Jurnal Teknologi

Full paper

Conceptualising the Indicators of Walkability for Sustainable Transportation

Farzaneh Moayedi[b], Rozana Zakaria[a*], Yeoh Bigah[b], Mushairry Mustafar[a], Othman Che Puan[c], Irina Safitri Zin[d], Mustafa M. A. Klufallah[e]

[a]*Construction Research Alliance (CRA), Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*
[b]*Master Students in Construction Management, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*
[c]*Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*
[d]*Sustainability Research Alliance (SUTRA), Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*
[e]*Department of Civil Engineering, Universiti Teknologi PETRONAS, 31750 Tronoh, Perak, Malaysia*

*Corresponding author: rozana@utm.my

Article history

Received :10 May 2013
Received in revised form :
25 September 2013
Accepted :15 October 2013

Graphical abstract

Abstract

Walkability is becoming a popular buzzword in planning cities that suffers high level of pollution due to, amongst others, emission from automobiles are embracing walkability in order to reap its benefits. In addition to that, walkability is the measure of how satisfactorily the transportation system meets the need of walking of the community. Several studies around the world have put great efforts to highlight the importance of walkability in urban as it is an important measure in determining a better environment. There is a strong relationship between walkability, sustainable transportation and the environment. In addition to that, walkability is a concept that is consistent with sustainable development and transportation system due to its economic, social and environmental benefits. Walkability satisfaction rating within a localized neighborhood can be measured at the macro level with the aid of GIS at the initial development stages. The methods and techniques used are varying and no single walkability assessment tool can be designed to suit different environmental conditions. Different groups of societies for whom the theoretical and practical perception of cities development vary, or different types of neighborhoods with different needs would warrant different approaches. Therefore, this paper examines the methods, techniques and indicators that have been used to measure walkability and highlights the important benefits of improving walkability in the built environment. Moreover it also describes the relationship between walkability, sustainable transportation and environment.

Keywords: Sustainable development; walkability; walkability indicators; walkability measures

1.0 INTRODUCTION

In the past, most of the people around the world used to walk for their daily life activities and it was the only way that has been used to do their activities. Nowadays, the demand for automobile is growing as vehicles are seen as the main transportation that has been used by people in order to reach their desired destinations. Moreover, in several part of the world there are many who still belief that owning cars will definitively solve mobility problems.

This is somehow related to the actual concept of the transportation system which prioritizes fast means of mobility at the expense sometimes of slow ones. Few years ago, walking has become a central issue in research works especially in the USA due to the benefits that it offers. Methods and techniques to quantify and audit the level of satisfaction that the actual routes system provide to pedestrians were the focus of several research works in order to find ways to improve walking habit of citizens by providing effective pedestrians facilities and favorable environment for the community.

Although there are advantages of developing buildings and maintaining a better living for human by providing a good transportation for travelling, it does make walking more difficult and unfortunately more unpleasant. Other than that there is a close relationship between walking and human being in term of health issues, people who use to walk in a regular basis they have the greatest gain to the health of general population. In another words, encouraging people to walk will create a better health condition and a healthier human being [1]. There are many advantages of walking such as low risk of diabetes, loss weight/weight control, less blood pressure, less risk of cancer etc. For example in Malaysia, citizen of the capital city (Kuala Lumpur) are ranked as the highest in level of obesity among 12 other Asian cities [2].

Recently, a survey revealed that there is a 280 per cent increase in obesity in Malaysian adults as compared to the survey done in 1996 [3]. Moreover, statistics for 2010 show that about 60 per cent of the Malaysian population is overweight. The argument to this statistics shows certain factors that contribute to the low interest of the Malaysian people towards walking activities. One of

the factors is the lack of suitable walking facilities in local neighborhood [4-6].

2.0 A SUSTAINABLE DEVELOPMENT CONCEPT

The most accepted definition of sustainability is the one that was in 1987 by the Organization for Economic Cooperation and Development (OECD) in terms of terms of the development path along which today's generation's well-being are maximized without undermining the future well-being. The sustainability concept is tridimensional: economic, social and Environmental.

