Which Factors Affect "Walkability" of Pedestrians on Sidewalk in Indian cities?

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Abstract: This study is an attempt to develop an alternative model for assessing walkability condition of two Indian cities based on land uses. Questionnaire survey was conducted at 12 locations from two cities that included various land uses. Factor analysis was used to condense pedestrian perceptions into important variables that affected walkability. Stepwise regression was undertaken to define walkability as a function of pedestrian perception. Pedestrian perceptions from land use of two cities were analysed using stepwise regression models to assess factors affecting walkability in residential location. Traffic speed, crossing facilities, walkable distance to commercial area and bus stops, potential vehicle conflict, curb cuts along sidewalks are identified as the main factors that contribute to walkability of a residential land use. Research results indicate that walkability can be improved by giving more attention to the factors that are identified important in the model.

Keywords: walkability, pedestrian perceptions, factor analysis, regression

1. INTRODUCTION

Walkability is directly related to the level of a built environment and how much it is friendly to the pedestrian in that particular area or facility. Neighbourhoods are walkable when peoples can walk safely and easily on foot. The assessment of walkability is an important concern in urban planning to evaluate the flaws of pedestrian networks. In the nineteenth century all streets were designed in order to support the pedestrian's walkability before major revolution in the transportation facilities (Newman and Kenworthy (1999). After that, in the twentieth century car transport became more preferable than public transport and walking for designing a transportation facility. Fast urbanization entails not only the movement of population from rural to urban areas but also interchange of values, beliefs and attitudes thereby causing rapid transformation of individuals, society and cities.

The CAI-Asia study tells that 62 % of people will shift their walking mode to other motorized mode if the walking facilities and environment are do not been improved. As per the report of Clean Air Initiative for Asian Cities (CAI-Asia, 2011), India is facing significant transport challenges and the solution of this problem is improving the walkability which can help to address transport challenges. Generally, Indian cities are naturally built for walking and cycling and therefore the majority of destinations are easily accessible by non-motorized modes. The data obtained from Ministry of Urban Development (MOUD 2008) Indian cities indicate that walking forms at least a quarter of all trips and sometimes as high as half of all trips (Table 1).

Table 1. Trip Mode Shares in Indian Cities

City Category	**Description**	**Trip Mode Share**						**Average Trip Length**
		Walk	**Cycle**	**2-wheeler**	**Public**	**Car**	**IPT**	
Category-1 a	<0.5 million, Plain Terrain	34	3	26	5	27	5	2.4
Category-1b	<0.5 million, Hilly Terrain	57	1	6	8	28	0	2.5
Category-2	0.5 to 1 million	32	20	24	9	12	3	3.5
Category-3	1-2 million	24	19	24	13	12	8	4.7
Category-4	2-4 million	25	18	29	10	12	6	5.7
Category-5	4-8 million	25	11	26	21	10	7	7.2
Category-6	>8 million	22	8	9	44	10	7	10.4
National		28	11	16	27	13	6	7.7

(**Source**: MOUD, 2008. Study on Traffic and Transportation Policies and Strategies in Urban Areas in India)

As per the latest accident analysis report of Ministry of Road Transport and Highways (MoRTH, 2015) 9.5 percent of accident involves pedestrians due to the improper design of sidewalk facilities. As the walkability has various benefits towards public health, economy and various others aspects, planning and design of the walkable environment became the point of interest of researchers and planners across the world. The neighbourhood is walkable or not walkability is totally dependent on the facilities provided to pedestrians. Therefore, it is essential to assess the pedestrian's facilities first to conduct walkability analysis of a particular region. The main objective of the study is to know about the pedestrians' perception towards existing sidewalks in their localities and to identify the principal parameters which that influences the walkability of a city.

2. LITERATURE REVIEW

2.1 Definition of Walkability

Walkability is a measure that examines how amenable a locality to walk. Rattan et. al. (2012) identified walkability as a measure of the effectiveness and as transportation alternatives to cars. Some researchers defined walkability as an important concern in sustainable urban design Shelton (2008) and some considered walkability as an important concern in urban planning (Stanford, 2003).

