Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

An evaluation of in-service infrastructural facilities of walk-access feeder paths to urban local bus stops

Subhojit Roy[1]; Debasis Basu[1]*

[1]*School of Infrastructure, Indian Institute of Technology Bhubaneswar, Email: sr19@iitbbs.ac.in; dbasu@iitbbs.ac.in*

Abstract

The work documents an experience in evaluation of the in-service infrastructural facility of walk-access feeder paths in the city of Bhubaneswar, India. The work follows a rational approach, whereby the existing infrastructural facilities of walk-access feeder paths to urban local bus stops are evaluated by considering their perceived in-service condition and relative importance to those bus commuters, who undertake walk-mode to access bus stops. Such evaluation framework allows determination of the relative priority among intervention areas by focusing on areas, where bus commuters' perception towards a particular infrastructure is low but its importance is high. In light of this, a two-dimensional analysis is employed considering both the in-service condition and the importance rating of an array of infrastructural attributes. Thereafter, a fuzzy C-means algorithm is employed to identify those infrastructure facilities, which are needed to be looked upon. Overall, the work documents valuable insights in the context of infrastructural facility requirements in walk-access feeder paths in a mid-sized urban area.

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

Keywords: walk-access infrastructural facility; in-service condition; importance rating; fuzzy c-means clustering

1. Introduction

Over last two decades, urban India has undergone a major shift in travel demand due to rapid urbanization, which has triggered a growing imbalance between vehicular demand and supply of road infrastructure. Under this circumstance, an increased use of city bus service (Luk 2003) is understood to improve urban mobility in a sustainable manner. Several works (Maitra and Sadhukhan 2013 a, b; Maitra et al. 2015) with reference to urban India highlighted the need for addressing various soft and hard factors of bus service characteristics including improvement of its access facility for making bus transport service an attractive travel option. However it has been realized that success of bus transport service depends not only on urban transportation network being served by it and its service quality; but also depends to a large extent on accessibility to this service by walk-mode and its related infrastructural facilities (Thompson et al. 2012). Although walk-mode is often considered as a viable transport opportunity to access any public transport such as city bus service (Srinivasan and Rogers 2005), the propensity to use the same is gradually

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY

diminishing in urban India. The effect of this has been felt in the markedly low city bus patronage in mid-sized Indian cities, where firstly the city bus service is not well-developed and also the accessibility to the said service remains poor. In a mid-sized Indian city such as Bhubaneswar, it is found that the patronage for city bus service is as low as 6%. The ridership is however found to be heavily skewed towards other forms of public transport such as shared-auto. The probable cause for this skewed ridership distribution may be attributed to not only the relatively inferior service quality of city bus, but also to the poor accessibility and lack of infrastructural facilities of walk-access feeder paths to urban local bus stops in the city. However, among all the commuters travelling in city bus service in Bhubaneswar, around 75%-80% (IIT Bhubaneswar Un-published Report, 2014) prefer to take the walk mode to access the city bus stops. In view of this, it becomes imperative to carry out a rational evaluation of the existing infrastructural facilities for walk mode on feeder paths to urban local bus stops in order to identify the requirement for their improvement as per bus commuters' preferences.

The requirement of infrastructural facilities in the context of walk-accessibility to public transport passengers has long been recognized in travel behavior research (Frank et al. 2004; Rahul and Verma 2014). Specifically, it is found that urban commuter's willingness to walk and propensity to access public transport service increases if the locality has pedestrian-centric urban forms (Thompson et al. 2012). In this domain of research a wide range of statistical and analytical tools have been employed, such as log-linear regression model (Handy et al. 2005), negative binomial regression (Cao et al. 2006) and ordinary least square regression (Jiang et al. 2012), DELPHI method (Araujo and Braga 2008). However all these studies have been carried out by taking into account bus commuters' perception either on the perceived importance of certain walk infrastructural attributes (Tilahun and Li 2015), or on their current service condition (Roy and Basu 2017). It is evident that the aforementioned studies are mostly one-dimensional in nature, and the inferences drawn may be used for identifying either the road users' desire (in terms of importance), or the adequacy of the service (in terms of the current service condition). However, such one-dimensional analysis often misleads planners and policy makers in terms of rationally identification of intervention areas. In this regard some researchers (Matzler and Sauerwein 2002) have emphasized on the fact that analysis of user perception in the context of rational evaluation of a service should involve an integration of both its importance to the users and also its current service condition as perceived by the users. Such integration allows decision makers to evaluate the relative priority they should place on the various intervention options, by focusing on areas where users' perception towards a particular service is low but its importance to the users is high (Iseki and Taylor 2010).