Sustainable development is the act of balancing the fulfillment of human needs and results in protection of the environment. These needs can be met not only in the present, but also in the future.

The World Committee on Environment and Development, or more popularly known as the (Brundtland Commission) set up by the United Nations General Assembly and clearly defined the sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs"[7], as shown in (Figure 1).

The construction industry is reflected by the progress of sustainable development fundamentals; which are social, economic and environmental factors. Therefore, it's necessary for developing countries like Malaysia to have the ability in assessing sustainability of their construction projects by using a combination of environmental, social and economic factors[8].

Many projects destroy our natural resources and natural areas by affecting their microclimates. For instant, the ecosystem may be affected by the heat generated from road surfaces and buildings, which are commonly referred to as the heat island effect [9]. A sustainable building also considers how the building will affect the environment through its deconstruction.[14] Furthermore, providing a sustainable building is not only to mitigate all environmental impacts but also to produce buildings that exist harmoniously with their natural surroundings and bring benefits to their occupants.

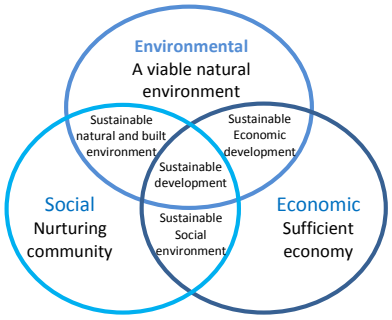

Figure 1 The integration of environmental, social and economical elements of a sustainable development

There are many challenges that may be associated with the building and construction sector. This sector provides sufficient shelter for all citizens and holds great importance to all human activities as well as ecological and environmental aspects. For example, sustainable design considers a building's environmental implications holistically, starting from the planning process to the building's deconstruction at the end of its useful life [10]. Therefore, a proper planning is important during the design phase of construction projects and must consider all of the environmental aspects in order to reduce their related impacts. Several studies also showed that people who lived and worked in buildings that do not provide outdoor views have a higher risk of running into health problem [11].

3.0 THE IDEAL SUSTAINABLE TRANSPORTATION

In general, a sustainable transport implies a proper balance between environmental, economic and social [12-15]. Although various attempts have been made to define sustainable transport indicators a key set of indicators that adequately reflects these qualities have not been identified. Ideally, theory-based conceptions and operationalisations of sustainable transport indicators should be developed. Therefore, by defining a sustainable transport, and then by deriving significant performance indicator to measure sustainable transport. Thus, the transportation system impacts the environmental aspect of the nature as it shapes neighborhood's visage. Sustainable transportation as part of sustainable development is a tridimensional concept: economic, social and environment. The OECD and the Canadian "Center for Sustainable Transport" (CST) define sustainable transport system the one that:

- Responds the wants of accessibility and mobility in individual and society level with esteem on human and environment, aiming to balance the wants of presence and future needs;
- Is sufficient and effective, gives alternative options of modes of transport, underpins a competitive economy and a balanced territorial development;
- Reduces the emissions, uses alternative power resources and minimizes the used space.

4.0 THE CONCEPT OF WALKABILITY

In recent years, the term "walkability" is getting its popularity among professionals in the aspect of built environment and in several research studies, but is there still confusion in its definition [16]. There are some difficulties in defining what walkability is in a concrete way. Many non-design determinants such as land use and housing density have been added and they play an important role than design factors in defining walkability.

Walkability is defined as the measures of how friendly an area is to walking. It differs from walking which is an activity while walkability is a measure [14]. Walkability has several benefits for human ranging from health, environmental and economic and is influenced by the presence or absence and the quality of footpaths, sidewalks and other pedestrian right of ways, traffic and road conditions, land use patterns, building accessibility, and safety, among others.

