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To cite this article: S. Nasrin and F. Afifah 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **527** 012073

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Walkability assessment tool for a developing country

S. Nasrin*¹ and F. Afifah¹

¹ Department of Civil Engineering, University of Asia Pacific, Dhaka, Bangladesh.

*Corresponding author e-mail: snasrin@uap-bd.edu

Abstract. In Dhaka, which is the capital city of Bangladesh, significant percentages of commuters walk to meet their daily commuting demand. However, there is scarcity of research in Dhaka for walkability assessment. This research tried to overcome that scarcity by developing a measurement tool to assess the walking environment. Methodological approach adopted by this research is the combination of subjective and objective method. Assessment results were converted into 1-point scale. Results showed that Dhaka is seriously lack of good quality footpath and disable facilities. Excessive noise pollution is also one of the significant issues for pedestrians in Dhaka. Any other similar cities walking environment can be assessed by this approach.

1. Introduction

Walking, a sustainable transport choice is good for health, good for the environment, good for the community, good for the economy and good for kids. In Dhaka, which is the capital of Bangladesh, significant percentages of commuters walk to meet their daily commuting demand. Among those who walk, mostly comprised a low-income group with income less than 12,500 BDT (about 150 USD) (about 73%) [1-3]. Lack of safety in the city for pedestrians are rising as most of the victims from road casualties are pedestrians. Statistics showed that from 2007 to 2011, 60 per cent of the road accident and fatality victims were among the pedestrians of Dhaka [4-5]. Alarming the percentages of walk mode share actually have been decreased about 40% from year 1994 to 2009 for Dhaka (in 1994 walk mode share was 60% and in 2010 19%) [1,6]. This is mainly due to lack of effective pedestrian facilities and safety promotions or measures. While developed countries are encouraging people to attain more active mode, such as walking or cycling, this situation in Dhaka is not acceptable.

To reduce the number of accidents and encourage people to walk, pedestrian planning standard has to be developed. In order to develop pedestrian planning standards for Dhaka, it is mandatory to conduct a study on local pedestrian environment characteristics. However, not many researches had been conducted to assess the walking environment in Dhaka. The prime aim of this research is to assess the walking environment in Dhaka. Research questions that will be answered by this research are 1) How is the overall pedestrian environment in Dhaka? and 2) Can a measurement scale be developed to assess the walking condition in Dhaka?

2. Literature review

“Walkability” is a term used to describe and measure the connectivity and quality of walkways, footpaths, or sidewalks in cities and it can be measured through a comprehensive assessment of available infrastructure for pedestrians [5]. According to Litman [7], walking can provide benefit from several dimensions, such as economic, social and environmental. In many developing countries including



Bangladesh, walking is the dominant mode of transportation option. Therefore, significant measures should be taken to improve the walking environment.

Mehta, Sisiopiku and Akin, and Villaveces *et al.* [8-10] in their research found that useful pedestrian facilities with sense of belonging and enjoyable walking environment, and proximity to public transport are some of the important criterion for pedestrians in US cities.

Similarly, proximity of destinations, good weather condition, safety, well-designed pedestrian facilities, comfort, convenience and safety are some of the factors that contribute to better perceptions of the walking environment for Kuala Lumpur and Beijing [11-13].

Through logit choice analysis, Fillone [14] found out that the access and/or egress time, cost over travel time, safety, and accessibility of the walking environment are some of the significant factors for commuters' decision to walk or use Pedicab in Ermita district of Manila.

Rankavat *et al.* [15] indicated that female respondents consider street lighting is one of the important factors to walk in Delhi, India. This is mainly because women commuters are comparatively more vulnerable than men commuters. Similar situation is prevalent in Bangladesh. Even though significant pedestrians are female in Dhaka, insecurity on walkways because of social problems (verbal abuse towards female pedestrians), is one of the major obstacle women commuters face while walking on road [16].

In another study, Kadali and Vedagiri [17] concluded that the rolling gap, driver yielding behaviour and frequency of attempt plays an important role in pedestrian uncontrolled road crossing in Hyderabad, India.

