same experts involved in expert input study for the fifth objective. The framework users who were three Urban Design Masters students were engaged to conduct the pilot study within nine case studies in Taman Universiti neighborhood. Consequently, the PAWDEX assessment framework was tested, and, usability of the framework was successfully confirmed by framework users. Urban professionals may use this assessment framework for their decision making of future corrective actions on neighborhood development and/or redevelopment.

ABSTRAK

Pada masa ini, memahami dengan lebih mendalam perkaitan antara alam sekitar, kebolehjalan kaki, dan aktiviti fizikal manusia yang lebih baik merupakan isu penyelidikan antara perekabentuk bandar, perancang bandar, perancang pengangkutan, dan arkitek landskap. Selain itu, perkaitan langsung antara alam sekitar dan tingkah laku berjalan individu yang terhasil dari reaksi peribadi dan persepsi masih belum dikaji dalam rekabentuk bandar yang mengintegrasikan kaedah membuat keputusan berdasarkan multi-kriteria. Sehingga kini, tiga model telah dibangunkan untuk menilai kebolehjalan kaki bandar bergandingan dengan kaedah membuat keputusan ini, iaitu Sistem Pembuat Keputusan Keutamman Infrastruktur Pejalan Kaki, Sistem Pemilihan Langkah Balas dan Panduan Keselamatan Pejalan Kaki, dan Sistem Pengukuran Prestasi Pejalan Kaki. Model-model tersebut terpakai untuk perancang bandar dan perancang pengangkutan tetapi bukan untuk perekabentuk bandar. Oleh itu, kajian ini bertujuan untuk membangunkan rangka kerja penilaian kebolehjalan kaki berdasarkan analisa pohon keputusan pejalan kaki yang sesuai dipakai oleh pereka bandar. Enam objektif telah dikenalpasti untuk memenuhi matlamat ini. Pertama, ialah mengkaji isu kebolehjalan kaki dan sebab-sebab berkaitan kemampanan perbandaran dan pembangunan kejiranan. Kajian awalan dibuat untuk mencapai objektif pertama dan menghasilkan tujuh belas isu yang perlu dikaji dalam penilaian rangka kerja pembangunan kebolehjalan kaki. Objektif kedua adalah untuk menetapkan prinsip penilaian kebolehjalan kaki. Objektif ketiga pula adalah untuk menentukan pembolehubah penilaian kebolehjalan kaki, termasuk, ciri-ciri kebolehjalan kaki, kriteria dan sub-kriterianya serasi dengan pejalan kaki runcit. Objektif keempat adalah untuk menentukan cara yang terbaik untuk membuat keputusan dan model proses pembangunan sistem bagi merekod laluan turutan yang biasa di ambil oleh pembeli yang berjalan kaki. Untuk mecapai matlamat objektif kedua, ketiga dan keempat, kajian literatur dan sumbangan para pakar dijalankan untuk mengesahkan hasil dari kajian literatur. Sesi input pakar adalah termasuk profesional dalam bidang rekabentuk bandar, perancangan bandar, arkitek landskap serta arkitek yang berpengetahuan luas dan berpengalaman dalam pembangunan kerangka penilaian perbandaran. Kaedah Pembuat Keputusan Berkumpulan Tersirat dan Kaedah Jumlah Terwajar digunakan untuk menilai data yang diperolehi dari para pakar. Hasilnya, empat belas prinsip kebolehjalan kaki yang berhubung kait dengan objektif kedua di kenal pasti. Selain itu, lima sifat kebolehjalan kaki, sebelas kriteria kebolehjalan kaki, dan lima puluh enam sub-kriteria kebolehjalan kaki yang berhubung kait dengan objektif ketiga telah dikenalpasti. Berhubung dengan objektif keempat, model Analisa Pohon Keputusan dan pembangunan sistem prototaip telah disahkan oleh kumpulan pakar tersebut di atas. Objektif kelima adalah untuk membangunkan penilaian rangka kerja Indeks Laluan Kebolehjalan kaki (ILK). Rangka kerja ini dibentuk menggunakan kaedah Synectics. Pengesahan awal kerangka telah dijalankan dengan input pakar perekabentuk bandar yang berpengetahuan tinggi berkaitan kaedah membuat keputusan perkakasan sokongan rekabentuk. Akhir sekali, objektif keenam adalah untuk mengenalpasti atau mengesahkan rangka kerja yang direkabentuk melalui satu kajian rintis dalam satu kawasan kejiranan yang dipilih. Kejiranan yang di pilih adalah berasaskan kepada cadangan dari pakar perekabentuk bandar yang sama yang dalam merujuk kepada objektif kelima. Pengguna kerangka yang digunapakai adalah tiga pelajar Sarjana Rekabentuk Bandar untuk menjalankan kajian awal ke atas sembilan kajian kes di kejiranan Taman Universiti. Rangka kerja penilaian 'ILK' telah diuji dan kebolehgunaan rangka kerja ini telah disahkan dengan jayanya sebelum ini oleh pengguna. Perekabentuk bandar boleh menggunakan rangka kerja penilaian ini untuk membuat keputusan terhadap tindakan pembetulan di dalam pembangunan kejiranan dan/atau pembangunan semula masa depan.

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LIST OF ABBREVIATIONS

CDC	-	National Centre for Chronic Disease Prevention and Health Promotion
MCDM	-	Multi Criteria Decision Making
ISO	-	International Standardization Organization
WHO	-	World Health Organization
PNPFDG	-	Pedestrian Network Planning and Facilities Design Guide
NZTA	-	New Zealand Transport Agency
AASHTO	-	American Association of State Highway and Transportation Officials
LCA	-	Life Cycle Analysis
HDI	-	Human Development Index
CRISP	-	Construction and City Related Sustainability Indicators
TRB	-	Transport Research Board
CABE	-	The Commission for Architecture and the Built Environment
WSM	-	Weighted Sum Method
CGD	-	Close Group Discussion
GGDM	-	The Grounded Group Decision Making method
HCI	-	Human-Computer Interaction

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CHAPTER 1

INTRODUCTION

1.1Introduction

This chapter is an introductory explanation of the study accomplished in this research. The chapter includes following sections; 'Background of Study', 'Problem Statement', 'Aim and Objectives', 'Scope of Study', 'Significance of Study, and 'Thesis Outline'. The chapter would hopefully help readers to have an overview on this research.

The terminologies, 'Walkability' and 'Walking Behavior', have been controversial issues in urban planning, urban design, transportation planning, and public health studies which dates backs to early 2000. The National Centre for Chronic Disease Prevention and Health Promotion (CDC) defines *"Walkability is the idea of quantifying the safety and desirability of the walking routes"* (CDC, 2009). Clifton and Livi (2007) express that the research involved with Walkability *"...can be considered in parallel with friendliness, because of variables included functional, safety, aesthetic and destination as well as security, comfort and convenience, continuity, system coherence, and attractiveness"*.

Study on 'Walkability' and 'Walking Behavior' directly impact on initial urban strategies included New Urbanism, Smart Growth, and Sustainability in future. Professionals and practitioners of sustainable urban development attempt to encourage individuals to walk rather than choosing other available modes of travel. There has been a considerable amount of studies across disciplines since last decade to understand better and measure more accurately the association between the built

environment walkability and individuals' walking behavior. Croucher et al. (2007) and Clifton and Livi (2007) claim although many studies state that walking behavior are influenced by neighborhood environment characteristics and form, understanding accurately the terminologies 'walkable' and 'walkability' are still being investigated. Saelens et al., (2003) conclude in their research that walkability was a great importance in compliance with physical activity. In addition, Saelens et al., 2003 express that the residents live in a high walkable neighborhood have had 'walking trips' almost two times more than residents of low walkable neighborhoods. Regarding a recent comprehensive review on neighborhood walkability, Moudon and Lee (2003) and Clifton and Livi (2007) investigated the existing walkability assessment tools on pedestrian Level-Of-Service indicators. They provided a numerous walkability indicators in a form of checklist that deals with both walking behavior approaches; including, transportation and recreation. However, this checklist of walkability indicators would not be used in any neighborhood areas with its own environmental, socio-economic, and cultural characteristics.

Policy-makers, urban planners and designers are investigating to find specific assessment tools towards measuring 'walkability' applicable for any neighborhood areas. Professionals and practitioners in Malaysia across disciplines relevant to sustainable urban development need such a reliable assessment tool as well. Such tool able to measure 'walkability' of a built environment affects individual's decision making in their walking activity. Indeed, using this assessment tool aids professionals as a design decision support tool which contributes to promote neighborhoods towards a walkable and pedestrian-friendly environment. Furthermore, this assessment tool would aid professionals and practitioners in Malaysia to result with the effective solutions on encouraging people to walk more and choose walking rather than other modes of travel. Eventually, it can rectify health problems of Malaysian people, such as, overweight, obesity, and respiratory disease.