Many designers and walking advocates think of walkability as the neighborhood with added some design characteristics. This neighborhood "urban form" defined and measured at the neighborhood level and it has some limitation on urban design and practice as shown in (Figure 2).

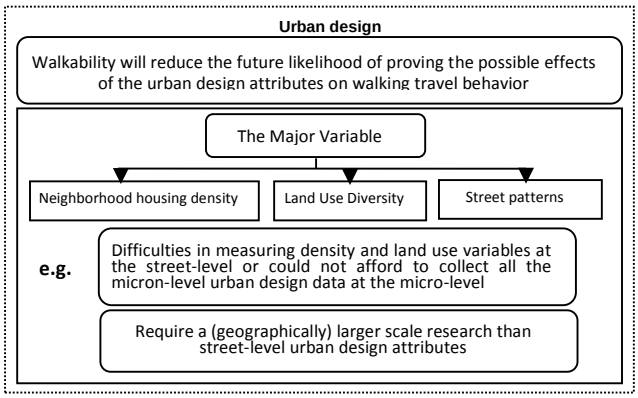

Figure 2 Urban design major walkability variables

In urban design practice, and in many existing urban areas, there is little control over land use, density and street patterns unless there is a design of a new town master plan. Changing of the street patterns/zoning codes in an existing urban setting is difficult and frequently beyond the urban designers' scope [17].

Human beings are pedestrian. Each mode of transportation comports walking segments. Every journey starts with walking and ends up with walking [18]. But walking must not be taken for granted. It needs to be planned by designers and community leaders who develop land areas. Transportation systems control substantially the way people move in the present and determine how they will move in the future [19].

4.1 Pedestrian Friendly Environment

Nowadays, the sake of creating pedestrian friendly environment is one parameter that governs neighborhoods sustainable transportation system. Walking requires beyond just possessing feet and legs; it requires walkable streets, the fundamental building blocks of a sustainable city [20].

Moreover, spatial compactness, efficient access and readability are the three key components that can support a successful pedestrian environment. These components work through land use plans, master plans, transportation plans, zoning ordinances as well as their physical assets. This can be done by encouraging an automobile alternative access with the use of transit systems, and improving parking facilities.

By supporting pedestrian environment, accessibility will play an important role in generating a larger population. In another word if there is no sufficient access provided by the town planners, regardless to their activities and desired destination with the quality environment, the generation of a larger population cannot be generated and results in a reduction of pedestrian environments.

Therefore, the provision of efficient access can be determined as the second key component to support a pedestrian friendly environment. While the first two key components (spatial compactness and readability) aim to maintain a critical mass to generate vitality in their pedestrian environments and provide pedestrians with comfortable and pleasant experiences.

Pedestrian friendly streets must fulfill several conditions [21]. It is suggested that a typical pedestrian friendly street should include the following elements:

- good interconnection of streets with small blocks model
- narrower streets which are less favorable to vehicles speeds
- well designed intersection to provide safe crossing
- traffic calming to slow down vehicle speeds
- wide and continuous sidewalk fully accessible with a proper maintenance
- well-designed and marked crosswalks at intersections and where needed, and at mid-block locations
- appropriate use of signs and signals for both pedestrians and motorists,
- planting buffers with landscaping and street trees that provide shelter and shade without obstructing sight distances,
- street lighting designed to pedestrian scale (e.g., shorter light poles and/or lower light fixtures that are designed to be effective in illuminating the pedestrian travel way)
- Street furnishings and public art intended like benches, trash receptacles, drinking fountains, and newspaper stands, which do not obstruct the pedestrian way.

The Institute for Transportation and Development Policy (ITDP), affirms that great city starts with great pedestrian friendly environment which includes factors such us Streets crossing and safety (low speed, presence of crossing signals, tighter turns, narrowed lanes and small crossing distance, restriction on free turns, speed bumps), sidewalks features (continuous, unobstructed, shaded, well-lit, pedestrian island and curb extension), accessibility, directness of the network, and pleasant and interesting routes (artistic streetscape).