2.2 Previous Studies

Researchers have broadly conducted study on walkability. Leslie (2005) carried out a study in order to assess the different environmental attributes with the help of geographic information system (GIS) which affects the adults' physical activity or walkability in Australia. Different attributes were used in the analysis named as dwelling density, connectivity, land use attributes and net area retail. Owen et al. (2007) conducted a study to examine the neighbourhood walkability and the walking behaviour of Australian adults. The walkability index used in this study did not capture access to recreational destinations nor the quality of the pedestrian environment (e.g., sidewalk maintenance, aesthetics). Because of that it was concluded that there is a need to recall the policy initiatives to create more-walkable neighbourhoods. Al-hagla (2009) proposed a comprehensive approach in order to assess the walkability measures at micro and macro scales in Saifi Village of downtown Beirut. It was concluded that mixed land use and diversity played a role as walkability generators with positive effect while connectivity showed a negative effect while working as walkability catalyst. Micro-scale evaluation concluded that the walkability generators has negative effect on walkability performance in comparison to walkability catalyst. Lo (2009) conducted a study in order to understand the walkability and the pedestrian's perception. It was concluded that the HCM level of service standards should be revised to reflect better the convergence of other literature and research on what constitutes walkability or what contributes to pedestrian comfort and safety. Guo (2009) analysed pedestrian environment to see the effect on the utility of walking in Downtown Boston with the help of path choice method. It was concluded that Pedestrian Environment (PE) indeed affects the utility of walking: ''good" PE can increase the utility of walking while ''bad" PE reduces this utility. The average effect in downtown Boston is equivalent to 2.4– 2.8 min of walking, which represents a 21–33% increase in walking utility. Tsukaguchi et al. (2009) concluded that gender difference did not make any difference in the attitude of the pedestrians towards walking while age of the respondents exhibited significant effect on attitude towards walking. Fabian et al. (2010) carried out a study to examine the condition of walkability in Asian cities. Among different nine parameters, wider, level and clean sidewalks/ footpaths were at the highest priority while crossings was at the least priority of the pedestrians.

Manaugh and El-Geneidy (2011) examined the correlation of walkability scores with household travel behaviour by using four indices of walkability namely; walkability index, walk opportunity index, Pedshed method and walkscore. Among all four methods, Pedshed method was found to be the best walkability index. Weinberger and Sweet (2012) evaluated the correlation between walk scores (as indicators of walkability; i.e., opportunity to walk) and walking. In the study, walk score was identified as a better predictor of walking mode choice across several trip purposes compared with population density. Kelly et al. (2011) assessed quality of the pedestrian environment at microscale level by using three different techniques namely, stated preference (SP) survey tool, on street survey and mobile method. The mobile method was found more appropriate for assessing the walkability of a particular route at a particular location as it provided the most contextual evidence of the interactions and issues that pedestrians were experienced. Although it is the most time consuming method. Azmi and Karim (2012) highlighted the implication of walkability towards promoting sustainable urban neighbourhood in the cities located within Klang Valley namely; Shah Alam and Putrajaya. From the study it was concluded that the pedestrian's facilities are still lacking to encourage people to walk at both the locations.

In another study, Glazier et al. (2014) examined the association between density and the destination. Blecic et al. (2015) conducted a study to provide an urban design support system centred on pedestrian accessibility and walkability of places to describe the urban quality, traffic and road conditions, land-use patterns, building accessibility, degree of integration with the surroundings, safety and any other feature. Jun and Hur (2015) examined the association of physical and perceived walkability with neighbourhood social environment in Franklin County by using four variables namely, net residential density, retail floor area ratio, intersection density and land use mix. Wibowo et al. (2015) conducted a study to identify the walkability measures in Indonesia by using different nine parameters. In this study to assess the walkability a walkability index model was developed which was expanded from a previous study (Leather et al. 2011). Yusuf and Waheed (2015) measured walkability of a city in the form of walkability indexes. Global walkability index and Asian index was used for the analysis. Tran et al. (2015) identified accessibility-by-foot, the fear of crime, walking facilities and traffic conditions as the principal parameters having significant influence on mode choice. Besides these, Muraleetharan et al. (2005) and Pamanikabud et al. (2003) were focused on pedestrian's sidewalk.

As many of the previous studies examined the walkability of neighbourhood or a city but the pedestrians perception and the facilities provided to them can be an issue (i.e. it can be varied from region to region or one country to another) to implement their suggestion in Indian cities.

3. METHODOLOGY

3.1 Study area

The study was carried out in two Indian cities, Hisar and Chandigarh. Hisar city is spread in an area of about 2180 hectares and it is the world's second largest Harappa site after Mohenjo-Daro. Hisar is a blend of the historic India with modern urban developing India. As per the Census (2011), total population of Hisar district is 17, 42,815 persons, 9, 31,535 males and 8, 11,280 females, which is 6.87 % of total population of the state. The share of road transport in land use is highest when compared with other cities of the state. The existing road design and infrastructure does not cater the needs of pedestrians. The adequacy of footpath width is found to be 30% which is a very less amount. The main reason for inadequacy of footpath width is the lack of space on the sides of the carriageway. The footpath are either not available or poorly maintained which reduces the walk trips of Hisar. Different six locations were chosen for Hisar city is shown in Figure 1.