From the literature review, it can be understood that safety, convenience, distance and moreover sense of belonging are some of the main criteria for pedestrians to walk regardless the research conducted in different cities. However, the perception of walking environment may be different from countries to countries. Not many researchers have revealed the perception of walking environment in Dhaka. This paper will try to overcome that scarcity by comparing different parameters on a common measurement scale to understand the walking environment in Dhaka.

3. Methodology

The methodology used in this study is based on the Global Walkability Index (GWI), developed by H. Krambeck for the World Bank [18]. The GWI method provides a qualitative analysis of walking conditions including safety, security, and convenience of the pedestrian environment and surveyor ranked/scored each segment based on the surveyors' (or pedestrians') judgment. Walkability Audit based on pedestrians' perception is well known approach to understand the condition of walking environment.

Researchers from different countries worked on pedestrian and walkability issues in context of developed and developing countries, among them many of them adopted the methodological approach of interview, questionnaire survey and walkability audit [8-15, 17].

Methodological approaches adopted for this research are:

- The walkability audit for the current study comprises both the subjective (assessment based on personal judgement as there is not countable measure, i.e., surveyors visually observed then assessed whether footpath is 100% or 50% broken) and the objective (surveyors counted and measured the extent of impacts of criteria, i.e., surveyors counted the traffic safety measures or devices) assessment of availability and features of pedestrian infrastructures. A scale has been developed for each criteria of the specified parameters. Increasing values of weight and rating of parameters means the condition of footpath is increasing as well.
- Based on local knowledge and reconnaissance survey of 49 segments of four areas in North Dhaka City Corporation (NCC) (Gulshan and College Gate) and in South Dhaka City Corporation (SCC) (Newmarket and Gulistan), have been selected as the study areas. To eradicate bias, study areas were chosen from different land use areas, such as diplomatic zone

(Gulshan), commercial (Gulistan and Newmarket) and mixed land use zone (College Gate) respectively.

- Surveyors carried out the field survey by visiting streets of different segments both during day and night time.
- The segments of the streets were surveyed using the parameters listed in the Table 1 (parameters are based on the researcher's interpretation of the parameters in the GWI, explicitly walking path modal conflict, security from crime (i.e., lighting), crossing safety, motorist behaviour, pedestrian amenities, maintenance and cleanliness, disability infrastructure, obstructions, availability of crossings and traffic safety measures/devices). Surveyors' assessed the segments and measured the extent of impact of the parameters on the segment. Each criterion of their relevant parameters was weighted based on their importance. Weighing method adopted based on different guidelines and logical reasoning [19-22].
- Each criterion of their relevant parameters was weighted based on their importance. Weighing method adopted based on different guidelines and logical reasoning [19-22]. Maximum weight was assigned for the most desired option of criteria (Table 1, column 3)
- Based on the extent of impact, the parameters were rated (Rating Method: for 0% impact= 0, for 1%-10% impact =1, for 11%-20% impact=2, for 21%-30% impact=3. For 31%-40% impact =4, for 41%-50% impact= 5, for 51%-60% impact=6, for 61%-70% impact =7, for 71%-80% impact =8, for 81%-90% impact =9, for 91%-100% impact =10) (Table 1, Column 6).
- Each division of criterion was scored (Score= Rating* Weight). Then total score was added to know the score achieved for the respective criteria.
- All score was converted into 1-point scale by the equation 1:

$$\text{Score in 1 – Point Scale} = \frac{\text{Achieved Score}}{\text{Maximum Score}} \dots\dots\dots (1)$$

4. Analysis

In Table 1 assessment methods, rating and scoring for the criteria of each parameters is listed. For assessment, various design guidelines have been considered [19-22].

Table 1. Rating and scoring the criteria for different parameters.