1.2 Background of Study

There is a belief that some communities or neighborhoods are more or less conducive to physical activities such as walking. A concept found in the literature is 'walkability' or the 'walkable environment'. There are numerous studies on walkability which have been considered from different perspectives. The previous studies focused on identifying the walkability attributes (including, dimensions and indicators), and the methodologies to measure walkability, and then, developing walkability models, measure tools or instruments.

According to Handy (1996) "because the pedestrian sees, hears, smells, and feels much of the surrounding environment, urban form is likely to play a greater role in the choice to walk". According to report by Parsons Brinckerhoff Quade and Douglas Inc. (1993) on the pedestrian environment in Oregon, Portland, the high quality of pedestrian environment can achieve 10% reduction in vehicle miles traveled (Leslie et al., 2007). The factors evaluated included, ease of street crossing, sidewalk continuity, street connectivity, and topography which may implement walkability in a neighborhood. Bradshaw (1993) developed a rating system to measure the walkability of a neighborhood. His walkability rating system evaluates the aspects of proximity and connectivity, as the measures of walkability, and also set of indicators including, density, persons per acre, parking spaces off-street per household, number of sitting spots per household, chance of meeting someone while walking, ranking of safety, responsiveness of transit services, number of neighborhood places of significance, acres of parkland, and sidewalks. Cervero and Radisch (1996) compared the choices between a pedestrian and an automobile-oriented neighborhood in San Francisco. The indicators were calculated to measure this walkability of the neighborhood are more in details than previous studies, which added, mixed-use of land, grid-like street pattern, traditional design qualities, integrated network of sidewalks and pedestrian paths walkability indicators.

Leyden (2003) states a walkable neighborhood is where enables residents to perform daily activities such as going to shopping, park, and even work without need to use a car. Leyden (2003) claims the walkable neighborhood as a traditional or complete neighborhood can be found mostly in older cities in where have mixed-land

uses within walking distances. Takano et al., (2002) used the term "walkable green spaces" in their research as defined as "…*greenery filled public areas that are nearby and easy to walk in such as parks and tree lined streets".* Saelens et al. (2003) express that "traditional neighborhoods purported to be highly walkable and bikable are characterized by high population density, a good mixture of land-use, high connectivity, and adequate bike/walk design including continuous sidewalks. Connectivity has been defined as "*the ease of travel between two points. The degree that streets or areas are interconnected and easily accessible to one another. An example of high connectivity would be a dense grid pattern in a downtown area*" (CDC, 2005).

Moreover, Saelens et al., (2003) concluded their research that walkability was a great importance in compliance with physical activity, and residents live in a high walkable neighborhood have had walking trips almost two times more than residents of low walkable neighborhoods. Similarly, Berke et al. (2007) found these results in their research; and also addressed that neighborhood characteristics are associated with the frequency of walking for physical activity in older people. Ewing et al., (2007, 2002) studied on walkability in the context of much larger problem. This study conducted on examining the links between urban sprawl and traffic, air pollution, central city poverty and degradation of scenic areas to highlight walkability aspects. The measures of their study included, residential density, and neighborhood land mixed-use, strengths of centers, and accessibility of street network.

Southworth (2005) in his paper '*Designing the Walkable City'* summarized six key aspects contributing to walkability from a landscape architecture perspective, including, connectivity of path network, linkage with other modes, fine-grained and varied land use patterns, safety, quality of path, and path context.

The previous studies on walkability have developed diverse methodologies to measure subjectively and objectively the association between built environment walkability and people walking behavior. These research have used different methods to capture and collect data; such as, Geographic Information System (GIS), Audit Tool, Recall Questionnaire, Self-report Tool, and Sensor Motion. Every

measure tool can be used in research with specific purpose and subjects; thus, choosing the most appropriate measurement tool compatible with aim of study, needs to be considered intensively. Besides, measurement strategies need to be incorporated at a cross-sectional level with practitioners who are seeking to develop studies that investigate on individuals' behavior in differing environments (Humpel et al., 2004). For instance, Lesli et al. (2007) in the research entitled '*Walkability of Local Communities'* used GIS to measure the features of the built environment that may influence adults' physical activity. This GIS-based tool was used to evaluate the walkability principles, such as, connectivity, land use attributes, dwelling density, and Net retail area. With a little improvement on previous studies, Moudon et al. (2006) developed an audit tool to measure environmental variables of neighborhood walkability associated with walking, and then, resulted with the values for residential density, street-blocks lengths around homes, distance of daily retail facilities from home to different destinations.

According to literature review, the study on walkability is one of the fastest growing integrated issues in urban design, urban planning, transportation planning, architecture, and landscape architect. Integration of diverse disciplines provides a valuable starting point for multidisciplinary research on walkability. In addition, integrating diverse disciplines safeguards the future performance of sustainable urban management. Besides, this integration creates opportunities for better combination within and between transport modes.

The current research focused on walkability in the perspective of Urban Design. Figure1.1 illustrates the association between Urban Design in the area 'walkability' across five disciplines, including Urban Planning, Transportation Planning, Architecture Landscape, and Architecture. As can be seen in Figure1.1, the level of association between disciplines is different which was depicted in different sizes and patterns. The figure shows that walkability has been mostly considered in urban planning. Then, walkability was taken account by urban design, transportation planning and landscape architecture, respectively. It was undertaken a little in architecture filed of research.

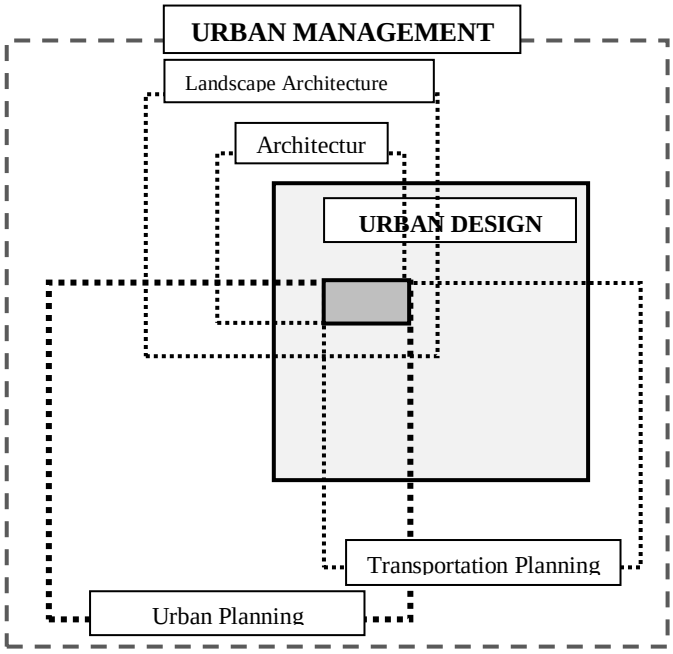

Figure 1.1: Association between Urban Design in the area of 'walkability' and Urban Planning, Transportation Planning, Architecture Landscape, and Architecture which is inscribed by Urban Management

Table 1.1 provides some walkability measure tools developed by researchers. The table presents a brief description for each about the goal of research, walkability principles/variables, assessment methods, and data sources. Table 1.1 shows existing models in walkability assessment models. These models are developed by difrent research disiplines in urban management studies. Indeed detail reveiw on this models will be elaborated in Chapter 2.