Chandigarh is a city and a Union Territory of India which serves as the capital of two states of India name as Haryana and Punjab. Chandigarh was designed by Swiss-French architect Le Corbusier and counted in one of the early well planned cities of India. Chandigarh city is internationally known for its architecture and urban design. As per report of Census 2011, Chandigarh city has population of 10.55 lakhs which is increased from figure of 9.01 Lakh (2001 census). Total population of Chandigarh as per 2011 census is 1,055,450 and out of which 580,663 and 474,787 are male and female respectively. According to walkability index score developed by Ministry of Urban Development of India (MOUD) by assessing pedestrian infrastructures of 30 cities, an average score of 0.52 was obtained out of 1 and Chandigarh has got the highest of 0.82. Different six locations were chosen for Chandigarh city is shown in Figure 2. Details of survey locations in Hisar and Chandigarh is provided in Table 2.

Figure 1. Schematic view of Hisar city

Figure 2. Schematic view of Chandigarh city

Table 2. Description of the Study Sites

Study Site	Location	Category
Hisar	Bus Stand	Terminal
	Red Square Market	Commercial
	Prem Nagar	Mixed Land use
	Govt. PG College	Institutional
	Sector 15	Residential
	Town Park	Recreational
Chandigarh	Sect. 17 Bus Stand	Terminal
	Shastri Market Sect. 22	Commercial
	Sect. 11	Mixed Land use
	PEC University	Institutional
	Sect. 21	Residential
	Rock Garden	Recreational

3.2 Criteria for site selection

Different considerations were taken in to account for selecting the study sites which are as follows:

a) Sidewalk facility (footpath) width should be greater than or equal to 1800 mm wide as per IRC: 103-2012.
b) Sidewalk should be physically separated or height of the kerb 150 mm.
c) Pedestrian volume should be high.

All the study sites had sidewalks with the reasonable width and height as per the IRC: (103-2012) guidelines. The width of the footpath was found to be vary from 1.8 m to 2.2 m in Hisar city and 1.8 m to 4.5 m in Chandigarh city. Figure 3 (a) and (b) is exhibiting the schematic view of institutional site of Hisar and Chandigarh city respectively.

Figure 3. Sidewalk Condition at (a) Hisar Govt. College and (b) Chandigarh PEC University

3.2 Study Design and Contents of Questionnaire

Data collection was conducted in six selected locations in both Hisar and Chandigarh. Questionnaire survey gathered information like pedestrian perceptions and socio economic characteristics of pedestrians. About 450 pedestrians were interviewed in Hisar and Chandigarh. Data collection was performed for seven days in each location starting from morning 8 A.M. to 6 P.M. except in institutional areas. In institutional areas, survey was conducted in the morning 8 A.M. to 10 A.M. and evening 4 P.M. to 6 P.M. as pedestrian flow was peak at that time.

Questionnaire was divided into two sections. First section included the questions related to socio-demographic characteristics like age, gender, occupation, reason for not walking and in the second section, respondents were asked to rate the sub factors defined under main factors that enhance walkability like safety from traffic, safety from crime, pedestrian convenience, sidewalk infrastructure and accessibility. A five point Likert scale was used with "one" representing poor condition and "five" representing excellent condition of sidewalks. Table 3 presents the factors and sub factors taken into consideration for the study. Pedestrians were also asked to give rating according to the importance given to main factors. A question was provided to score overall walkability of sidewalk using five point Likert scale where "one" for the lowest point and "five" for the highest point. Also pedestrians were asked to give level of importance for the main factors.

Table 3. Description of Study Parameters

Factor	Variable ID	Variables
Safety from traffic (TRA)	TRA1	Traffic volume
	TRA2	Potential for vehicle conflict
	TRA3	Pedestrian signal
	TRA4	Traffic control devices
	TRA5	Traffic speed
	TRA6	Convenience for people crossing
	TRA7	Guard Rail
	TRA8	Underpass/Foot-overbridge
Safety from crime (PER)	PER1	Provision of lighting
	PER2	Outdoor lighting
	PER3	Police patrolling
	PER4	CCTV cameras
	PER5	Abandoned building or lot
	PER6	Good visibility
	PER7	Safety for walking
Pedestrians Convenience (COM)	COM1	Cleanliness of sidewalk
	COM2	Street furniture
	COM3	landscapes
	COM4	Public utility functions
	COM5	Tactile flooring
	COM6	Curb cut
	COM7	Ramps
	COM8	Trees and shades
Sidewalk Infrastructure (PIS)	PIS1	Footpath width
	PIS2	Footpath surface
	PIS3	Sidewalk maintenance
	PIS4	Continuity
	PIS5	Obstruction
	PIS6	Location of sidewalk
	PIS7	Encroachment
	PIS8	Footpath Height
Accessibility (ACC)	ACC1	Pedestrian volume
	ACC2	Walkable distance to commercial area
	ACC3	Walkable distance to bus stops
	ACC4	Walkable distance to institutional building
	ACC5	Walkable distance to mixed land uses
	ACC6	Another pedestrian access point
	ACC7	Two – way movement of pedestrian