Parameter	Criteria	Assessment Method for Criteria	Weight of Criteria	Average Percentages of Segments Impacted with Different Criteria (Method mentioned in the column 3)	Rating ^a	Score = (weight* rating)	Max Possible Score (Max Rating ^{b*} Weight)	Score at 1 Point Scale (Score/Max Total Score)
Footpath Presence	Footpath in one side	Visual Observation (Count segment with the criterion)	1 – Less weight as footpath only in one side.	10%	1	1	10	
	Footpath in both side	Visual Observation (Count the segment with the criterion)	2 - Higher weight as footpath should be in both direction	83%	9	18	20	0.63
	No footpath	Visual Observation (Count the segment with the criterion)	0 – 0 as no footpath.	6%	0	0	0	
	Complete footpath in one side	Visual Observation (Count the segment with the criterion)	1 – As completed only in one side less weight.	12%	2	2	10	
	Complete footpath in both side	Visual Observation (Count the segment with the criterion)	2 – As completed in both side pedestrians can walk freely, so higher weight [20-22].	80%	8	16	20	0.60
	Not completed ¹	Visual Observation (Count the segment with the criterion)	0 – As not completed in any direction no weight.	9%	0	0	0	
	No Buffer Available	Visual Observation (Count the segment with buffer)	0 – No weight as no buffer for extra safety.	100%	10	0	0	
	Buffer Available	Visual Observation (Count the segment without buffer)	1 – Higher weight as buffer should be available to provide barrier for moving vehicles from splashing pedestrians [19-22]	0%	0	0	10	0.00
	Any paving materials (slab, brick, concrete, tactile, tile) used	Observe and count different types of materials	1 – Higher weight as pavement materials used. According to Indian Road Congress (2012) footpath should be made with non-skid/matt finish tiles, interlocking paving tiles, unpolished stone, tiles and pavement quality concrete [20].	96%	10	10	10	1
	No paving material Used	Observe and count segments without any paving materials	0- No weight as no paving materials used.	4%	0	0	0	
Quality of Footpath	Width- 2 ft to 4 ft	Measure width	1 - Minimum weight as very narrow footpath.	20	2	2	10	0.38

Parameter	Criteria	Assessment Method for Criteria	Weight of Criteria	Average Percentages of Segments Impacted with Different Criteria (Method mentioned in the column 3)	Rating ^a	Score = (weight* rating)	Max Possible Score (Max Rating ^{b*} Weight)	Score at 1 Point Scale (Score/Max Total Score)
	Width 4 ft to 6 ft	Measure width	2 – Less weight as width do not meet standard and there is no space for wheelchair to pass. 3- Higher weight as the minimum width of a clear unobstructed pathway (through route) should be 1800 mm (6 ft) in roads of right of way of 10 m or above [20].	28	3	6	20	
	Width more than 6 ft	Measure width		46	5	15	30	
	No Footpath		0- No weight	6	0	0	0	
	Footpath Condition- Poor	Poor	1- Less weight as almost whole segment is dirty	29%	3	3	10	
	Footpath Condition- Fair	Fair	2-Medium weight as 50% (half) of segment is clean	51%	6	12	20	0.35
	Footpath Condition- Good	Good	3 Higher weight as about 100% (whole segment) is clean.	14%	2	6	30	
	No Footpath		0	6%	0	0	0	
	Footpath Obstructed	Visual Observation	1 – Less weight as footpath is somehow obstructed with garbage, construction materials, pillars or vendors' presence.	93%	10	10	10	0.4
	Footpath Not Obstructed	Visual Observation	2 – Higher weight as footpath should be free from obstruction for pedestrian walking.	7%	1	2	20	
	Leave Footpath	Often	1 – Least weight as left footpath due to obstruction (from ≥ 4 times)	33%	2	2	10	
	Leave Footpath	Sometimes	2 - Medium weight left footpath due to obstruction (From 1 to 3 times leave footpath)	41%	4	8	20	0.41
	Leave Footpath		3 – Higher weight as never left footpath due to obstruction	18%	5	15	30	
	Cannot walk on footpath as whole segment is obstructed	Always on road due to obstruction	0 – No weight as footpath is fully obstructed and not possible to walk.	5%	0	0	0	
	Clean Footpath		1	0%	0	0	10	0
	Dirt or Garbage on footpath		0	100%	10	0	0	
	Extent of Clean footpath	Poor	1 - Least weight as segment is fully broken, fully obstructed, smelly	21%	3.00	3.00	10	0.33
	Extent of Clean Footpath	fair	2- Medium weight as segment is 50% broken, 50% obstructed and somewhat smelly	63%	7.00	14.00	20	