Table 1.1: Walkability assessment models, descriptions walkability principles/variables, methodologies, and assessment methods

Tool/Instrument	Reference/ Year/Country	Goal of Research	Walkability Principles / Variables	Assessment Methods/ Data source
Pedestrian Location Identifier 1	Moudon et al., 2002, Washington State Department Of Transportation USA	This tool aids state and local authorities in identifying suburban locations where investments in pedestrian infrastructure enhancement will lead to the most increases in pedestrian travels.	It focuses on residential land development, and captures the characteristics of land-use mixes that have the highest potential for substantial volumes of pedestrian trips.	It uses Census GIS Data and Aerial Photo Analysis, that are explored to capture spatial data to identify the most potentially areas with high demand on pedestrian infrastructure design and construction.
Pedestrian Location Identifier 2	Moudon et al., 2002, Washington State Department Of Transportation, USA	This tool aids pedestrian infrastructure providers in allocating investments suburban clusters and corridors locations with potential increases in pedestrian travel.	It focuses on residential land development, and captures the characteristics of land-use mixes that have the highest potential for substantial volumes of pedestrian trips.	It uses Parcel Data and Tax lot level GIS Spatial Analysis.
Pedestrian Infrastructure Prioritization Decision System	Moudon et al., 2002, Washington State Department Of Transportation, USA	It identifies the environmental and policy variables that affect pedestrian travel by ranking and prioritizing areas that have latent pedestrian demand. This tool aids pedestrian infrastructure improvement in clusters or corridors.	It evaluates environmental factors affect pedestrian travel demand: land uses and development patterns, transportation facilities, and policies.	It comprises open-ended responses and user-weighting scores by using a checklist of criteria.
Pedestrian Potential Index	Portland Planning Department, 1998, Portland	It was used to prioritize pedestrian projects improvements. It measures potential pedestrian demands. The index evaluates every street segment within the City of Portland was assigned an index value based on a number of factors.	The measured factors categorized in three sets: 1-certain areas and corridors, Street segments; 2- proximity factors, walking distance of destinations; 3- quantitative pedestrian environmental variables travel behavior	It conducted a household activity filed survey.
Pedestrian Environmental Factor	Parsons Brinkerhoff, Portland, 1993	It measures factors of pedestrian friendliness.	The four main variable include; sidewalk continuity, distance between intersections, and grades, Ease of street crossings, Sidewalk continuity, Local street characteristics , Topography	The points for a total LOS score out of 12 points added up together.
Bicycle and Pedestrian Performance Measure System (The Gainesville Mobility Plan Prototype)	Linda B. Dixon,1996 Delaware Department of Transportation, USA	LOS evaluations that indicate the degree of accommodation for pedestrian along a given corridor.	Totally 16 variables divided into two groups of bicycle and pedestrian; including, facility provided, conflicts, speed deferential, maintenance, crossing width, amenities.	A composite score(4-12) was created for each zone. Points of scores added together and then converted to LOS scaling tool.
Walking Permeability Indices	Allen Andrew, 2001, World Transport Policy and Practice, Australia	It assesses degree to which walking is a significant mode of transport.	Direct distance between origin and destination divided by actual distance between origin and destination.	Data from the 1996 census of population and housing for Adelaide's metropolitan area was examined

Pedestrian Level of Service	Moe and Bracke, 2003, City of Fort Collins, USA	It provides pedestrian LOS	Totally 8 criteria evaluated, including, directness, continuity, security, sidewalk, visual interest, and street crossing.	It determines an LOS for each criterion by a matrix.
Qualitative Level of Service	Jotin Khisty, 1997, TRB, USA	It measures the qualitative aspects of environment that impacts on pedestrian behavior to supplement more quantitative approaches.	The weighted variables are combined to provide the rating from 0 to 5, Corresponding to LOS A-F.	Each variable is weighted by using the method of Constant-Sum Comparison. Method is based on a questionnaire survey which asks respondents to rank the variables.
Pedestrian Deficiency Index	Portland Planning, Department, 1998, Portland	It was used to prioritize pedestrian environment projects improvements. It measurers the current deficiencies of facilities.	Deficiency Index were chosen to measure missing sidewalks, difficult and dangerous street crossings (traffic speed, traffic volume, roadway width, and locations with automobile-pedestrian crashes), and lack of a connected street network.	The questions mostly organized and structured based on a point system.
Pedestrian Sketch-Plan Method	Ercolano et al., 1997, USA	It develops sketch-plan method for forecasting pedestrian travel demand projects for zones, nodes, and links, based on vehicle volumes. The sketch-plan method is introduced to estimate peak-hour pedestrian trips for crossings at intersections (node) and parallel sidewalk-midblock (link) locations.	Method to identify walk trips based on vehicular trips and land use patterns. It measures different Pedestrian Trips; including, Car-walk linked person-trips, Walk-only and bike-only person-trips, Transit-walk linked person-trips.	This tool integrates pedestrian travel into routine trip estimating by applying standard traffic data to quantify pedestrian trips.
Florida pedestrian Level of Service	Landis, 2001, Florida Department Of Transportation, USA	It measures factors that correlate with pedestrians' perceptions of safety and comfort for street segments.	The method measures variables include width of sidewalk, vehicle traffic of volume, vehicle speed, presence of on-street parking, etc. Regression analysis was used to weight the variables.	The method uses field survey method of data collection.
PEDSAFE	Harkey and Zeegeer, 2004, University of North Carolina Highway Safety Research Center, USA	The PEDSAFE provides information on the countermeasures available to prevent pedestrian crashes and/or improve motorist and pedestrian behavior, highlights the purpose, considerations and cost estimates associated with each countermeasure.	The main categories of improvements include; Pedestrian Facility Design, Roadway Design, Intersection Design, Traffic, Calming, Traffic Management, Signals and Signs.	It has the on-line based checklist for data collection, and data analysis.

1.3 The Problems with Walkability Assessment Tools

Although empirical evidences investigated in background of study makes a theoretical framework of positive association between walkability and walking behavior, it could not find any 'global' solution for this problem. The result of investigation on previous researches in different disciplines (including, urban planning, transportation planning, urban design, and urban management) shows inconsistencies in built environment 'perceptual qualities' and 'qualitative variables measurements'. Indeed, the studies on perceptual qualities and qualitative variables of built environment highlight that interpretation of these variables into quantifiable variables was a very difficult work. Undoubtedly, the previous research constructed a firm foundation in emerging to this research on understanding precisely association between local neighborhood design and its residents' perceptions in route-choice making to walk.

Most of the reviewed statically-driven studied have not interpreted the built environment qualities into measurable variables. The research conducted by Ewing et al. (2006) and Sealans et al. (2003) improved the previous research by indicating a critical relationship between 'perceptual qualities' and 'personal reactions' in walking behavior within a local neighborhood. It is while, path design in the scale of local neighborhood has been rarely considered from the perspective of 'urban design'. To date, only Ewing et al. (2007) 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 related disciplines are following general and same series of guidelines, codes, and standards in sustainable neighborhood development. In fact, the decision made by this group of professionals is being similarly applied in different neighborhoods with different environmental, economic, demographic, and cultural characteristics. However, each neighborhood has its own characteristics, and thus, it needs its adapted development plan. In that manner, urban designers and urban planners can act more effectively in neighborhood development plans. According to Park (2008), Coa et al., (2006), and Boarnet et al, (2005) changing urban form cannot change people behavior, but

changing urban areas based on people attitudes, perception, and self-selection would ameliorate their behavior in both travel and walking behavior, which is the duty of urban designers and urban planners.

Moreover, Badland and Schofield (2005) state that researchers need more detailed knowledge and information regarding global perspective in leading the current trends in built environment and walking behavior research. Referring to Badland and Schofield (2005), the majority of walking behavior studies is based on country-specific and self-report cross-sectional designs, which need intensively to inherent current certain and faults through consisting between studies, and making inter-study comparison. Badland and Schofield (2005) claim that there is a crucial need to enhance systematically existing assessment tools regarding the inclusive-user approach.

To date, forty five (45) walkability assessment tools have been developed all around the world. These assessment tools used different methods and techniques in data collection and analysis; including, Geographic Information System (GIS), self-report, field survey, recall report, sensor, and questionnaire to measure walking activity. Amongst them, twenty four (24) assessment tools were developed as 'audit tools' (i.e. questionnaire-based tool) which sounds as a highly selected method. The audit tools able to measure subjectively association between built environmental variables and individuals' walking activity (Pikora et al., 2003; Clifton et al., 2007; Reid, 2008; Millington et al., 2009, Forsyth et al., 2009; Forsyth et al., 2010; Cerin et al., 2011).

The multi-criteria decision making (MCDM) approach has been applied in many diverse built environment disciplines. The literature study shows that the walkability assessment tools have used MCDM approach as well; albeit, the numbers of assessment tools are very few. The literature study highlights only three (3) assessment tools have been developed till now which integrate MCDM methods in the development and implementation process. These assessment tools are; 1) Pedestrian Infrastructure Prioritization (PIP) Decision System (Moudon et al, 2006) by University of Washington, USA; 2) PEDSAFE (Harkey and Zegeer, 2004) by University of North Carolina, USA; and 3) Pedestrian Performance Measure System

(Dixon et al, 2007) by University of Delaware, USA. These three assessment tools have been developed in transportation planning and urban planning area of study. However, there is no assessment tool within urban design perspective which has being developed based on MCDM methods. Specifically, there is a big gap in urban design studies in capturing individual's decision making patterns during their walking trips.