3.3 Data Analytical Tools

Walkability analysis was conducted in SPSS software using pedestrian perceptions. Factor analysis was conducted in order to identify the main factors that considered important regarding walkability. Then multiple regression analysis was used to build a walkability model using pedestrian perceptions about the existing conditions of sidewalks by assessing various important parameters of walkability.

3.3.1 Exploratory factor analysis

Factor analysis is a technique to identify the correlation between a large number of measured variables and to reduce the number of variables. So it can be called as a data reduction method or structure detection method. Factor analysis can be used to reduce original variables which can be described into smaller variables without losing the information. These smaller variables could explain the original variables. The factor analysis makes the subsequent analysis easier by reducing the number of factors.

In order to determine the sampling adequacy of factors in the model and to determine whether the factor analysis can be used with interviewed data Kaiser Meyer Olkin (KMO) test should be conducted. KMO value ranges from 0 to 1, the KMO value equal to or greater than 0.5 is recommended for a satisfactory factor analysis (Hidayat et al. 2011).

3.3.2 Analysis of variance

Analysis of variance (ANOVA) is a test to determine whether there are any statistically significant differences between the means of three or more independent (unrelated) groups. ANOVA is used to test general rather than specific differences among means. Analysis of variance differs from regression in two ways: the independent variables are qualitative (categorical), and no assumption is made about the nature of the relationship (that is, the model does not include coefficients for variables).

3.3.3 Multiple regression analysis

Multiple regression is one of the statistical methods that helps in assessing the relationship between several independent and a dependent variables. Independent variables can be continuous or categorical. The main aim of multiple regression model is to either for explanation or prediction of dependent variable using a set of independent variables. As a prediction model it investigates the extent to which independent variables can predict dependent variable. As an explanation model, the relationship between dependent and independent variables can be examined in terms of sign, value, and significant value. The general, the multiple regression equation of Y on $X_1, X_2, \ldots, X_k$ is given by:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + \ldots\ldots\ldots + b_k X_k \quad (1)$$

Here b_0 is the intercept and $b_1, b_2, b_3, \ldots, b_k$ are analogous to the slope in linear regression equation and are also called regression coefficients.

4. RESULTS AND DISCUSSION

4.1 Pedestrians Characteristics of Hisar and Chandigarh's City

Pedestrian characteristics of Hisar and Chandigarh are presented in Table 4. The percentage of female pedestrians in Hisar and Chandigarh are 40 and 42%. The majority of pedestrians are in average age group between 19 and 45 years (65% vs. 75% respectively). The majority of respondents in respondents were students (51% from Hisar and 50% from Chandigarh). Safety is the main reason given by pedestrians for not walking on sidewalks (21% from Hisar and 18% from Chandigarh). A survey was conducted on women (Madan and Nalla 2016) to know their perception about safety. Almost 40% of the participants were found to feel unsafe on the street while going for shopping, night walk etc. Beside this, National Crime Record Bureau (NCRB, 2015) also found an increment of 7.39 percent and 47.80 percent in the murder and kidnapping incident respectively.

Table 4. Description of Socio-Demographic Characteristics

Attributes	Categories	Hisar (%)	Chandigarh (%)
Gender	Male	60	58
	Female	40	42
Age	< 18	15	9
	19 – 45	65	75
	45 - 60	17	10
	>60	2	6
Profession	Student	51	50
	Service	11	12
	Housewife	12	10
	Business	10	8
	Self Employed	12	15
	Retired	1	2
	Unemployed	2	2
	Others	1	1
Reason for not to walk	Encroachment	23	2
	Footpath Surface	11	33
	Walking Environment	3	4
	Safety	21	18
	Comfort	12	12
	Continuity	15	16
	Cleanliness	15	16

4.2 Pedestrian's response

Responses of pedestrians regarding importance and performance of existing sidewalks of Hisar and Chandigarh's pedestrians were compared using a five point scale. In the present study, pedestrian perceived walkability and remaining 38 parameters were taken as dependent and independent variables respectively. A total of 450 participants were participated in the questionnaire survey but in the data cleaning process, 60 forms were removed which were not completely filled by participants. After the data cleaning process, a total of 390 questionnaire samples were used for analysis. Percentage of responses for all the five points in Likert Scale were compared and difference was measured. Mean weights were calculated for each sub criteria for two cities. Weighted mean of perception ratings was calculated for both Hisar and Chandigarh as presented in Table 5.

