Factors of the Built Environment that Affects the Walkability in a Sri Lankan Urban Neighborhood

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Abstract

The quality of the neighboring environment plays a major role in encouraging people to walk when attending to their daily needs. Although many previous studies identified a relationship between different factors of the built environment and the level of walkability, this interdependence is poorly understood in urban planning in Sri Lanka. This Study analyses the relevance of thirty factors of the built environment, identified by previous studies as affecting the walkability, to Sri Lankan urban context, using thirty five residents within a selected neighborhood in the town of Panadura. The identified factors were examined within a 100m radius of each participant's residence through a questionnaire survey and field observations. Chi-squared analysis and bivariate correlation analysis were carried out to identify the most decisive factors for walkability. The results show that block length, the number of street lights, vehicle ownership, having relatives in the neighborhood and unpleasant land uses are the most significant factors.

Keywords: *walkability, factors of built environment, neighborhood*

1.0 Introduction

Numerous studies have observed that residents of higher-density, mixed-use neighborhoods tend to walk more and drive less than do the inhabitants of lower-density, suburban areas (Cervero and Duncan, 2003, Crane and Crepeau, 1998, Frank et al., 2007). Pedestrianization has become an integral part of any sustainable, modern urban design, where pollution-free, convenient, safe, and comfortable pedestrian facilities are ensured. The influence of attributes of the built environment on habitual behavior patterns such as walking are not yet well understood by behavioral scientists (Sallis and Owen, 1999), but community design disciplines (particularly transportation and urban planning research) have identified some strong patterns of association (Frank et al., 2003). Some studies have reported the associations between perceived environmental variables and walking (Owen et al., 2004; Frank and Pivo, 1995). There are only a limited number of studies that have investigated the relationship between factors of the built environment and walkability in Sri Lankan urban setting. This paper further discusses the definitions and concepts of walkability, the built environment and the neighborhood. Further, it examines in detail the factors of the built environment that affect the level of walkability. In this case study of Panadura urban area, Chi-squared and bivariate correlation analysis were used to identify the most significant out of 30 factors which have been forwarded in literature as influential for walkability .

2.0 Literature review

2.1 Concepts of Walkability, the Built Environment and the Neighborhood

'Walkability' is becoming a buzzword in planning today, as new ideas of urbanism are spreading throughout the profession. Many individuals define walkability using different terms (e.g., proximity, accessibility, and suitability). Walkability is a measure of how friendly an area is to walking. It takes into account the quality of pedestrian facilities, roadway conditions, land use patterns, community support, security and comfort for walking (Ariffinand Zahari, 2013). Walkability is the measure of the overall walking and living conditions in an area and is defined as the extent to which the built environment is friendly to the presence of people walking, living, shopping, visiting, enjoying, or spending time in an area (Abley, 2005). The built environment refers to the physical form of communities (Brownson et al., 2009), which has been operationalized in six dimensions: residential density, street connectivity, accessibility to services and destinations, walking and cycling. Leslie, (2005) defines a neighborhood as a physical environment in which all basic community facilities such as a school, playground and local shops are provided within a walking distance; an environment in which a community may have an easy walk to a shopping center where they may get the daily household goods, and employed people may find convenient transportation to and from work. Foesyth et al. (2007) show that neighborhoods can create and use a network of interactions and this connection help improve their quality of life as well as help get information, ideas, influences and resources. Accordingly, the built environment of a neighborhood plays a major role in enhancing the walkability by creating networks among the physical setting of communities.