US Green Building Rating System, Leadership in Energy and Environmental Design (LEED) has set out workable streets features in its portion, Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND), as function of safety, appeal, comfort and health that provide the walkways to users [19]. The concept of urban and neighborhoods developments vary theoretically and practically from one region to another, and that LEED-ND items cannot be applied worldwide integrally.

Kansas City Departments of Planning and Development and Public Works categorizes four group of neighborhoods and uses fives indicators (Directness, Continuity, Street Crossings, Visual Interest and Amenities, and Security) and defines various level of walkability that requires each group for a specific indicator [22]. The Kansas City walkability system recognizes particular needs for each neighborhood group and seems to be more practicable. Further, it sets targets to achieve for each walkability indicator.

In general, the basics factors of walkability are [23]:

- Accessibility,
- Convenience,
- Attractiveness,
- Road safety,
- Personal safety.

The five groups of neighborhoods are:

- Pedestrian Zones, Great Pedestrian Streets
- Mixed used & transportation Centers, Transit Zones
- Neighborhood Activity Centers &Corridors
- Schools/Parks
- Walking to/from Transit
- Other Areas within the city

4.2 Walkability and the Environment

The features of urban road environment such as route distance, the topography, the weather condition and the neighborhood are the important factors linked to walkability [24]. The land use, the recreational areas, the road network and social factors are also positively linked to walkability.[33] the citizens walking level increase substantially with convenient neighborhood environment [29]. Moreover, they ascertain that shorter destination encourage people walk. A study in Canada reveals that adult citizen's level of walking is positively correlated to absence of obstacle on their desire route, maintained level, road safety, personal security, and the directness of the street [25].

Through extensive study of literature review, the determinant factors between walkability and the environment are the accessibility of a destination, the type and mix of land use, the convenience and maintenance of the pedestrian infrastructure and the pedestrian road and personal safety [23]. The state of knowledge of the link between the neighborhood environment and walkability is still diffuse as no precise quantification exists yet.

4.3 Walkability Strength

The need in developing pedestrian friendly environment lies on the principle that smart growth generates economic, social and environmental benefits to which walkability contributes positively. The tendency to undervalue walkability in planning and economic evaluation is due to its difficult character to be quantified. However, the author ascertains that walking ensures basic mobility, warrants consumer cost savings and reduces external costs, allows efficient land use, provides livability to community, improves fitness and public health (heart disease, hypertension, stroke, diabetes, obesity, osteoporosis, depression, some types of cancer),

enhances economic development, and supports for equity for the community [26].

The cost of sprawl to which walkability contributes to the detraction of social, economical and environmental is summarized in Table 1.

Table 1 Cost of sprawl

Economic	Social	Environmental
• Reduce accessibility and higher transportation cost. • Increased land devoted to roads and parking facilities. • Increased costs to provide public services. • Reduces economies of agglomeration. • Reduced economies of scale in transit and other alternative modes. • Treats to environmentally sensitive businesses (e.g. farming and resorts).	• Reduced accessibility for people who are transport disadvantaged. • Reduced housing options. • Increased external transport costs (crashes, facility costs, etc.). • Degraded public realm. • Reduced neighborhood interaction and community cohesion. • Reduced opportunities to preserve cultural resources. • Reduced exercise by walking and cycling.	• Increased impervious surface. • Reduced greenspace and habitat. • Increased energy consumption and pollution emission. • Aesthetic degradation. • Increased water pollution. • Increased "heat island" effects.

4.4 Measuring Walkability

Walkability assessment methods and techniques are numerous. For instance, the Kansas City Departments of Planning and Development and Public Works classifies into four categories of methods of measuring walkability, which is summarizes in (Figure 3).