Table 5. Satisfaction Rating as per Pedestrians Perception

Parameters	Weighted mean of rating as per pedestrian perception	
	Hisar City	Chandigarh City
Traffic volume	4.34	4.36
Potential for vehicle conflict	3.10	3.41
Pedestrian signal	1.00	1.50
Traffic control devices	2.70	2.65
Traffic speed	3.22	3.90
Convenience for people crossing	2.31	2.79
Guard Rail	1.00	1.31
Underpass/Foot-overbridge	2.09	1.88
Provision of lighting	3.41	3.88
Outdoor lighting	3.36	3.86
Police patrolling	2.48	2.42
CCTV cameras	1.45	1.75
Abandoned building or lot	1.92	2.04
Good visibility	3.13	3.89
Safety for walking	2.38	3.16
Cleanliness of sidewalk	2.19	2.68
Street furniture	1.16	1.47
landscapes	1.40	2.96
Public utility	1.96	1.88
Tactile flooring	1.96	2.18
Curb cut	1.39	1.65
Ramps	1.42	1.68
Trees and shades	2.49	4.50
Footpath width	2.85	4.15
Footpath surface	2.58	2.65
Sidewalk maintenance	1.92	2.41
continuity	2.08	2.99
Obstruction	2.58	1.90
Location of sidewalk	3.21	3.81
Encroachment	3.24	2.01
Footpath Height	2.72	2.50
Pedestrian volume	4.31	4.07
Walkable distance to commercial area	3.21	3.63
Walkable distance to bus stops	2.04	3.64
Walkable distance to institutional building	3.14	3.82
Walkable distance to mixed land uses	3.18	3.63
Another pedestrian access point	1.90	2.14
Two – way movement of pedestrian	2.83	4.07

In order to determine the importance relative weight of main factors mean of importance rating given by pedestrians across both sites were calculated as shown in Table 6. A spider net graph is used to present the how relative weight of importance changes between pedestrians of Hisar and Chandigarh city (Figure 4). Hisar spiral is found almost to shadow the Chandigarh spiral. Only the factor 'accessibility' was found to be significantly more important in Hisar area compared to Chandigarh. In Chandigarh, factor 'safety from crime' got slightly high importance than Hisar.

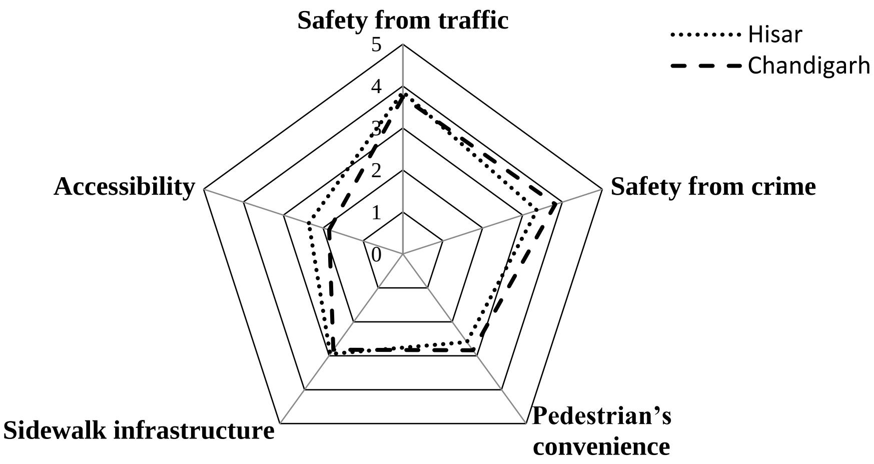

Figure 4. Spider net graph showing relative importance weight of Hisar and Chandigarh

Table 6. Weighted mean of importance rating at Hisar and Chandigarh city

Parameters	Hisar city	Chandigarh city
Safety from traffic	3.86	3.74
Safety from crime	3.36	3.82
Pedestrian's convenience	2.60	2.84
Sidewalk infrastructure	2.95	2.82
Accessibility	2.36	1.85

By examining all the results for both the study sites following observations were made:-