2.2 Factors of the built environment that affect the walkability in Urban Neighborhoods

Researchers in planning and transportation have identified that diversity of land uses, access to facilities and street connectivity are the key aspects contributive to walkability in urban neighborhoods (Frank and Pivo, 1994, Cervero and Kockelman, 1997, Krizek et al. 2012). Similarly, the proximity of destinations, good weather conditions, safety and well-designed pedestrian facilities can significantly contribute to better perception of the walking environment (Ariffin and Zahari, 2013). Frank and Pivo, (1995) argue that population density and, to a lesser extent, pedestrian infrastructure, can affect the rate of walking. As Leslie (2005) mentions more varied and interesting built environment leads neighborhoods conducive to walking. Park and Schofer (2006) show that grid networks, sidewalks, setbacks and parking play a role in creating a pedestrian-friendly area. Further, they also show that large setbacks increase the effort required to reach buildings from the street; small building setbacks make commercial establishments and residences easily accessible to pedestrians. Nankervis, (1999) shows that out of the variables of weather, the average temperature and total precipitation impact walking. According to the study done by Campos et al. (2003), street lighting, the width of walk ways, the gradient of walk ways, weather conditions, proximity to main transport facilities and signage show a higher degree of importance in encouraging people to walk. At the same time, safety is also a point of concern for pedestrians' walkability. Individuals who live in areas that are more walkable and have lower crime rates tended to walk more (Doyle et al., 2007). Further, Schofer (2006) also illustrates that pedestrian activity is associated with the level of personal safety within a neighborhood. Table 1 summarizes thirty factors of the built environment that affect the walkability in urban neighborhood as identified through the reference to literature in this study.

Table 17: Factors of Built Environment that affect Walkability in an Urban Neighborhood

Factor	Measures	Recent Literature
1. Land use variation	Entropy calculation	Ewing & Cervero, (2010), Forsyth et al, (2007), Cervero & Kockelman, (1997), Handy (2002), Sallis et al. (2005)
2.Accessibility / Connectivity		
• Distance to destinations	Time spent for walking from home to bus stop	Krizek et al (2010), Litman,(2010), Cervero&Kockelman, (1997), Saelens et al,(2003) Frank et al.,(2007), Frank et al.,(2004), Sallis et al., (2005)
• Street connectivity •	Number of intersections within buffer	
• Block length •	Block length of particular buffer	
• Street pattern	Grid = 1 Not grid = 0	
3. Facilities in walking ways		
• Presence of sidewalks	Available = 1 Not available =0	Frank &Pivo, (1994), Schlossberg et al.,(2007), Ariffin&Zahari, (2013), Senevirathna&Morrall, (2013)
• Sidewalk width	More than 3 feet =1 Less than 3 feet=0	
• Side walk paving treatment	Concrete Block Paving =3 Bricks Paving = 2 Asphalt Paving =1 Unpaved= 0	
• Disability infrastructure	Available=1	

	Not available=0	
• Walking trails	Available = 1 Not available = 0	
• Street furniture	Available = 1 Not available = 0	
• Traffic calming features	Number of traffic calming signals within the block	
• Cleanliness	Clean = 1 Not clean = 0	
4. Aesthetic		
• Attractive architectural design	Available = 1 Not available = 0	Humpel et al.,(2002), Owen et al.,(2004), Booth et al., (2000), Ball et al, (2001)
• Presence of street trees	Number of street trees within buffer	
• Recreation	Number of places to exercise	
5. Safety		
• Undesirable land uses & activities	Available =1 Not available = 0	Berrigan, (2002), Ariffin&Zahari,(2013), Southworth,(2005), Foster & Giles, (2008), Leslie et al.,(2005), Troy & Grove, (2008), Sapawi& Said,(2012)
• Vacant & abandoned buildings	Available =1 Not available = 0	
• People present	Almost always= 2/Usually=1 /Not = 0	
• Street lighting	Number of street lights	
• Street access control	Number of street access controls within buffer	
• Signal coverage	The total number of pedestrian signals	
• Traffic volume and speeds	Average speed of the vehicles within buffer	
• Safety from crime	Number of CCTV cameras within buffer	
• Crossing facilities	The total number of pedestrian crossings	
• Company (Walking with another person or a pet)	Yes = 1 No = 0	
6. Weather		
• Preferred time to walk	Daytime= 1 Night time= 0	Nankervis, M., (1999), Saelens, B., Sallis, J., & Frank, L. (2003)
• Will rain matter?	Yes = 0, No= 1	

Source- Compiled by author

3.0 Methodology

The above thirty factors of built environments that affect walkability in urban neighborhoods were identified as indicated in table 1. The time spent on walking to work and other places during a week was calculated considering the time walked to each of those places and to the nearest bus terminal to go to work daily. The total time spent for walking during a week is considered the dependent variable, while the above identified thirty factors are considered as independent variables of walkability of people. The data related to 20 factors of categorical independent variables and 10 factors of continuous independent variables was collected through the tools of a questionnaire survey, direct interviews and a field observation survey.