Theory of decision making on human travel behavior covers two descriptive focuses; including, how people actually make decisions, and how a normative vision should be made based on their decision (Svenson, 1998). Sequential decision-making is commonly associated in structural models (Svenson, 1998), which links residential location and auto ownership to short-term travel decisions made in active 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 (Shay, 2007). Indeed, the sequential decision-making approach has been generated in 'travel behavior' which has a potential to be applied in 'walking behavior', and also, in walkability assessment tool development.

To sum up, pedestrian behavior is a complex and controversial issue in walkability and walking behavior studies. Capturing and forecasting pedestrian's sequential decision making during walking activity needs advanced modeling and assessment tools. There is an absence of 'walkability assessment tool' as the 'decision support tool' which will be able to evaluate neighborhood's physical and environmental qualities influencing residents' walking behavior warranting their sequential decision making. In this regards, the current research proposes a 'Path Walkability Assessment Tool. This tool integrates multi-criteria decision making (MCDM) methods with built environment walkability assessment. Also, this tool, as a 'decision support tool', aids urban designers for future neighborhood development and redevelopment. Juxtaposing the outputs of this tool helps urban designers to make future decisions on path development through implying much more adaptability between local neighborhood environment characteristics and its residents' needs, preferences, and perceptions. Besides, techniques and models to

incorporate resident's decision making behavior on route choice making still need to be enhanced more which is in line with the aim of this research.

1.4 Importance of Urban Walkability Practices in Malaysia

Malaysian cities generally are car-oriented with low to moderated densities. Confronted with increasing air pollution, fuel and energy sources consumption, traffic congestion, and specially increasing obesity and respiratory problems, urban planners and transportation planners are searching to find solutions to reduce these problems; and in turn, enhance more urban environments for people walking (Deakin, 1989). In fact, it is not easy to persuade government and local government to invest more on pedestrian facilities, partly because walking travel mode is not chosen usually as the main mode of travel to meet daily needs. This may make it tough to convince spending public money in upgrading urban public environments such as sidewalks and open spaces for people walking. In this regard, this research planned to overcome this conflict by focusing on the priority areas where investment in walking facilities will result the best and somewhat maximum benefit. According to World Bank Report (World Bank, 2008), percentage of urban development in Malaysia, in comparison with world and South Central Asia countries, was the considerably highest in the years 2000, 2005, and 2010 (Figure1.2).

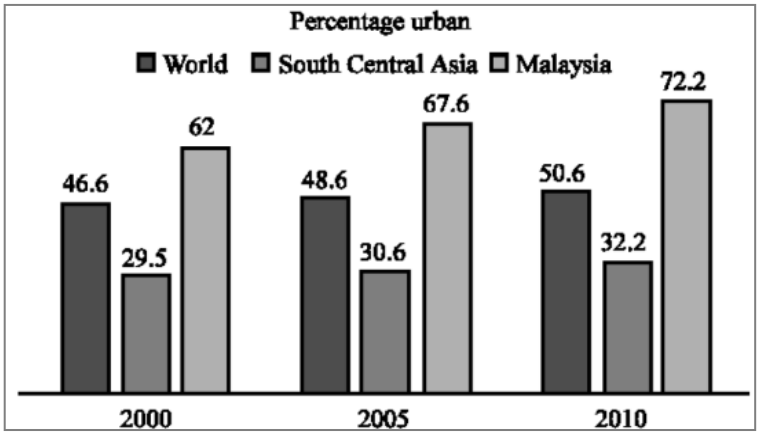

Figure1.2: Urban development Percentage in Malaysia (Adopted from World Bank Report, 2008)

The most important feature about the urban development in Malaysia is the urban population. There was an increase of 50.7% in proportion of urban population in Malaysia from 1991-2000 (Ho, 2008). It is anticipated that 71% urban population in 2010 will increase to 80% in 2020 (Ho, 2008) (Figure 1.3and Figure 1.4). According to United Nations reports, population of Malaysia is comprised of 72% (expected growth rate by 2015; +2.4%) urban and 28% rural (expected growth rate by 2015; -1.2%). To balance the expected growth by 2020, it is necessary to improve sustainable development practices.

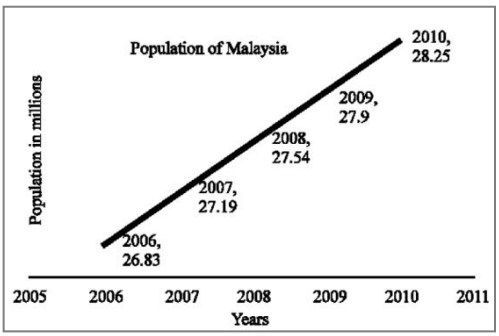

Figure 1.3: Population of Malaysia between 2000 and 2010 (Department of Statistics, 2010)

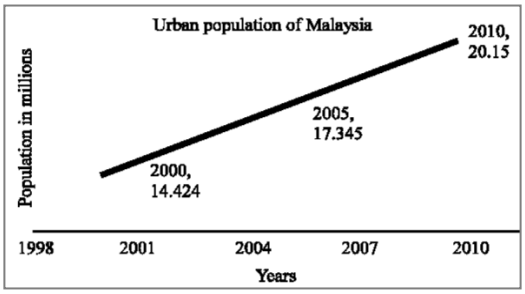

Figure 1.4: Urban Population of Malaysia between 2000 and 2010 (Adopted from World Bank, 2008)

On the other hand, overweight and obesity was found to be a major problem among people, and particularly for the older age groups in Malaysia. In this regards, the focus on overweight as a national public health problem has come about in parallel with the emergence of heart disease as the primary cause of mortality since the 1970s (Chee, 1990; Chee et al., 2004). In the 1990s, this focus was incorporated into the national health agenda with the healthy lifestyle campaigns, which kicked off in 1991, and continued till present. The Malaysian non-communicable disease surveillance of 2005/2006 reported that 16.3% of Malaysian adults aged 25-64 years were obese (MOH, 2006), representing a four-fold increase in the prevalence of obesity in 10 years (4.4% in 1996, Malaysia Ministry of Health [MOH]), and an approximate two-fold increase in overweight (from 16.6% to 30% in 1996 and 2006, respectively). A national survey on the prevalence of obesity among Malaysian adults recorded that there had been a 280% increase in obesity since the last survey

in 1996 (Lekhraj et al. 2007). As recently as 2010, the Ministry of Health, Malaysia presented further statistics that showed that60% of Malaysians were overweight. In Malaysia, overweight is an increasing problem in both urban and rural areas (Ismail et al., 1995; Khor et al., 1999). Ng et al. (2005) found that 23.5% of male and 46.0% of female adults had an overweight problem and exemplify that the mild to moderate forms of obesity have reached alarming proportions in rural adult populations. Regarding Chang et al. (2009) trend of overweight and obesity in Malaysia is of concern, due to the influence of substantial weight gain on chronic diseases, such as diabetes, heart disease, arthritis and stroke.

According to Mohd Din et al. (2001) walking accessibility has been recognized as one of the important factors affects people's willingness to travel. Urban and transportation planners evaluate pedestrian travel systems in Kuala Lumpur particularly in the aspect of walking accessibility to different destinations, such as transit terminals (Mohd Din et al., 2001). However, the lack of proper provisions for pedestrians to cross roads or to walk along roads safely is a major contributing factor to the high number of pedestrian casualties in Malaysia Jabatan Kerja Raya (1995).

According to Zaly Shah (2010), it is very important to encourage planners and engineers to design complete streets, or streets that consider the needs of all urban residents, specially, pedestrian travelers. Zaly Shah, states that "access to good pedestrian infrastructure is a social right of every individual similar…" (Zaly Shah , 2010). Also, he claims that " the problem with pedestrian planning, however, is not due to lack of policies or standards, but it's more due to the lack of political will which is indirectly related to the absence of an objective method of assessing the provision of pedestrian walkways". Zaly Shah (2010) expresses without any objective tools, assessments are done subjectively and, thus, are opened to query and criticism."

Figure 1.5 illustrates some existing sidewalk and paved verge physical and environmental deficiencies in Malaysia.

Figure 1.5: Some existing sidewalk and paved verge physical and environmental deficiencies

Regarding the aforementioned 'gap in research' and 'need in practice', this study planned to answer the following 'Research Question',

"*How can urban professionals (especially, urban designers and transportation planners) improve the walkability of the neighborhoods based on its residents' decision-tree making patterns in fulfilling their walking needs, preferences, and perceptions*?"