- In Hisar city, pedestrians were found more concerned about the safety from traffic as the guard rails were not provided on the footpaths. There were no crossing facilities like foot-over bridge and under pass for pedestrians at many locations except in terminal areas.
- Safety from crime was another important parameter followed by the parameters like sidewalk infrastructure, pedestrian's convenience and accessibility. The main reason for feeling unsafe is due to the absence of CCTV cameras and very low frequency of police patrolling. Besides this, pedestrians complained about the absence of other facilities like provision of benches, public utility and cleanliness etc.
- On the other hand, in case of Chandigarh city, safety from crime was identified as the major concerns for the pedestrians while walking in the streets in early morning and late nights as it got the highest importance rating of 3.82 (Table 6) because of the inadequate lighting facilities. However, on the major roads of the Chandigarh city light arrangements were found up to the mark.

- Safety from traffic was identified as the other main concern after safety from crime having importance rating of 3.74 as s there were no availability of foot-over bridge and under pass for pedestrians crossing at all the locations except terminal area.
- Alternatively, pedestrians were also bothered for other parameters which were ordered as convenience, sidewalk infrastructure and accessibility with an importance rating of 2.84, 2.82 and 1.85 respectively.

4.3 Factor analysis results

Four different analytical strategies were employed using SPSS software to develop walkability model. Initially, 38 parameters were factor analysed with the help of principal component analysis with orthogonal varimax rotation, to reduce the number of factors in order to being group all the variables having high correlation. In the primary phase of factor analysis, number of variables were removed which showed correlation less than 0.40 (Stevens (1992). Suitability of factor analysis was evaluated with Kaiser Meyer Olkin (KMO) which exhibits the overall sampling adequacy of 0.663 and 0.764 for Hisar and Chandigarh city respectively which is greater than required KMO of 0.5 (Hidayat et al. 2011) as shown in Table 7. Initially, factor analysis was done separately for both the study sites. In the primary phase of factor analysis, a total OF four parameters were removed in case of Hisar city while in case of Chandigarh city only 1 parameter (PIS7) was showing less correlation among all the variables. In the secondary phase, an 11 factor solution was suggested for Hisar city which was explaining 69.93% of the variance in the data with eigenvalue more than 1. In case of Chandigarh city 9 factor solution was obtained which was explaining 68.97% of the variance in the data with eigenvalue more than 1.

Bartlett test of sphericity also exhibited the overall significance of correlation matrix < 0.000001. Bartlett test of sphericity having values of 2357.821 and 5366.039 for Hisar and Chandigarh respectively shows that the data had sufficient correlation in order to conduct the factor analysis. Cronbach's Alpha test was performed to examine the reliability and internal consistency of the variables for both study areas. The alpha coefficient for 34 parameters in case of Hisar city was only 0.48, exhibiting poor internal consistency among all the parameters. While for the Chandigarh city, alpha coefficient value of 0.756 was obtained which exhibited good internal consistency among 37 variables.

Table 7. Summary of Factor Analysis

Analytic Strategy	Hisar	Chandigarh	Combine Data Set
Cronbach's Alpha	0.48	0.756	0.770
Kaiser Measure of Sampling Adequacy (KMO)	0.663	0.763	0.789
Bartlett test of sphericity			
Chi-square	2357.821	5366.039	6869.768
DF	561	666	703
Significance	0.000	0.000	0.000

It is to be noted that a Cronbach's Alpha coefficient value equal to or greater than 0.70 is acceptable (Choi et al. 2015). Consequently, factor analysis was done for combined data set and a 10 factor solution was obtained having KMO value of 0.789. Bartlett test of sphericity value of 6869.768 confirmed that the data has internal consistency with Cronbach's Alpha coefficient 0.770 and factor analysis can be performed.

4.4 Stepwise Regression Analysis and Model Development

A stepwise regression analysis was carried out separately for both the study areas separately and combined data sets to determine the best combinations of different parameters to predict the perceived walkability at 95% significance level. Total of 38 parameters were used as independent variables and perceived walkability is the dependent variable. Stepwise regression systematically adds the most significant variable or removes the least significant variable during each step and by doing so the coefficients of best set of the variables that defines the suitable model will be finalized as the coefficients of regression analysis. Table 8 exhibits the result obtained from stepwise regression analysis for combined data set.