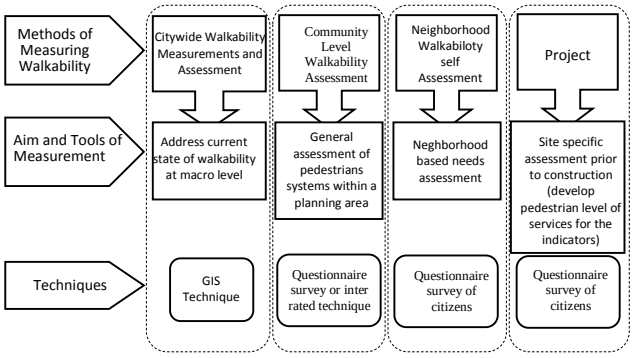

Figure 3 Methods and techniques of measuring walkability

4.5 Indicators of Walkability

The first step to deductive operationalization of walkability, or developing a composite walkability index, was to divide the construct of walkability into a small number of more concrete and tangible components, which are called "walkability components". There is no agreement on a single tool on measuring and quantifying walkability. The walkability indicators are broad.

Park [27] defines, measures, and evaluates fifty two (52) Paths Walkability Indicators, and a composite Walkability Index which tests the impact on transit users' mode choice and walking in California. The composite Walkability Index components and Paths Walkability Indicators are grouped accordingly and summarized respectively in Table 2 and Table 3. Table 3 shows the conceptual indicators of the 4 path walkability and their components.

Table 2 Composite walkability index indicators [27]

Group	Values	Walkability Components	K*	K_V
Traditional transportation	I. Sense of Safety (from traffic)	1. Sense of Safety in Pedestrian Crossing Affected by Traffic Study	6.6	21.6
		2. Sense of Safety in Pedestrian Crossing Affected by Crossing Facilities	7.8	
		3. Sense of Safety in Walking on the Sidewalk Affected by Traffic	7.2	
	II. Sense of Security (from crime)	4. Sense of Security from Existence of Others	9.0	32.4
		5. Sense of Security Affected by Visibility Night	13.8	
		6. Sense of Security from Visual Surveillance from Nearby Buildings	9.6	
	III. Comfort	7. Sidewalk Level-of-Service & Continuity	0.001	10.6
		8. Buffering Negative Environmental Effects	7.5	
		9. Sense of Street Scale & Enclosure	3.0	
Urban design	IV. Convenience	10. Ease of Pedestrian Crossing	12.6	21.0
		11. Easy Access to Local Stores	8.4	
	V. Visual Interest	12. Visual Variety	7.5	14.4
		13. Visual Attractiveness	9.6	
TOTAL			100	100

KC* = Components Weighting Factor
Kv = Values Weighting Factor

The coefficient Kv represents the importance of each value of the composite index in the composite system. It shows that the sense of security against crime is the highest need of the population around the area of study. The traffic safety and the pedestrian facilities convenience have the same importance and second the sense of neighborhood security.

The findings also show that the indicators clustered under the group of traditional transportation value have more than 60 percent of the total weightage.

The index measures the walkability by integration of a walker perception survey and measurement of factors of street urban design. The results of the study emphasized the value of users' perceptions such as security, safety and their comfortability.

The Path Walkability Indicator (PWI) will increase if the walking conducive increases and the path indicator will decrease if the driven conducive increases. Knowing this, it is possible to influence positively the Path Indicator in order to enhance the level of Walkability.

Galanis A. and Eliou Nikolaos (2011), measures in Greece, segments of roads features using three main indicators which are [23]:

- Road segment indicators which contain 22 elements subdivided in two categories (pedestrian infrastructure and street furniture),
- Corner indicator is composed of five elements, and
- Cross-walk indicator made up with three components. The authors use in their analysis the mean value for the road segment indicators while the corner and the crosswalk

indicators take into consideration as well the minimum and maximum values.