The land use variation was examined using 'entropy' within a 100m buffered circle of the selected thirty five houses. "Entropy" was calculated using the formula developed by Cervero and Kockelman (1997) to assess the similarity of the proportion of land use of the area in parcels reserved to retail, residential, institutional, office and other purposes.

$$H = -1\left[\frac{\sum (P_j) * \ln(P_j)}{\ln(K)}\right]$$

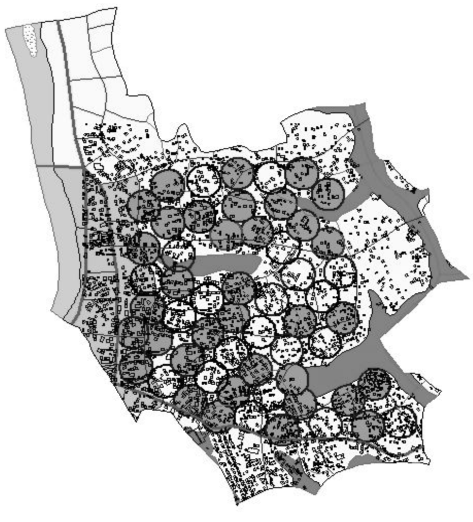
Where: H is the Entropy value. *K* is the different types of land uses in the buffer. P_j indicates the proportion of land area in the j^{th} land use type and ln is the natural logarithm using e (approximately 2.718) as its base. Entropy values range between 0 and 1, with 1 representing equal proportion (25%) among the four uses in the neighborhood and 0 representing the presence of a single dominant land use. Table 01 shows that independent variables of bus service, sidewalks, facilities for the disable, places to exercise, accesses to buffer, abandoned or vacant building and having relatives were measured considering the availability inside the 100m buffered circle and the number of intersections, block length, block size, number of street trees and number of traffic calming signals were measured as numerical values.

Chi-square analysis and Bivariate correlation analysis were applied to identify the factors that affect walkability most in the selected case study area. The Chi-squared test was the statistical test used to compare observed data with expected data obtained through a specific hypothesis (H_0 = Two categories of data are independent). In addition, the Chi-squared test was used to find the relationship between the level of walkability and other dummy variables. Bivariate Correlation analysis tests whether the relationship between two variables is linear or not. Bivariate correlation analysis was used to describe the relationship between the level of walkability and the factors affecting walkability which are not categorical. The correlation of each factor to the level of walkability was identified as weak or strong according to the strength of relationship.

4.0 Case study and Data Analysis

The area selected for the case study was the Panadura town which belong to the Panadura Urban Council and is located about 32 km south of Colombo City on the western coastal belt of Sri Lanka. According to the 'Sustainable Colombo Core Area Project (SCCP II)' done by UN-Habitat has identified residential (402.64Ha) is the main land use pattern while commercial (15Ha), public (31Ha) and Industrial (17.75Ha). As evident from the above fact, residential land uses dominate the activity pattern of the city. Litman (2010) stated that it is more likely to walk through a shorter distance like 100m, while a longer distance requires a combination of walking and usage of public transport. This walking link is often ignored if a motorized link has taken place on public. Therefore, buffered circles of a radius of 100m were drawn around 56 randomly selected houses in the Panadura urban neighborhood excluding the arterial and city center. Accordingly, 35 out of the 56 buffered circles were selected using a systematic sampling technique for conducting a questionnaire survey, interviewing the owner of the randomly selected house in each buffered circle. Figure 1 shows the sample of buffered circles selected from the neighborhood. The data on age, gender, race/ethnicity, family income, and education level of each respondent were examined during the questionnaire survey. Just over half of the sample size (60%) was women and most of the respondents' ages were between 40–59 years. Out of the total 35 buffered circles, 23 buffered circles provided entropy values close to 0 which emphasizes the fact that the homogeneous land use character of the area predominantly being residential. There is a good road network all over the area of Panadura. Out of 35 buffered circles, 6 buffered circles were recorded with the facility of good side walk and 97% of the area of the neighborhood was facilitated with street lighting.