Table 8. Stepwise regression analysis for pedestrian perceptions based on location

Model	Unstandardized Coefficients		Standardized Coefficients	Model R Square	T	Sig.
	B	Std. Error	Beta			
(Constant)	2.325	.148			15.704	.000
(Constant)	1.566	.313			5.006	.000
ACC2	.155	.054	.186		2.859	.004
COM8	.163	.043	.193		3.752	.000
COM5	-.186	.059	-.164		-3.136	.002
COM4	.164	.059	.135		2.762	.006
COM6	.350	.110	.197		3.173	.002
COM7	-.257	.096	-.160	0.24	-2.682	.008
ACC3	.101	.046	.144		2.188	.029
PIS4	-.151	.062	-.131		-2.447	.015
ACC6	.133	.054	.124		2.452	.015
PER2	.114	.055	.102		2.055	.041

In general, stepwise regression model independent variables were selected automatically through step-by-step iteration. From Table 9 it can observed that a model (Model 10) of ten parameters of interest found significant at 95 % confidence level having R^2 value of 0.24 which is showing low adequacy of the model. Therefore, data from two cities was combined based on the residential land use and step wise regression has been conducted for residential land use to assess the factors affecting walkability.

4.5 Factor analysis for pedestrian perceptions based on land use

Due to the low R-square value of the combined model (Table 8), analysis was conducted based on land use (i.e. residential area). The data collected from residential area of both the cities, Hisar and Chandigarh were combined together for the analysis. The results of analysis are shown below. Table 9 shows the summary of factor analysis with KMO value, Cronbach's alpha and significance of correlation coefficient. The pedestrian perception data about the level of service gained using various attributes were reduced to an eight-factor solution. This eight-factor solution had an eigenvalue greater than one and it explained a satisfactory variance of 76.19%. The Bartlett test got a significant value ($p<0.001$) of 1477.00 that confirmed the overall significance of correlation matrix. KMO value of 0.67 indicates that sampling is adequate. Cronbach's Alpha coefficient of 0.771 indicates the reliability and internal consistency of the variables for residential land use.

Table 9. Summary of Factor Analysis

Analytic Strategy	Values
Cronbach's Alpha	0.771
Kaiser Measure of Sampling Adequacy (KMO)	0.672
Bartlett test of sphericity	
Chi-square	1477.902
DF	378
Significance	0.000

Table 10 provides the results of the best stepwise regression model for residential land use. This analysis translates respondents' answers into numerical values. Each factors are weighted by coefficients derived from Stepwise regression analysis. The correlation coefficient (R^2) of the best-fit model is 0.6085 based on the perceptions of pedestrians from residential land use. The coefficients are statistically significant at the 95 percent confidence level. Residential model can be represented in mathematical form as shown in equation 1.

Table 10. Regression results of pedestrian perception based on residential land use

Model Variables	Unstandardized Coefficients		Standardized Coefficients	T	Model R Square value	Sig.
	B	Std. Error	Beta			
(Constant)	2.399	.639		3.758		.000
ACC3	.247	.063	.426	3.937		.000
COM1	-.263	.067	-.372	-3.909		.000
ACC6	.307	.079	.351	3.891		.000
TRA2	.321	.078	.417	4.089		.000
TRA5	-.266	.095	-.251	-2.796	0.60	.007
TRA6	.330	.088	.390	3.766		.000
COM6	-.341	.102	-.300	-3.332		.001
ACC7	-.294	.093	-.306	-3.142		.002
ACC2	.269	.106	.272	2.533		.014

$$Y = 2.399 + 0.247X_1 - 0.263X_2 + 0.307X_3 + 0.321X_4 - 0.266X_5 + 0.330X_6 - 0.341X_7 - 0.294X_8 + 0.269X_9 \quad (1)$$

Where,
Y = Walkability
X_1 = Walkable distance to bus stops (ACC3)
X_2 = Cleanliness of sidewalk (COM1)
X_3 = Another pedestrian access point (ACC6)
X_4 = Potential for vehicle conflict (TRA2)
X_5 = Traffic speed (TRA5)
X_6 = Convenience for people crossing (TRA6)
X_7 = Curb cut (COM6)
X_8 = Two – way movement of pedestrian (ACC7)
X_9 = Walkable distance to commercial area (ACC2)

5. DISCUSSION

The terms of the model were developed and refined through extensive regression and transformation testing. The T-test results indicated that all independent variables are statistical significant. The nine variables from the model exhibits positive and negative relationship with walkability. In a developing country like India, most of the people depends on the public transportation for their daily travel and most of the public transport users access their bus stops by walking. Thus walking gives the travelers not only transportation options but also provides them continuity from home to destination via bus stops. Hence walkable distance to bus stops is one of the important factor of the walkability of road environment. In general, presence of walkable distance to bus stops will result in the improvement in walkability. The factor 'cleanliness of sidewalks' is one of the important factor to be considered while explaining about the walkability and level of service of walking environment. In many previous studies the factor has highly influenced the walkability (Parida, 2007; Sarkar, 2002). In this study the 'Cleanliness of sidewalks' has a counterintuitive negative coefficient with walkability which may be explained by the reality that walking on the sidewalks in Hisar and Chandigarh is an option rather than an obligation; people walks on road sides rather than the sidewalk to avoid littered, low quality sidewalks.