Parameter	Criteria	Assessment Method for Criteria	Weight of Criteria	Average Percentages of Segments Impacted with Different Criteria (Method mentioned in the column 3)	Rating ^a	Score = (weight* rating)	Max Possible Score (Max Rating ^{b*} Weight)	Score at 1 Point Scale (Score/Max Total Score)
Safety	Extent of Clean Footpath	good	3 - Highest weight as segment is about 100% unbroken, and no obstruction and not smelly at all	9%	1.00	3.00	30	
	No Footpath							
	Drivers aggressively driving the car – Yes	Visual Observation	0- Less weight as segment has more aggressive drivers	8%	1.00	0.00	0	
	Drivers Aggressively Driving the Car- No	Visual Observation	1- Higher weight as segment has less aggressive drivers	45%	5	0	0	0.60
	Traffic Controlling Device – Yes	Count segments with different traffic controlling devices	1- Higher weight if segments have at least 1 traffic controlling device.	55%	6	6	10	
	Traffic Controlling Device- No	Count segments with different traffic controlling devices	0-Less weight as segments do not have any traffic controlling device	63%	7	7	10	0.70
	Crossing Aid for Pedestrians – Yes	Count Segments		37%	4	0	0	
	Crossing Aid for Pedestrians – No	Count Segments		57%	6	6	10	0.60
	Barriers to Cross the Street – Yes	Count Segments with the criterion		43%	5	0	0	
	Barriers to Cross the Street – No	Count Segments without the criterion		57%	6	6	10	0.60
Disable Facility	Footpath accessible for Wheelchair Person- Yes	Count Segments with the criterion		43%	5	0	0	
	Footpath accessible for Wheelchair Person- No	Count Segments without the criterion		6%	1	1	10	0.10
	Tactile Used in whole Footpath – Directional	Assess and observe types of tactile	2 -As in whole footpath directional tactile should be used, this criteria has higher weight [19-22].	94%	10	0	0	
	Tactile Used in whole Footpath- Blister (As Blister Should be Used only at the Edge or if there is discontinuity, this criteria has lesser weight)	Assess and observe types of tactile	1- As Blister Should be Used only at the Edge or if there is discontinuity, this criteria has lesser weight [19-22].	39%	4	8	20	
	No Tactile Used in Whole Footpath		0 – As Footpath should be accessible by everyone. No weight if no tactile is provided in whole footpath.	4%	1	1	10	0.30
				56%	6	0	0	

Parameter	Criteria	Assessment Method for Criteria	Weight of Criteria	Average Percentages of Segments Impacted with Different Criteria (Method mentioned in the column 3)	Rating ^a	Score = (weight* rating)	Max Possible Score (Max Rating ^{b*} Weight)	Score at 1 Point Scale (Score/Max Total Score)
Social and Environmental Friendliness	Free From Noise Pollution	No Pollution - Based on surveyors' judgment assessed extent of noise pollution	3 - As no noise pollution assigned higher weight	2%	1	3	30	
	Free From Noise Pollution	A little- Based on surveyors' judgment assessed extent of noise pollution	2- As little noise pollution assigned medium weight	16%	2	4	20	0.17
	Free From Noise Pollution	Some -Based on surveyors' judgment assessed extent of noise pollution	1- as some, significantly lower weight assigned	25%	3	3	10	
	Free From Noise Pollution	A lot- Based on surveyors' judgment assessed extent of noise pollution	0 As lot of exposure to noise pollution assigned weight of 0.	57%	6	0	0	
	Friendly Environment - Yes	Assess pedestrians' attitude	1	79%	8	8	10	0.8
	Friendly Environment - No	Assess pedestrians' attitude	0	21%	3	0	0	
	Service Amenities-Present	Count segments with different service amenities (seating arrangement, toilet, trash bin, and vendor)	1 - assigned weight of 1 if any service amenities present	25%	3	3	10	0.30
	Service Amenities- Absent	Count segments without different service amenities	0 - no value as no service amenities present	75%	8	0	0	
	Light Availability- Road Oriented	Observe type of lighting	2- As for pedestrian road -oriented light is not favorable. However, 3 as pedestrian lighting more favorable for pedestrians, weight is higher	52%	6	12	20	
	Light Availability- Pedestrian Oriented	Observe type of lighting		0%	0	0	30	0.34
	Light Availability- Other No Lighting	Observe type of lighting	1	48%	5	5	10	
			0	0%	0	0	0	