According to this research question, the study structured the aim and objectives as explained in the next section.

1.5 Aim and Objectives of Study

According to evidence study presented in previous section, this research aimed to develop the Path Walkability Assessment Framework based on Decision Tree Analysis of pedestrians in their retail walking trips applicable for urban designers. This research planned to develop the path walkability assessment framework which is able to be used as a 'design decision support tool' for urban designers to evaluate the walkability performances of each path within a neighborhood. To address this aim, six (6) objectives were outlined as the following;

Objective 1: To investigate walkability issues and causes in sustainable urban and neighborhood development.

Objective 2: To identify path walkability assessment principles compatible with pedestrian retail travelers in the urban context.

Objective 3: To indicate path walkability assessment variables compatible with pedestrian retail travelers in the urban context.

Objective 4: To determine a decision making method and a system development process model compatible with capturing pedestrian retail travelers' perception and sequential route choice patterns.

Objective 5: To develop the path walkability assessment framework based on pedestrian retail travelers' decision tree analysis patterns.

Objective 6: To validate the path walkability assessment framework in a pilot study.

To justify the objectives setting, this research used the established procedures in its 'sustainable assessment development'. According to Lorenz and Lützkendorf (2008), the ISO (International Standardization Organization) assessment development process commonly involves, first: to translate principles of sustainability, second: to investigate variables of sustainability, and finally: to develop harmonized basis to measure the sustainability of the research object (i.e. walkability in this study). The current research also followed this approach in the path walkability assessment framework development.

1.6 Scope of Study

To develop the path walkability assessment framework, the research indicated the following scopes of study; Scope on Retail (Shopping) Walking, Scope on System Development Process Models, Scope on End-users of the Framework.

1.6.1 Scope on Retail (Shopping) Walking

According to reviewed literature on taxonomy of living activity in built environment studies, there are two main categories; walking activity and cycling activity. As mentioned in problem statement, the current research focuses on walking activity with travel purpose which is the critical issue in many countries as well as Malaysia. Thus, this research does not focus on walking with recreation purpose.

According to literature review, 'travel walking activity' constitutes various typologies based on various destinations in walking trips. The travel walking typologies include, Walking for Shopping (i.e. Retail Walking), Walking to School, Walking to Work, and Walking to Religious Place (such as, mosque, church, and temple). Notably, the research considered the Walking to Metro/Bus/Taxi station under typology of Walking to Work.

The typologies involved in 'travel walking' have different characteristics. The first typology, called 'Walking for Shopping', is considered as a 'Non-Scheduled action'; whereas, the other typologies are considered as a 'Scheduled action'. For researchers in urban design and planning, it is not easy to deal with scheduled travel walking activity, due to have regular and structured plan to do them. Meaning, the schedule of going to school or work was determined by the related organizations, and individuals just follow it. While, the non-Scheduled travel walking is a kind of 'Open Scheduled' activity that individuals modify and adapt it based on their desire, needs, and attitude. This typology would be much more applicable for urban designers and planners to infer with it. In fact, focus on 'travel walking' may come up with more fruitful results which affect positively on sustainable urban development. Moreover,

focus on ‘travel walking’ will simultaneously increase the average of public health and decreases auto-dependency in urban areas.

In this regard, Cervero (1996) states shopping services within neighborhoods may motivate residents to choose walking rather than other motorized mode of travel. Shopping centers located within 300 feet buffer zone able to encourage residents to the non-auto traveling; while shopping services located between 300 feet and 1 mile associated with more auto traveling and more different mode choices Cervero (2002). Crane and Boarnet (2001a) state that alternatives to conventional low density, single-use development offer potential benefits in reduced auto-dependency; however, this matter within open-fine grid, short block, mixed used, and higher density neighborhoods is an empirical question. Figure 1.6 illustrates the summary of scope on ‘retail walking’ for shopping.

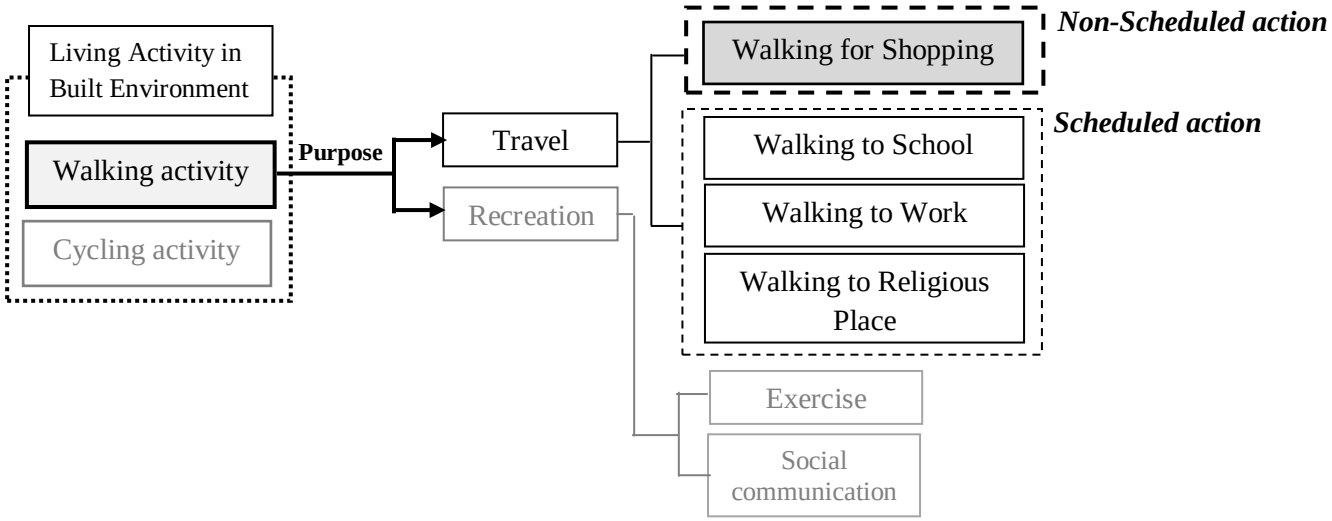

Figure 1.6: Taxonomy of living activity in built environment study, different purpose of walking activity, and various typologies of travel walking

1.6.2 Scope on System Development Process Models

According to reviewed literature on ‘system development process models’, there are numbers of process models used to analysis, design, development, and maintenance of information systems. The most famous process models are, Waterfall, Iterative, Prototyping, Exploratory, Spiral, and Reuse process model. These models have similar goals and common tasks; however, each would be adapted to the specific purpose of a research. The ‘Path Walkability Assessment Framework’ as a ‘decision support tool’ needs to follow one of the most appropriate system development process models. Regarding the aim and objectives of the research, the most appropriate process model is ‘Prototyping Process Model’. Dennis et al., (2005) states that the ‘Prototyping Process Model’ in comparison with other existing process models has ‘Excellent’ ability to develop a system with ‘Unclear User Requirements’ and ‘Unfamiliar Technology’. In addition, Dennis et al., (2005) claims that prototyping process model has ‘Excellent’ ability with the system that are ‘Complex’ and ‘Reliable’, and also, has ‘Good’ capabilities in ‘Short Time Schedule’ and ‘Schedule Visibility’. Based on aim and objectives of this research, two steps out of six steps of prototype development have been accomplished. The two steps are; Prototyping Requirements Study, and Prototyping Design. Indeed, the rest of steps are not in the scope the current research, and can be conducted in further studies. Figure 1.7 illustrates the scope of current research in system development, and prototyping system design.

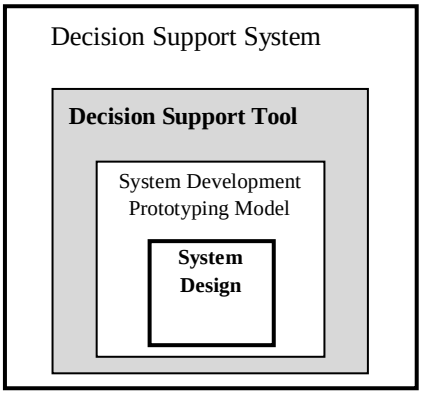

Figure 1.7: Scope of research on System Development Process Models and its extent on prototype development

1.6.3 Scope on End-users of the Framework

According to Haapio and Viitaniemi (2008), there are different possible end-users for the assessment models/frameworks; including, urban design and planning professionals, transportation planning professionals, contractors, consultants, facility managers, researchers, authorities, and practitioners. This research, determined urban design and planning professionals and transportation planning professionals, and local authorities as the main end-users based on application of the final framework. They may use this framework in the pre-design and design phases of project life cycle. Local authorities may use the final framework in the operation phase, and as a performance benchmarking tool.