After remarking that the walkability assessment in work place is often overlooked develop an audit tool to address the issue. The tool is comprised of nine independents indicators which are:

- pedestrian facilities,
- pedestrian-vehicle conflicts,
- crosswalks,
- route maintenance,
- walkway width,
- roadway buffer, universal accessibility,
- aesthetics and,
- shade.

The tool differs from traditional neighborhood walkability assessment tools as it is applied for non residential campuses and parks areas. It therefore diminishes the importance accorded to traffic quantity and speed at the benefit of shaded areas and recreational walking routes which the authors ascertain may be of significant importance. However, the tool assess only single segment of roads and cannot be used to measure the sufficiency of road connectivity to the various places and their efficiency. In addition, the weightage assigned to the attributes may not represent the reality in different environmental condition. It might not be surprising to weigh shade attribute as high importance in a hot, humid and showery environment such as Malaysia. In such conditions, the shade can be achieved through a shelter or by means of trees planting. As shown in (Figure 4), there are 9 attributes summarized and it is related to pedestrians and their elaborated elements. Also, each attribute has its level of importance.

Table 3 Paths walkability indicators and 5 path walkability factors [27]

Factors	Path Walkability Indicators	Walking Conducive	Driving Conducive
Sidewalk Amenities	1. Average Number of Intermediaries / 500 ft. Sidewalk	more	less
	2. Number of Mid-block Crossings / 500 ft. Block Length	more	less
	3. Average Numbers of Street Furniture / 500 ft. Sidewalk	more	less
	4. Average Number of Upper-Level Windows / 500 ft.	more	less
	5. Average Number of Street-Facing Entrances / 500 ft.	more	less
	6. Average Ground-Level Luminosity after Sunset (fc.)	higher	lower
	7. Average Skyline Height (ft.)	higher	lower
	8. Number of Traffic Calming Elements / 500 ft.	more	less
	9. Percentage of Walking-Conducive Commercial Uses	higher	lower
	10. Average Pedestrian-Level Façade Transparency	higher	lower
	11. Average Width of Walking Zone (ft.)	wider	narrower
	12. Average Building Height (ft.)	higher	lower
	13. Average Width of On-street Parking	wider	narrower
	14. Percentage of Sidewalk Length with Building Façades	higher	lower
	15. Percentage of Sidewalk Length with Special Pavement	higher	lower
Traffic Impact	16. Fence Coverage Rate	lower	higher
	17. Pedestrian Signal Coverage Rate	lower	higher
	18. Average Number of Traffic Lanes	less	more
	19. Pedestrian Crossing Facility Design Index	lower	higher
	20. Average Building Width (ft.)	narrower	wider
	21. Pedestrian Crossing Coverage Rate	lower	higher
	22. Average Width of Curb-to-Curb Roadway	narrower	wider
	23. Average Width of Traffic Zone	narrower	wider
	24. Percentage of Residential Uses (1st floor frontage)	higher	lower
	25. Percentage of Sidewalk Covered by Tree Canopies (%)	higher	lower
	26. Average Width of Bike Lane (both sides together)	narrower	wider
Street Scale and Enclosure	27. Average Width of Through Traffic Lanes	narrower	Wider
	28. Enclosure Ratio in Cross Section II (BB Dist to Skyline)	lower	higher
	29. Enclosure Ratio in Cross Section I (BB Dist to Bldg. Ht.)	lower	higher
	30. Average Building-to-Building Distance (ft.)	narrower	Wider
	31. Average Building Setbacks (ft)	smaller	larger
Landscaping Elements	32. Average Number of Street Trees / 500 ft. Sidewalk	more	less
	33. Average Width of Landscape Strip (both sides)	wider	narrower
	34. Average Width of Buffer Zone (both sides together)	wider	narrower