^a Rating: 0% = 0, 1%-10% = 1, 11%-20% = 2, 21%-30% = 3, 31%-40% = 4, 41%-50% = 5, 51%-60% = 6, 61%-70% = 7, 71%-80% = 8, 81%-90% = 9, 91%-100% = 10.

^b For any criteria maximum rating will be 10.

A sample calculation for the parameter “Free from Noise Pollution” is provided in Table 2.

Table 2. Sample calculation for the parameter “free from noise pollution”.

Different Criteria for “Free From Noise Pollution”	% of Segment Impacted at New Market	% of Segments Impacted at College Gate	% of Segments Impacted at Gulistan	% of Segment Impacted at Gulshan	Average % of Segments Impacted	Rating ^a	Weight	Score = Rating * Weight	Max Possible Score (Max Rating that a parameter can achieve* Weight)	Score for the “Free From Noise Pollution” at 1 point scale (Score Attained/Max Total Score that a criteria can Achieve for a Segment)
None	9%	0%	0%	0%	2%	1	3	3	30	0.17
A little	9%	47%	0%	8%	16%	2	2	4	20	
Some	0%	24%	0%	75%	25%	3	1	3	10	
A lot	82%	29%	100%	17%	57%	6	0	0	0	
								Total Score for this Parameter = 10	Total Maximum score that could have achieved for this parameter = 60	

^aRating: 0% = 0, 1%-10% = 1, 11%-20% = 2, 21%-30% = 3, 31%-40% = 4, 41%-50% = 5, 51%-60% = 6, 61%-70% = 7, 71%-80% = 8, 81%-90% = 9, 91%-100% = 10.

Figure 1 illustrates the comparison of different criteria for the parameter’s quality in 1-point scale. Width of footpath scored less than 0.2 as very few footpaths meet the international standard of the minimum required width [19-21].

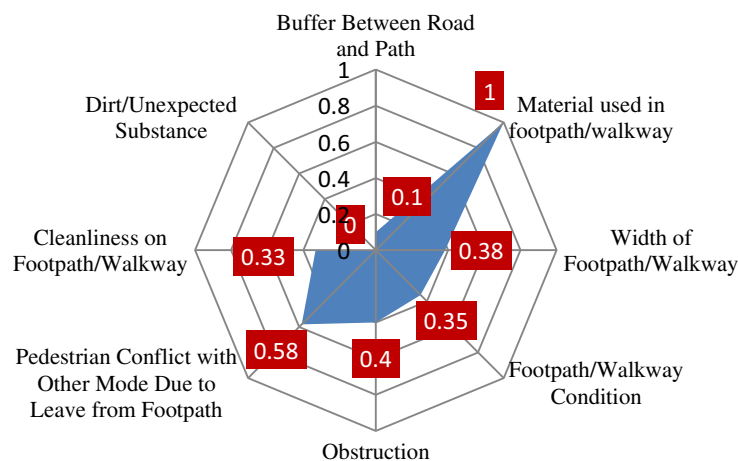


Figure 1. Comparison of different criteria for quality of footpath.