1.7 Research Methodology

This section presents the research design and the methods used in this study. Detailed explanation of the research methodology will be discussed in Chapter 3. The research methodology engaged to achieve the aim and objectives of this research was designed into five (5) phases, including fourteen (14) research steps. Basically, 'Phase I' is a preliminary study of the research. 'Phase I' is to investigate the 'issues and causes' of 'walkability' in compliance with New Urbanism, Smart Growth, Quality of Life, and Sustainable Urban Development. In forward, 'Phase II' is structured as the phase of literature review; accordingly, 'Phase III' is the phase of experts inputs on what reviewed in literature study. The 'Phase IV' is the phase of framework development. Finally, the 'Phase V' is pilot study to validate and minimize the unforeseen biases of 'Phase V'. The following present each phase of research and involved steps in detail. The research methodology flow is illustrated in Figure 1.8.

Phase I: Preliminary Study (to fulfill requirement of first objective)

- **Step 1: Evidence Study:** This step conducted a Systematic Review on issues and causes affect in development of a walkability assessment framework; Codes: walkability assessment, path design assessment, public health, climate changing, environment pollution, national and international thinking.

- **Step 2: Expert Input (Data Collection and Data Analysis):** This step conducted academic expert validation on the findings of the evidence study (i.e. step 1). It includes field expert Delphi structured close group discussion. It includes four (4) sessions of close group discussion within which totally eight (8) experts have been participated. The participating experts were selected who had experience in urban assessment model development and implementation. Data analysis was conducted using Grounded Group Decision Making (GGDM) method (Lamit et al., 2012).

Phase II: Literature Study

- **Step 3: Literature Study (to fulfill requirement of second objective):** This step conducted the Systematic Review Analysis on path walkability assessment principles compatible with pedestrian retail travelers' decision making analysis in urban context (Codes: walkability principles, mobility principles, path/sidewalk design, retail walking behavior, pedestrian decision making).

- **Step 4: Literature Study (to fulfill requirement of third objective):** This step conducted a Systematic Review Analysis on path walkability assessment variables compatible with pedestrian retail travelers' decision making analysis urban context (Codes: walkability variables, street design variables, path/sidewalk design variables, path/sidewalk design standards and guidelines, retail walking behavior, pedestrian decision making, and etc.)

- **Step 5: Literature Study (to fulfill requirement of fourth objective):** This step conducted a Systematic Review Analysis on decision making methods compatible with capturing pedestrian retail travelers' perception and sequential route choice patterns (Codes: decision making theory, decision making methods, decision tree analysis, sequential decision making, pattern recognition, decision support systems, and etc.)

Phase III: Expert Input Collection and Analysis

- **Step 6: Expert Input's Data Collection (to fulfill requirement of second objective):** This step conducted to validate the literature review findings on path walkability assessment principles compatible with pedestrian retail travelers' decision making analysis in urban context. The data collected using field-expert Delphi structured close group discussion, including four (4) sessions of close group discussion. Eight (8) experts have been involved. The participating experts were selected who had experience in urban assessment model development and implementation..

- **Step 7: Expert Input's Data Collection (to fulfill requirement of third objective):** This step conducted to validate literature review findings on path walkability assessment variables compatible with pedestrian retail travelers' decision making analysis in urban context. The data collected using field expert Delphi structured close group discussion, including, two (2) sessions of close group discussions, one (1) round of brainstorming and one round of validation. Totally eight (8) experts were invited who had experience in urban assessment model development and implementation across different disciplines (including, urban design, urban planning, transportation planning, architecture, landscape architecture, and public health).

- **Step 8: Expert Input's Data Collection (to fulfill requirement of fourth objective):** This step conducted the academic expert validation to literature review findings on decision making methods compatible with capturing pedestrian retail travelers' perception and sequential route choice patterns. The data collected using field expert Delphi structured close group discussion, including two (2) sessions of close group discussion. Eight (8) experts have been engaged with who had a rich knowledge in decision making methods and decision support tools.

  Step 9: Data Analysis of Expert Inputs: This step conducted to analyze the experts' validations to literature review findings accomplished in step 6, step 7, and step 8. The research used Grounded Group Decision Making

(GGDM) method and Weighted Sum Method (WSM) to analyze the expert inputs. Since GGDM is a relatively new method of data analysis, this study applied WSM as control data analysis method.

Phase IV: Framework Development

- **Step 10: Framework Development:** This step developed the 'path walkability assessment framework' based on pedestrian retail travelers' decision tree analysis'. It includes Synectics Session with five (5) professionals who had experience in assessment framework development.

- **Step 11: User Validation (Data Collection and Data Analysis):** This step conducted to validate the developed framework. The preliminary validation was done by expected users of the framework. It includes a Delphi structured close-group discussion with five (5) urban designers, urban planners, and transportation planners who had knowledge in using and implementing urban/neighborhood frameworks and models. The research used Weighted Sum Method (WSM) to analyze the users' inputs.

Phase V: Framework Validation

- **Step 12: Case Study Site Selection:** This step selected the appropriate neighborhood sites to conduct the case study. It includes a brainstorming discussion with five (5) urban designers, urban planners, and transportation planners who are practicing urban/neighborhood design and development.
- **Step 13: Pilot Study**: This step conducted the pilot study and established the 'Path Walkability Assessment Framework'. This step was to address unforeseen biases of the developed framework resulted from step 12.

- **Step 14: User Validation (Data Collection and Data Analysis):** This step conducted the validation of findings of pilot study. The validation was conducted by expected framework-users. It includes a Delphi structured close-group discussion with five (5) urban designers, urban planners, and transportation planners who are practicing urban/neighborhood design and development. The research used Weighted Sum Method (WSM) to analyze the expert inputs.