Figure 1: Selected sample buffered circle from the neighborhood



Source- 1:10,000 Digital data base, Survey Department, Sri Lanka

The main objective of this study was to identify the most significant factors of the built environment that affect the walkability of people in the Panadura neighborhood area. Accordingly, 20 categorical variables were correlated with two categories of walking time (0-175minutes & 176- 350 minutes), using the Chi-squared analysis and 10 continuous variables were correlated with the continuous variable of walking time using bivariate correlation analysis. The Chi-squared analysis reveals that relatives within a buffer (4.610, 0.032), availability of undesirable lands (4.610, 0.032) and the availability of people in streets (9.927, 0.042) are the factors which show significant dependence on walking time. The Bivariate correlation analysis shows that block length (-0.412*, 0.014) and the number of street lights (0.369*, 0.032) are the variables which show significant correlation (significant level = 0.05) with walking time.

5.0 Conclusion

Although many previous studies identified a relationship between different factors of the built environment and the level of walkability, this interdependence is poorly understood in urban planning in Sri Lanka. The findings of this study indicate that the block length, the number of street lights, availability of relatives within a radius of 100m of the buffered area from their residence, availability of undesirable lands and the number of people found in streets are the most significant factors of the built environment in the Panadura urban neighborhood that affect the level of walkability in the area. In planning a walkable city with a sustainable transport system, planners should be concerned on the factors which play a major role in enhancing the level of walkability in different contexts and encourage walking either to attend to diverse needs or man-made or natural environment that facilitates walking.

References

Abley, S. (2005)."Walkability Scoping Paper".Retrieved March 04, 2011.

Ann Forsyth, Kevin J. Krizek and Asha Weinstein Agrawal (2010), Measuring Walking and Cycling Using the PABS (Pedestrian and Bicycling Survey) Approach:, *Mineta Transportation Institute, San Jose State University*

Ariffin, R. N. R. &Zahari, R. K., (2013) 'Perceptions of the Urban Walking Environments', *Social and Behavioral Sciences,* 105,589 – 597.

Ball, K., Bauman, A., Leslie, E., & Owen, N. (2001). Perceived environmental aesthetics and convenience and company are associated with walking for exercise among Australian adult, *American Journal of Preventive Medicine*, Nov;33(5):434- 40.

Berrigan, D.,&Troiano, R. (2002). The association between urban form and physical activity in U.S. adults.*American Journal of Preventive Medicine*, *23*(2S), 74-79

Booth, M., Owen, N., Bauman, A., Clavisi, O., & Leslie, E. (2000). Social-cognitive and perceived environment influences associated with physical activity in older Australians. *Preventive Medicine*, *31*, 15-22

Brown, B. B. et al., (2010) 'Mixed land use and walkability: Variations in land use measures and relationships with BMI, overweight, and obesity', *Health place,* 15,1130 -1141.

Brownson, R. C. et al., (2009) 'Measuring the Built Environment for Physical Activity', *Cities,* 36, 99-123.

Campos, M.B., Chiaraida, A., Smith, A., Stonor, T. & Takamatsu, S. (2003). Towards a 'walkability index'.*Proceedings of the European Transport Conference*. Online 24th June 2013. http://trid.trb.org/view.aspx?id=771383.

Cervero, R., &Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research D, 2* (3), 199–219.

Cervero, R., Duncan, M., 2003. Walking, bicycling, and urban landscapes: evidence from San Francisco Bay Area. *American Journal of Public Health 93 (9), 1478–1483.*

Crane, R., &Crepeau, R. (1998). Does neighborhood design influence travel? A behavioral analysis of travel diary and GIS data.*Transportation Research Part D, 3(4), 225–238.*

Doyle, S., Kelly-Schwartz, A., Schlossberg, M., &Stockard, J. (2006). Active community environments and health: the relationship of walkable and safe communities to individual health. *Journal of the American Planning Association, 72(1), 19-31.and morbidity. Urban Ecology, 567–582.*

Ewing, R., &Cervero, R., (2010) 'Travel and the Built Environment', *Journal of the American Planning Association,* 76,1-31.