Figure 2 illustrates the comparative assessment of different criteria to achieve disable friendly pedestrian environment. From the figure, it can be understood that most of the time, tactile

implementation did not consider design guidelines. Footpaths in Dhaka are not disable friendly at all, as all criteria scored significantly low.

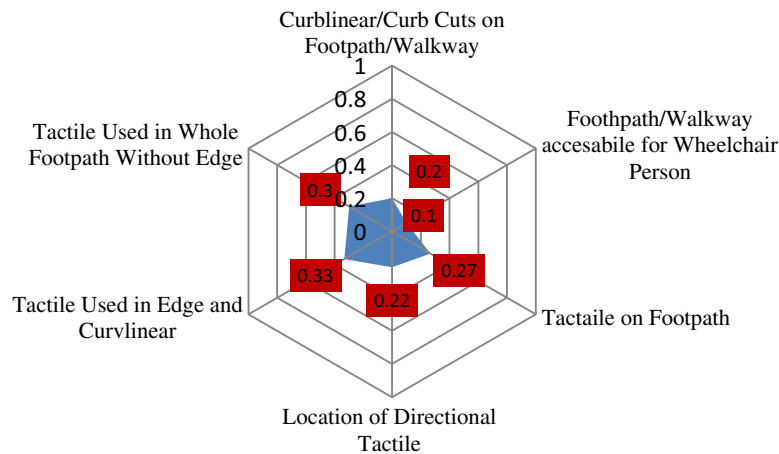


Figure 2. Comparison of different criteria for availability of disabled facility.

Figure 3 illustrates the comparative assessment of different criteria of the parameter “social and environment friendliness”. As the score of the “free from noise pollution” is severely low it can be understood, that exposure to significant noise pollution can cause serious health hazard to pedestrians. With inadequate pedestrian lighting and service amenities, Dhaka’s footpaths are unsafe and less comfortable. From the analysis, it can be understood that pedestrians’ attitude to each other is friendly.

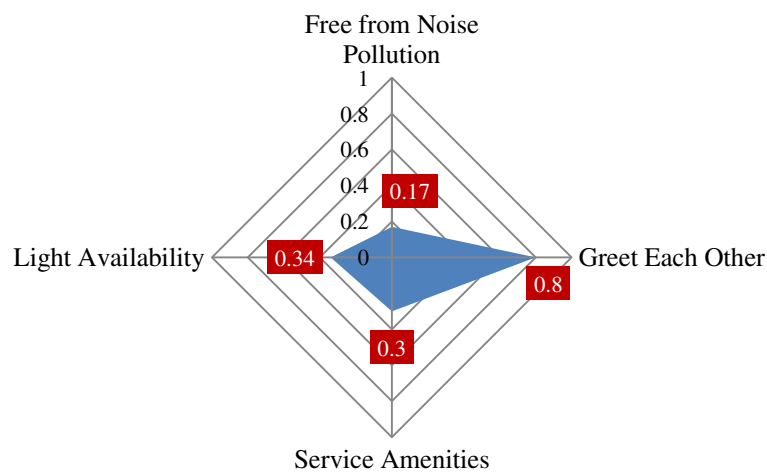


Figure 3. Comparison of different criteria for social and environmental friendliness.

Figure 4 illustrates the comparative assessments of different criteria for the parameter “Road Safety”. Figure revealed that criterion for the parameter safety achieved higher score than criterion for other parameters. However, driving aggressively is the negative criteria for the parameter. Therefore, unlike other criterion increased value would reflect negative impact on the parameter. Even though the score

of the parameters are higher, due to greater percentages of pedestrian accident, it can be concluded that either road safety devices are not implemented properly or there is scarcity of road safety awareness among the pedestrians. In any case, there is no doubt that it needs Government's intervention to improve the situation.