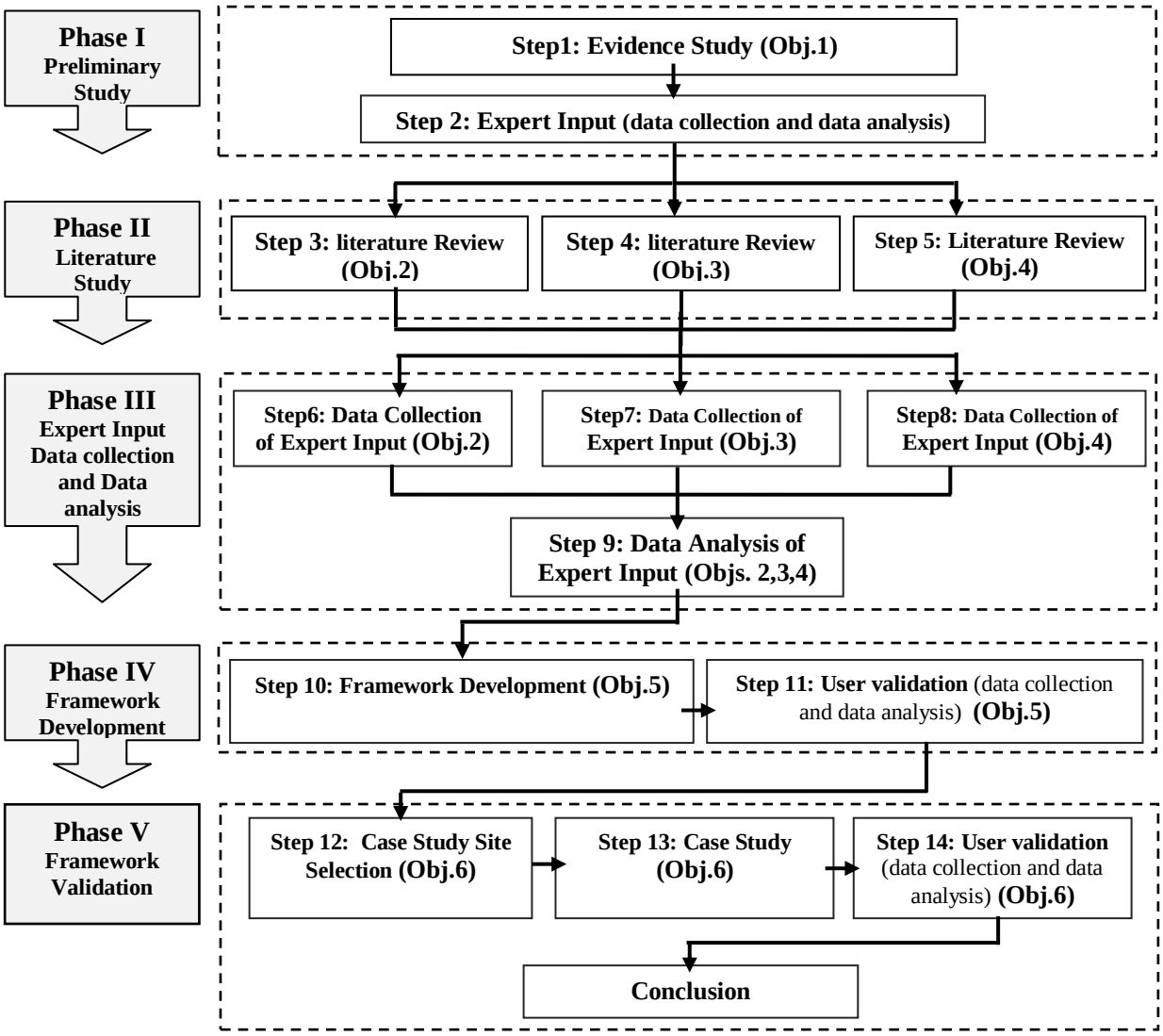

Figure 1.8: Research Methodology Flow Diagram

1.8 Significant of Study

This section explains the significance of the current research. Indeed, this issue is grounded in gap in research and need in practice sections. The research addresses the following significance of studies, first, 'Pedestrian Decision-Tree Patterns in a Micro-Scale Urban Area', secondly, 'Urban Design Quality and Individual Reaction', and finally, 'Urban Development Life Cycle'.

1.8.1 Significance of Study on Pedestrian Decision-Tree Patterns in a Micro-Scale Urban Area

Researchers have mostly considered pedestrian behavior in macro-scale urban planning and transportation planning. They evaluated walkability of urban areas quantitatively and physically. However, pedestrian behavior has been not sufficiently considered in micro-scale urban design and qualitatively. Previous studies have evaluated pedestrian walking behavior towards critical destinations within the urban area, such as, transit station, school, shopping center, and park (For example, Frank and Pivo (1994), Cervero (1996), Boarnet and Crane (2001). As justified earlier in the scope of study, the current research focuses on 'retail walking', hence, the shopping centers are indicated as the targeted destinations in walkability assessment.

Since there is no scientific yet developing a walkability assessment framework based on pedestrian decision tree patterns within the micro-scale urban area, this research planned to conduct it. To capture much more accurately the pedestrian's decision tree patterns, this research planned to indicate more than one (1) shopping center as the targeted destination. Base on urban development polices, the maximum number of mega-scale shopping center located in a neighborhood is three; thus, the research determined three (3) 'uni-functional' shopping centers as the targeted destinations for pedestrian decision tree patterns analysis (Figure 1.9). As presented in Chapter 6, the research explored pedestrian's decision tree patterns towards three (3) 'uni-functional' shopping centers as three (3) case study areas within a selected neighborhood. The research claims that conducting pilot study in (3) case study areas contribute to generalizability of the issue.

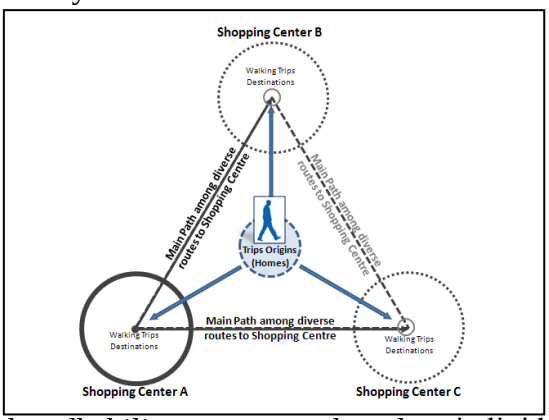

Figure 1.9: Path walkability assessment based on individuals' decision-tree patterns within three alternatives of shopping centers

Moreover, the research highlights that capturing pedestrian's decision tree patterns towards triple shopping centers of a neighborhood provides the following advantages;

- First, the final path walkability decision tree pattern of the surveyed neighborhood completely matches with the overall lifestyle, preferences, and attitudes of the residents. The final pattern essentially guides urban designers and urban planners for their future corrective actions on enhancing walkability and also upgrading walkability facilities within that surveyed neighborhood. Greatly, this advantage aids urban designers and urban planners to provide a unique pedestrian-context-oriented-design for that neighborhood. This advantage aids them to rectify the problems with just implementing the 'general' pedestrian-oriented design guidelines and standards which does not adequately consider end-users and their attitudes and perceptions.

- Second, the research specifically rectifies the problems with individuals' self-selection behavior. The research extracted the strengths and weaknesses of each three shopping centers in terms of quality of service to customers. It aids to balance strengths and weaknesses of the shopping centers, and then, helps to make a dipolar shopping land use within the neighborhood. Thus, the final result of the research provides a balanced and equal chance for each shopping center to be selected as walking destination. In a micro-scale, it can considerably solve the self-selection problem of the neighborhood. Moreover, this phenomenon helps residents to decide easier on their residential location based on shopping center that is one of the most effective factors in residents' self-selection (Handy et al, 2002).

- Third, the research contributes urban designers and planners in managing more wisely their sources and budget. According to Boarnet (2005), upgrading and enhancing urban forms is costly, while improving the urban infrastructure is considerably less costly. In this regard, this research provides a very trustable guide for urban designers and planners regarding accurate investment on redevelopment, reshaping, or corrective actions with the surveyed neighborhood. Urban developers can follow the final output of this walkability framework to

achieve higher performance in enhancing walkability and walking facilities within the targeted neighborhood, and also, to manage better their sources and budget.

- Fourth, the research claims that focusing on psychological and sociological factors of residents' attitude and perception will lead to huge benefits in improving quality of life, well-being, and health as the most important factors (United Nations Development Programme, 2012).

- Fifth, the final output of this walkability framework aids urban professionals as a 'Decision Support Tool'. Using this tool helps them to make more precisely decisions about enhance walkability within the targeted neighborhood.

1.8.2 Significance of Study on Urban Design Quality and Individual Reactions

Walking behavior quality measurement was published by Ewing et al., (2006). The research yielded qualitative urban design concepts to measure its related attributes. Regarding the results of this model, Ewing et al. (2006) developed urban design attributes determining walkability through an 'operational definition' and 'measurement protocols'. In fact, their study is the only existing study which proposed measurement protocols for such perceptual qualities and personal reactions as urban design attributes. This conceptual framework yet was not practically used in most of empirical studies, specifically, in walkability assessment tool development integrating with multi criteria decision making (MCDM) methods.

The current research improved the conceptual framework developed by Ewing et al., (2006). Figure1.10. illustrates the conceptual framework of the current research which includes two main sections:

The up-side section refers to previous practice conducted by Ewing et al., (2006). Bottom-side section proposes the development of a new 'Walkability Assessment Framework' which can be used a 'decision support tool'. This decision support tool helps urban designers and planners to measure more accurately the

association between local neighborhood walkability and its residents' walking behavior. In fact, the results of this tool would be very useful for both professionals and practitioners to make decisions on future path development and corrective actions.