Forsyth, A., Oakes, J. M., Schmitz, K. H., & Hearst, M. (2007). Does residential density increase walking and other physical activity? Urban Studies, 44(4), 679.

Foster, S., & Giles-Corti, B. (2008). The built environment, neighborhood crime and constrained physical activity: An exploration of inconsistent findings. *Preventive Medicine, 47(3), 241–251.*

Frank, L. D., Andresen, M. A., &Schmid, T. L. (2004). Obesity relationships with community design, physical activity, and time spent in cars. *American Journal of Preventive Medicine, 27(2), 87–96.*

Frank, L., Kerr, J., Chapman, J., &Sallis, J. (2007). Urban form relationships with walk trip frequency and distance among youth. *American Journal of Health Promotion, 21(4 Suppl), 1–8.*

Frank. L. and Pivo, G. (1995) The impacts of mixed use and density on the utilization of three modes of travel: the single occupant vehicle, transit, and walking. *Transportation Research Record 1466, 4452.*

Handy, S., Boarnet, M. G., Ewing, R., &Killingsworth, R. E. (2002). How the built environment affects physical activity: views from urban planning. *American Journal of Preventive Medicine, 23(2S), 64–79.*

Humpel N., Owen N., Leslie E. (2002), Environmental factors associated with adults' participation in physical activity: A review. *Journal of Preventive Medicine*, 22:188-199.

Jackson, G &Anglin, K 2001, Street crossing details, viewed 2010, <http://www.walkable.org/assets/downloads/streetcrossingdetail.pdf>.

Karim, H. A., &Azmi, D. I., (2013) 'Convenience and Safety of Walking Experience inPutrajayaNeighbourhood Area, *Social and Behavioral Sciences,* 101, 318 – 327.

Leslie, E., et al.(2005) 'Residents' perceptions of walkability attributes in objectively different neighborhoods: a pilot study', *Health & place,* 11, 227–236.

Leslie, E., et al., (2007) 'Walkability of local communities: Using geographic information systems to objectively assess relevant environmental attributes', *Health & place,* 13, 111–122.

Litman, T. (2010).Measuring Transportation: Traffic, Mobility and Accessibility.*ITE Journal* ,*73* (10), 28-32. Retrieved from http:// www.vtpi.org..

Nankervis M: The effects of weather and climate on urban bicycle commuters' decision to ride: A pilot survey. *Road and Transport Research.*1999, *8*:85–97.

Owen N, Humpel N, Leslie E, Bauman A, Sallis JF, (2004) Understanding environmental influences on walking: Review and research agenda. *Journal of Preventive Medicine*, 27:67-76.

Parks, J. R., &Schofer, J. L. (2006).Characterizing neighborhood pedestrian environments with secondary data.*Transportation Research Part D, 11, 250–263.*

Rodríguez, D. A. et al., (2009) 'Land Use, Residential Density, and Walking: The Multi-Ethnic Study of Atherosclerosis', *Health & place,* 37(5), 397–404.

Saelens, B. E., & Handy, S. L., (2008) 'Built Environment Correlates of Walking: A Review', *Health,* 40,128-200.

Saelens, B., Sallis, J., & Frank, L. (2003). Environmental correlates of walking and cycling: Findings from the transportation, urban design, and planning literatures. *Annals of Behavioral Medicine, 25(2), 80–91.*

Sapawi, R.,&Said, I., (2012) 'Constructing Indices Representing Physical Attributes for Walking in Urban Neighborhood Area ', *Social and Behavioral Sciences ,50,179 – 191.*

Seneviratne, P. N. &Morral, J. F., (2013) 'Analysis of factors affecting the choice of route of pedestrians', *Transportation Planning and Technology,* 10:2,147-159.

Southworth, M. (2005).Designing the walkable city.*Journal of Urban Planning and development, 131(4), 246–257.*

Troy, A., & Grove, J. M. (2008). Property values, parks, and crime: A hedonic analysis in Baltimore, MD. *Landscape and Urban Planning, 87(3), 233–245.*