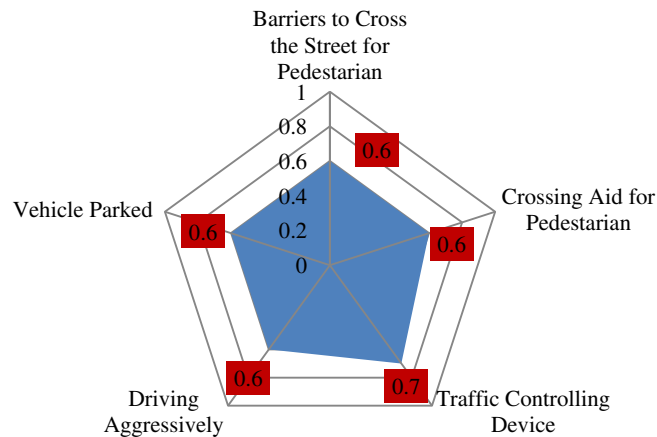


Figure 4. Comparison of different criteria for safety.

Figure 5 illustrates the comparison of different parameters with the average score of criteria for those respective parameters.

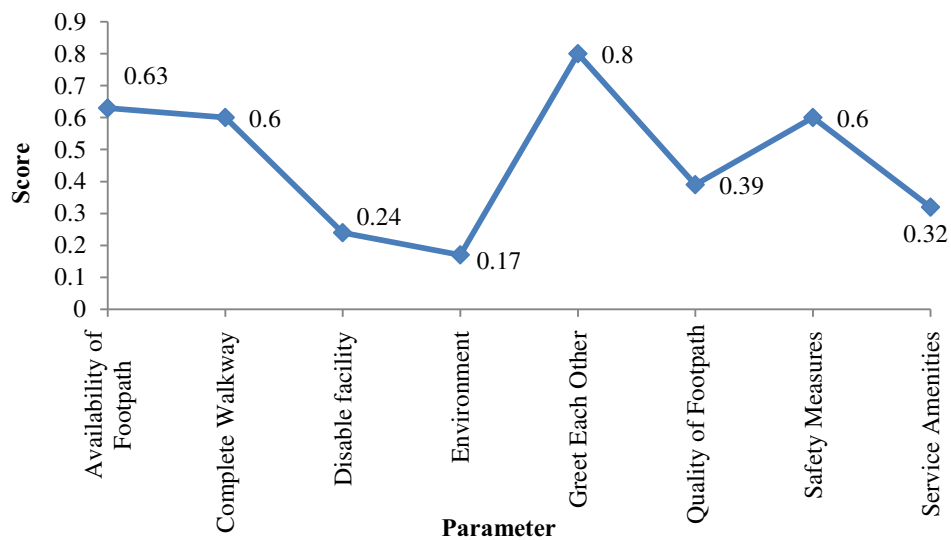


Figure 5. Comparative assessment of different parameters.

5. Conclusion

In this research, a measurement tool has been developed to assess the walking condition in Dhaka. Measurement tool is simple; rating and weighing criteria for the respective parameters are straightforward and explained. Even though the assessment methodology is influenced by Global Walkability Index (GWI) method, still this research took a further step by assessing the footpath condition with the percentages of segment impacted by the parameters. In the GWI method surveyors ranked the parameters based on their personal judgement. Even though the scoring method is arbitrary, still as the scoring criteria are logically justified it can be adopted for whole city or other cities in Bangladesh to understand the walking environment. Other developing country's cities with similar characteristics also can adopt the methodology.

Assessing Dhaka's footpath condition with the measurement tool revealed that Dhaka's footpaths do not meet the international standard. With dirt and garbage everywhere sometimes it's difficult for pedestrians to walk on footpath. Especially there is negligible provision for disable people. While there is a very high modal share for walking in Dhaka, little attention has been or is being, paid to this important mode of transportation in existing transport plans. Some of the limitations of this research are limited numbers of segment assessment, not considering pedestrian opinion in the analysis, and not considering crossing methods.