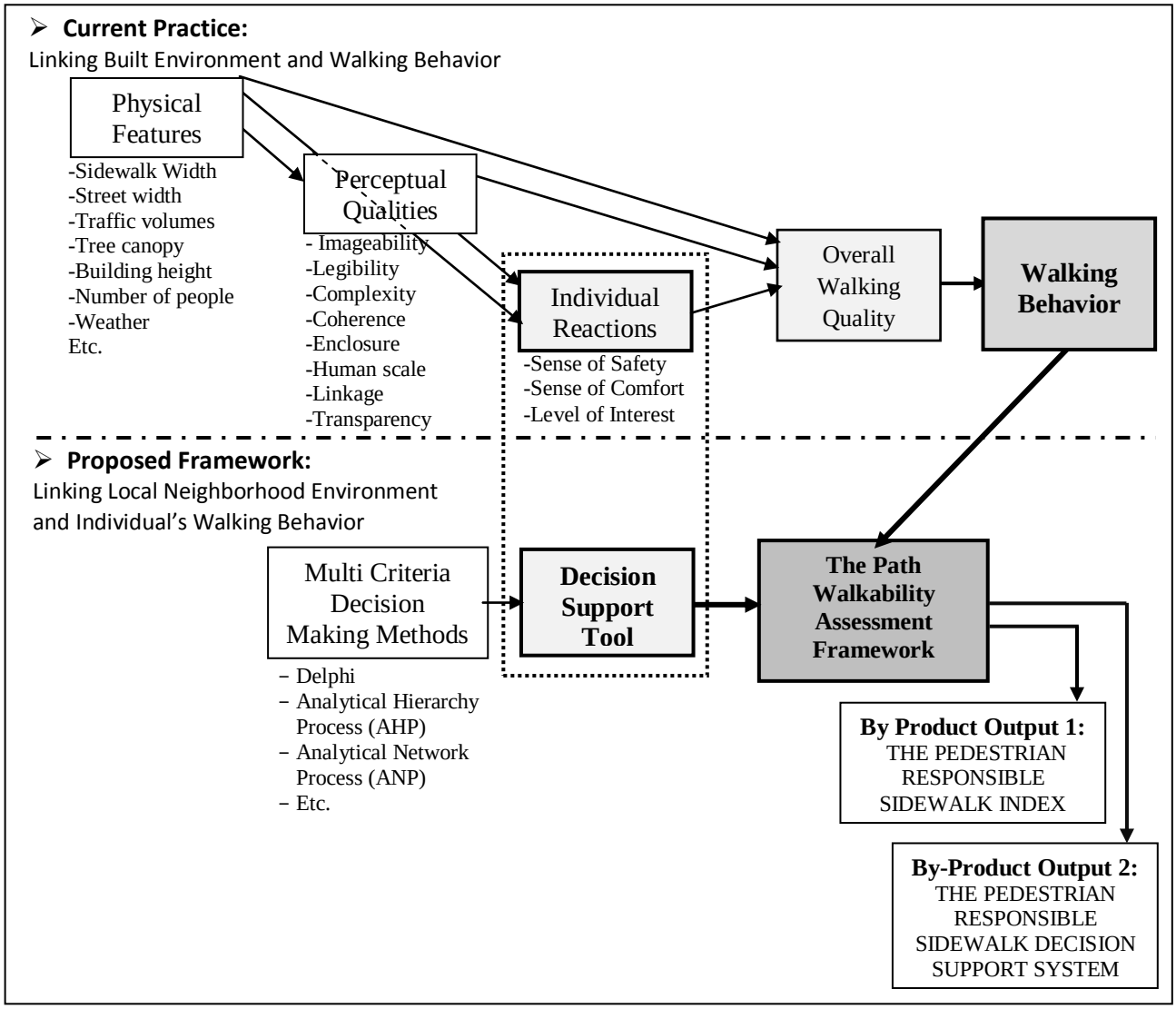

Figure 1.10: Proposed Framework on the Path Walkability Assessment Framework, the Current Practice adopted from Ewing et al., 2006

1.8.3 Significance of Study on Urban Development Life Cycle

Stages of project life cycle are, respectively; feasibility study, design, construction, operation and maintenance, and demolish. Indeed, the mentioned stages that have been interpreted in urban development life cycle have been indicated into three phases; including, 'Pre-Design', 'Design', and 'Post-Design'. These phases

cover a range of plans and actions towards supporting walking and walkability in neighborhoods. Local governments as the head of development/redevelopment plans to improve active living (i.e. walking) of residents within a neighborhood, follow these phases and detailed components. Local governments consider effectively and objectively the issues in measuring and implementing walking and its related problems. The following describes these phases and involved components (Figure 1.11);

- **Pre-Design Phase:** the investigation and analysis scheme comprises the assessment of existing situation of sidewalk environment, and then, determines a few options to enhance where the inclusive-design would benefit all end-users.
- **Design Phase:** the choosing scheme involves selecting across prioritized initiatives one option as the most appropriate and beneficial to improve the existing path/sidewalk situation, and then implements the option practically.
- **Post-Design Phase:** economical repair, reinforce, and maintenance for any damaged or deficiencies, or defective conditions.

The current research planed to develop an assessment framework which contributes urban designers, urban planners, and transportation planners in their decision makings on corrective actions and development within the targeted neighborhood in present and future. Thus, this assessment framework covers both 'Design' and 'Post-design' phases.

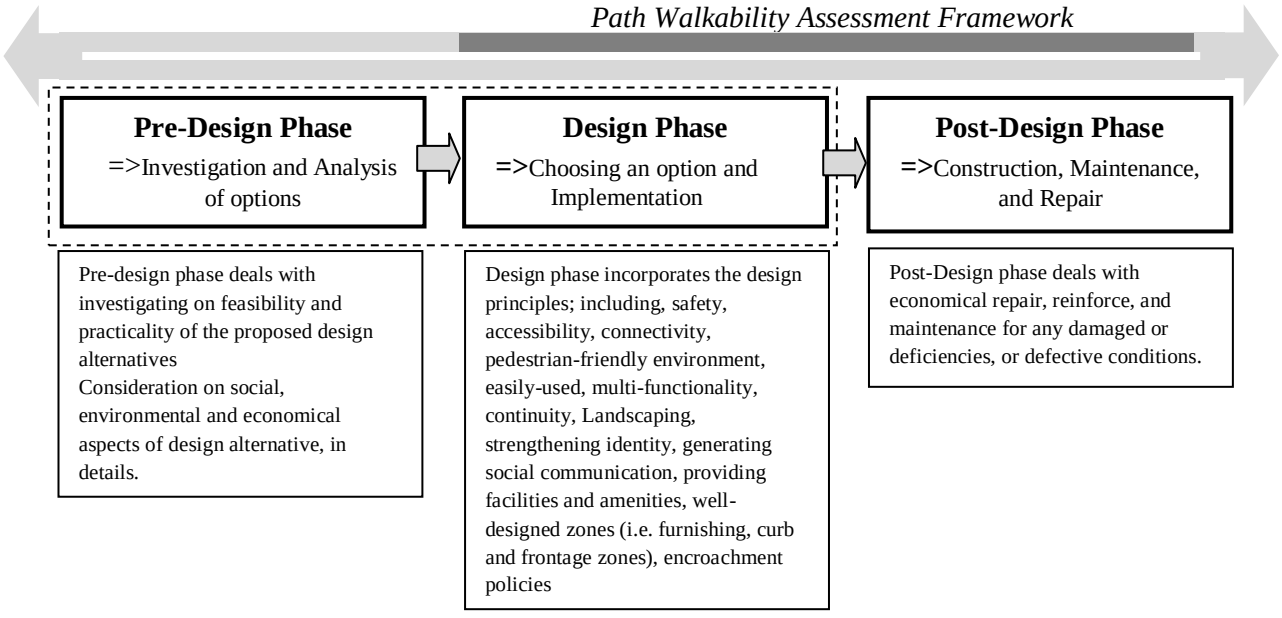

Figure 1.11: Phases in Urban Development Life Cycle

To sum up, the current research across different stages of project life cycle focused on the design stage and operation and maintenance stage based on possible application of the final tool (will be explained in Chapter 5-Discussion). Indeed, this is match with either expected end-users of the model and the mentioned class of the model.

1.9 Thesis Outlines

The thesis outline includes the detail actions undertaken in the process of this research. The following explains the action plans of each chapter, respectively.

- Chapter one (1): Introduction,
  This chapter presents introduction to the research. This chapter includes the first phase of research methodology flow within which aim and objectives , scopes, brief research methodology, and significance of study are presented.

- Chapter two (2): Literature Review,
  This chapter presents critical reviews on the related literatures to each objective. Validated finding of literature review is implemented in the final model.

- Chapter three (3): Research Methodology,
  This chapter addresses the grounded research methodology of the study in details. In this chapter methods and techniques undertaken to conduct the research were explained. Mainly this chapter is presenting rational of research methodology flow engaged in this study.

- Chapter four (4): Data Collection and Analysis of Phase I and III of Research Methodology Flow,
  This chapter presents data collection and analysis on literature study and then proceeds to develop the framework.

- Chapter five (5): Path Walkability Assessment Framework Development,
  This chapter presents validation done from literature finding and the development of the framework.

- Chapter six (6): Pilot Study to Test Path Walkability Assessment Framework,
  This chapter addresses the pilot study to validate the developed framework, and then, evaluates and analyzes the collected data from pilot study survey.

- Chapter seven (7): Discussions on Developing the Path Walkability Assessment Framework
  This chapter discusses on strength and weakness of the final outputed framework, and also, highlights its limitation faced in this research.

- Chapter eight (8): Conclusion and Recommendations,
  This chapter, as the final chapter, reviews objective findings of the researcn. Furthermore, this chapter presents possibilities and potentials for further research on this issue.

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