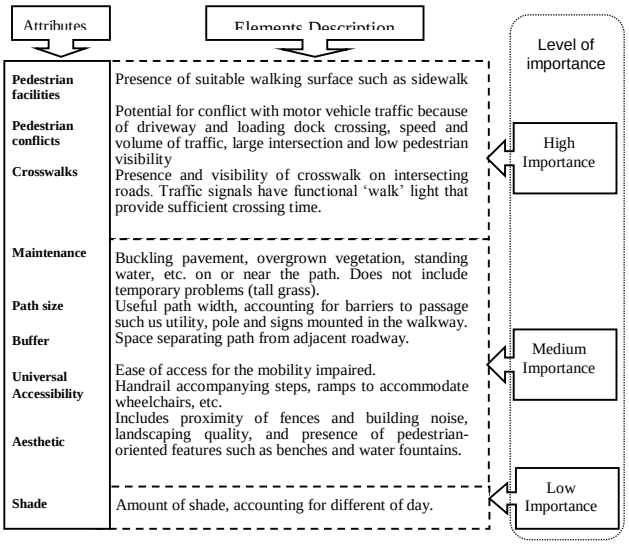

Figure 4 Summary of walkable street indicators [28]

■5.0 CONCLUSIONS

"People should not be forced to withdraw from the streets because of the discomforts caused by traffic"[30].

There is a necessity to enhance the quality of the environment and to create a livable environment. For instance, the streets should be economically healthy.

In general, the groups of indicators governing walkability are sidewalk-related, traffic-related, security-related, and nearby buildings and properties related. Due attention should be to those factors in the early planning and design stage of neighborhood by the community leaders in ensuring a satisfactorily level of walkability. Walkability is also an important measure in determining a better environment within a sustainable development due to its economic, social and environmental benefits. At the end, the main goal of conceptualizing the walkability indicators is to understand how walkability can affect our life and to expand our knowledge on how to measure and assess sustainability in the built environment. In other words, creating more livable pedestrian environments.

Acknowledgements

This work was financially supported by Research University Grant (Vot No: O6J99), research team members Construction Research Alliance, group of students MAM 1133 Sem I (2012/2013), and Transportation Research Alliance, Sustainability Research Alliance, Universiti Teknologi Malaysia.

References

[1] Cleland, V. J., Timperio, A. & Crawford, D. 2008. Are Perceptions of the Physical and Social Environment Associated with Mothers Walking for Leisure and for Transport? A Longitudinal Study. *Preventive Medicine.* 47(2): 188–193.

[2] Tee, E. S. 2002. Obesity in Asia: Prevalence and Issues in Assessment Methodologies. *Asia Pacific Journal of Clinical Nutrition.* 11(8): 694–701.

[3] Lekhraj, R. *et al.* 2007. A National Survey Study on the Prevalence of Obesity Among 16,127 Malaysians. *Asia Pacific Journal of Clinical Nutrition.* 16(3): 6–561.

[4] Notari. 1993. *Catalysis Today*. 18: 163.

[5] Henderson, K. A. 2006. Urban Parks and Trails and Physical Activity. *Journal of Leisure Research.* 9(4): 201–213.

[6] Vojnovic, I. *et al*. 2006. The Renewed Interest in Urban Form and Public Health: Promoting Increased Physical Activity in Michigan. *Cities.* 23(1): 1–17.

[7] Deborah, A. C. *et al*. 2007. Contribution of Public Parks to Physical Activity. *American Journal of Public Health*. 97(3): 509.

[8] Cohen, D. A., Scribner, R. A. & Farley, T. A. 2000. A Structural Model of Health Behaviour: A Pragmatic Approach to Explain and Influence Health Behaviours at the Population Level. *Preventive Medicine*. 30(2): 146–154.

[9] Ugwu, Haupt, T. C. 2007. Key Performance Indicators and Assessment Methods for Infrastructure Sustainability In South African Construction Industry Perspective. *Building and Environment*. 42(2): 665–680.

[10] K. A. Gray and M. E. Finster. 2010. The Urban Heat Island, Photochemical Smog, and Chicago: Local Features of the Problem and Solution. Dept. of Civil Eng. Northwestern Univ., Evanston, IL, June.