6. References

- [1] Japan International Corporation Agency, Katahira & Engineers International, Oriental Consultants Co. Ltd. and Mitsubishi Research Institute Inc. 2010 Preparatory survey report on Dhaka urban transport network development study in Bangladesh Government of the People's Republic of Bangladesh
- [2] Hoque M M, Barua S, Ahsan H M and Alam, D 2012 BRT in Metro Dhaka: towards achieving a sustainable urban public transport system *Proceedings of CODATU XV: The Role of Urban Mobility in (re) shaping Cities* 1-11
- [3] Nasrin S 2015 *Acceptability bus rapid transit by commuters' in Dhaka* PhD thesis Queensland University of Technology
- [4] Ahmed I, Ahmed B and Hainin M R 2014 Road Traffic Accident Characteristics in Dhaka, Bangladesh *Jurnal Teknologi* 71(3) 75-82
- [5] Fabian H, Gota S, Mejia A, Leather J and Center A C 2010 Walkability and pedestrian facilities in Asian cities: state and issues *Asian Development Bank, Manila, Philippines*
- [6] Efrogmson D 2012 Dhaka Bus Rapid Transit Walkability Strategy. Sustainable Urban Transport, Technical Assistance Consultant's Report (TA 6350)
- [7] Litman T 2004 Economic value of walkability *World Transport Policy & Practice* 10(1) 5-14
- [8] Mehta V 2008 Walkable streets: pedestrian behavior, perceptions and attitudes *Journal of Urbanism* 1(3) 217-245
- [9] Sisiopiku V P and Akin D 2003 Pedestrian behaviors at and perceptions towards various pedestrian facilities: an examination based on observation and survey data *Transportation Research Part F: Traffic Psychology and Behaviour* 6(4) 249-274
- [10] Villaveces A, Nieto L A, Ortega D, Ríos J F, Medina J J, Gutiérrez M I and Rodríguez D 2012 Pedestrians' perceptions of walkability and safety in relation to the built environment in Cali, Colombia, 2009–10 *Injury prevention* 18(5) 291-297
- [11] Ariffin R N R and Zahari R K 2013 Perceptions of the urban walking environments. *Procedia-Social and Behavioral Sciences* 105 589-597
- [12] Bahari N I, Arshad A K and Yahya Z 2013 March. Assessing the pedestrians' perception of the sidewalk facilities based on pedestrian travel purpose In *2013 IEEE 9th International Colloquium on Signal Processing and its Applications* 27-32
- [13] Guo H, Zhao F, Wang W, Zhou Y, Zhang Y and Wets G 2014 Modeling the perceptions and preferences of pedestrians on crossing facilities *Discrete dynamics in nature and society* 2014 1-8

- [14] Fillone A and Mateo-Babiano I 2018 Do I walk or ride the rickshaw? Examining the factors affecting first-and last-mile trip options in the historic district of Manila (Philippines) *Journal of Transport and Land Use* 11(1) 237-254
- [15] Rankavat S, Tiwari G, & Singla N 2013 Analysis of pedestrian perception towards pedestrian facilities in World Conference Transport Research Group (Rio)
- [16] Rahman M M 2013 *Planning for sustainability of non-motorised public transport in a developing city* Doctoral dissertation, Queensland University of Technology
- [17] Kadali B R and Vedagiri P 2013 Modelling pedestrian road crossing behaviour under mixed traffic condition. *European transport* 55(3) 1-17
- [18] Krambeck H V 2006 *The global walkability index* Doctoral dissertation Massachusetts Institute of Technology
- [19] New Zealand Transport Agency 2009 *Pedestrian planning and design guide* New Zealand.
- [20] Indian Road Congress 2012 Guidelines for Pedestrian Facilities (First Revision) Indian Road Congress (New Delhi)
- [21] Jani A and Kost C 2013 Footpath Design A Guide to Creating Footpaths that are safe, comfortable and easy to use Institute for Transportation and Development Policy
- [22] Maryland Department of Transportation 2017 *Maryland SHA Bicycle and Pedestrian Design Guidelines* (Maryland)