Walkability is positively affected by the variable named as 'another pedestrian access point'. Many access points for pedestrians to reach at the destination without facing any inconvenience can always increase walkability of the environment. Having a safe walk from vehicle conflict along road side is one of the basic necessity of the pedestrian. The model results confirms that improving pedestrian perceptions with the condition of sidewalk in terms of potential to vehicle conflict intuitively by reducing potential vehicle conflicts by providing lateral separation between sidewalks and road, raised sidewalks, guard rails, etc. would have a positive effect on walkability.

As expected traffic speed has got a negative influence on walkability confirming speed of vehicular traffic significantly affects pedestrians' sense of safety there by walkability. The pedestrian discomfort increases with the speed of the traffic similar to that relationship found by many of the previous studies (Landis, 2001). The presence of crossing facilities like zebra crossings and convenience of pedestrians in using those facilities has got a positive effect on walkability. Therefore, conveniently crossing the road increases the walkability also. The variable 'curb cuts' has got negative coefficient with walkability. Provision of curb cut can improve the walkability for physically disabled pedestrians (i.e. wheel chair users). Along with this, uncontrolled access of the two wheeler to the sidewalk or footpath through these curb cuts has resulted in negative influence to walkability. As per the Pedestrian's perception it becomes the issue of safety when the two wheelers access the sidewalks through low curb cuts along roadway segments that consequently affects the walkability of the environment.

Two-way movement of people along sidewalks negatively affects walkability as it affects the easiness in mobility along sidewalks. The sidewalks becomes congested and the absence of separation between two-way movements of the pedestrians can cause discomfort to walk. The ninth variable that affected walkability is 'walkable distance to commercial areas' has got positive coefficient with walkability. Proximity to markets areas, grocery, shops etc. can encourage the people to walk. At less walkable distance to commercial areas, the walkability of the environment gets enhanced.

6. CONCLUSION AND RECOMMENDATIONS

The study focused on developing a walkability model by assessing pedestrian perceptions on performance of existing sidewalks from two Indian cities (Hisar and Chandigarh) based on various parameters of sidewalk which includes its physical and user characteristics. First stepwise regression was conducted to identify the factors affecting walkability based on location wise. The results of the analysis produced low R-square value for the developed model for walkability. Later the analysis was conducted based on land use of the study area. The perceptions collected from residential land use area of the two cities are used in the model that give best models of walkability. This study also confirms the importance of considering land uses while conducting pedestrian studies. As sidewalks from different land uses serves differently because of the varying pedestrian traffic and pedestrian behavior. Consequently, it affects the pedestrian perceptions on various factors of walk environment. Moreover, pedestrian movement is directly affected by type and purpose of trip which is further depended on surrounding land use activities.

Considering pedestrian perceptions on safety from traffic, safety from crime, pedestrian convenience, sidewalks infrastructure and accessibility, a walkability model is developed by analysing the relationship among walkability and the various variables defined under these factors. Finally, a walkability model with nine significant independent variables were defined. traffic speed, convenience of people crossing, potential for vehicle conflict, cleanliness of sidewalks, curb cuts, walkable distance to commercial area and bus stops, pedestrian access points, two way movements of pedestrians are the factors that influences walkability in residential areas of two cities.

Even though there are many studies that developed walkability model using macroscopic factors like residential density, intersection density, proximity, connectivity etc. (Frank et. al, 2010, Kim et. al., 2014), only limited walkability studies have included microscopic sidewalk elements. Research results also implies that walkability can be improved by giving more attention to the factors considered in the walkability model such as by reducing traffic speed along residential areas of the two cities which can be implied by enforcing traffic rules and installing speed limit sign boards along the sidewalks. Also by providing guard rails and raised sidewalks, the potential pedestrian-vehicle conflict can be reduced by improving safety for pedestrians can positively affect in improving walkability. Providing more crossing facilities can thus increase the convenience of pedestrians in crossing which, in turn, can also improve the walkability. The results of the study can be applied in residential land use of other cities similar to Hisar and Chandigarh. This study can be extended by developing different models for walkability analysis of sidewalk based on different land uses (i.e. commercial land use, terminal land use etc.) and gender difference also.

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