[11] P. Graham. 2003. *Building Ecology: First Principles for a Sustainable Built Environment*. 1st ed. Oxford: Blackwell Science.

[12] J. Bergs. The Effect of Healthy Workplaces on the Well-being and Productivity of Office Workers. Symposium Paper, plants-in-buildings.com, Netherlands. 1–12.

[13] OECD. 1996. *Towards Sustainable Transportation.* OECD Publications, Paris.

[14] Ruckelhaus, W. D. 1989. Toward a Sustainable World. Scientific American, September. 114–120.

[15] Litman, T. 2003. Sustainable Transportation Indicators. Victoria Transport Policy Institute, Victoria, BC, Canada. Available from http://www.vtpi.org.

[16] WCED (World Commission on Environment and Development). 1987. *Our Common Future.* Oxford University Press, Oxford.

[17] Southworth, Michael. 2005. Designing the Walkable City. *Journal of Urban Planning and Development*. 131(4): 246–257.

[18] Handy, Susan, Xinyu Cao, and Patricia L. Mokhtarian. 2006. Self-selection in the Relationship between the Built Environment and Walking. *Journal of American Planning Association*. 72(1): 55–74.

[19] Zande R. D. 2006. *Recommendations for a Pedestrian Friendly Campus*. West Virginia University, Orlando.

[20] Lloyd Wright. 2005. Car-Free Development (Eschborn, GTZ, 2005). Available from www.sutp.org (accessed 27 April 2012).

[21] Our Cities Ourselves, Ten Principles for Transport in Urban Life. (2002). The Future of Transportation in Urban Life. Institute of Transportation and Department Policy (ITDP) Gehl Architects.

[22] Aya Miyakoda. 2004. A Pedestrian Friendly Environment for Downtown Baton Rouge, Master thesis, B.D. Kobe Design University.

[23] Measuring Walkability: Tools and Assessment, March 12, 2010. From http://ww4.kcmo.org/planning/walkplan/measure.pdf.

[24] Galanis A., Eliou Nikolaos. 2011. Evaluation of the Pedestrian Infrastructure Using Walkability Indicators. *WSEAS Transactions on Environment and Development*. 12(7): 385–394.

[25] Cervero, R., and Duncan, M. 2003. Walking, Bicycling and Urban Landscapes: Evidence from the San Francisco Bay Area. *American Journal of Public Health*. 93(9): 1478–1483.

[26] Craig, C. L., Brownson, R. C., Cragg, S. E., and Dunn, A. L. 2002. Exploring the Effect of the Environment on Physical Activity: A Study Examining Walking to Work. *American Journal of Preventive Medicine.* 23(2S): 36–43.

[27] Litman, T. 2012. Evaluating Transportation Land Use Impacts: Considering the Impacts, Benefits and Costs of Different Land Use Development Patterns, Victoria Transport Policy Institute (VTPI), Canada.

[28] Park, S. 2008. Defining, Measuring, and Evaluating Path Walkability, and Testing Its Impacts on Transit Users' Mode Choice and Walking Distance to the Station. University of California Transportation Center, Berkeley

[29] Dannenberg, A. L., Cramer, T. W., Gibson, J. C. 2009. Assessing the Walkability of the Workplace: A New Audit Tool. *The Science of Health Promotion*. 20(1): 39–44.

[30] Hoehner, C. M., Brennan Ramirez, L. K., Elliott, M. B., Handy, S .L., and Brownson, R. C. 2005. Perceived and Objective Environmental Measures and Physical Activity Among Urban Adults. *American Journal of Preventive Medicine*. 28(2): 105–116.

[31] Powell, K. E., Martin, L.M., and Chowdhury, P. P. 2003. Places To Work: Convenience and Regular Physical Activity. *American Journal of Public Health*. 93(9): 1519–1521.

[32] Appleyard, D. 1981. Liveable Streets. Berkelery: University of California Press.