In light of the above, the current work attempts to evaluate the existing infrastructural facilities of walk-access feeder paths to urban local bus stops by jointly considering both their perceived in-service condition and their relative importance to the bus commuters who access the bus stops by walk-mode. The work is demonstrated with reference to the existing infrastructural facility of walk-access feeder paths to urban bus stops in Bhubaneswar city, India.

2. Elicitation of Users' Perception

In order to evaluate the existing infrastructural facilities of walk-access feeder paths to urban local bus stops in Bhubaneswar, it was necessary to identify an array of possible infrastructural facilities that are predominantly required for a feeder path for the bus commuters to access bus stops by walk-mode. In this regard a thorough literature review was initially carried out, which highlighted various aspects of walk-access feeder paths such as presence of sidewalk (Rastogi and Rao 2003), pedestrian right-of-way (Parida and Parida 2007), presence of ramp facilities (Agarwal et al. 2010), sidewalk shelters (Lovasi et al. 2012) and safety from vehicular traffic (Stoker et al. 2015) etc. Drawing on the experience gained from relevant literature and reconnaissance survey across the study area, a total of 12 survey attributes were selected (Table 1), which were found to be essential requirements of a walk-access feeder path to bus stops, and were found in service in the city of Bhubaneswar.

Table 1. List of attributes pertaining to infrastructural facility of walk-access feeder path

Code	Survey Attributes
P1	Presence of dedicated sidewalk facility for access path
P2	Provision of adequate width for sidewalk or right-of-way i.e. RoW
P3	Crosswalks are present at frequent intervals along the access path
P4	Presence of traffic calming measures like bollards/rumble strips on access road
P5	Presence of kerb ramp
P6	Presence of sitting facility like benches on access path
P7	Presence of temporal shelter from natural elements (sun, rain etc.) on access path
P8	Quality of road surface of the Sidewalk/access path
P9	Presence of street lights on access path
P10	Presence of pedestrian way-finding sign boards
P11	Presence of public awareness and knowledge based messages on access path
P12	Presence of regulatory and informatory signs near schools, offices, hospitals, etc. on your access path

As mentioned before, the work has been carried out by jointly considering both perceived service condition and relative importance of the above mentioned infrastructural facilities according to the bus commuters. Accordingly a survey instrument was designed, using which bus commuters' perception towards the current in-service condition of the selected survey attributes and their importance were measured on a 7 point Likert scale. In order to measure the in-service condition of the selected survey attributes, the questionnaire was prepared in order to ask the survey respondent about how satisfied he/she felt with the said attribute, and the perception was recorded on a 7 point satisfaction scale (where point 1 meant extremely dissatisfied and point 7 meant extremely satisfied). On the other hand, the importance of the said attributes were measured on a 7 point importance scale (where point 1 meant extremely unimportant and point 7 meant extremely important). Apart from the perception data, the survey instrument also included questions regarding respondents' socio-economic and trip-characteristics related information.

In order to elicit the responses from the bus commuters, a specific bus corridor was chosen in the city through which the maximum number of bus routes were found operational. Consequently, this corridor also experiences the maximum boarding and alighting activity of the bus commuters. The study corridor is served by a dense network of feeder and access roads which are usually used by bus commuters for accessing city bus stops by walk mode. A face-to-face survey interview was conducted on such feeder paths near bus stop locations falling on the selected corridor between the months of December, 2017 and February, 2018. As a part of survey administration, the bus commuters were randomly intercepted, and only those respondents are considered who were found to access city bus stops by walk mode. Over the course of the survey, a total of about 717 bus commuters were approached with a request to participate in the survey, out of which only 615 commuters finally agreed. However, due to inconsistency and some incompleteness in filling out of some questionnaires, 510 sample responses have been used to develop the database and further analysis.

3. Analysis of Users' Perception Data

The bus commuters' perception towards in-service condition and importance rating of the 12 survey attributes were recorded by carrying out a comprehensive user perception survey on various feeder paths of a bus service corridor. It may be re-iterated that the work attempts to focus on intervention areas, where users' satisfaction level towards a particular attribute is low, but its importance is high. It requires an analysis on a 2-dimensional plane, where both the in-service condition and the importance rating are jointly considered.

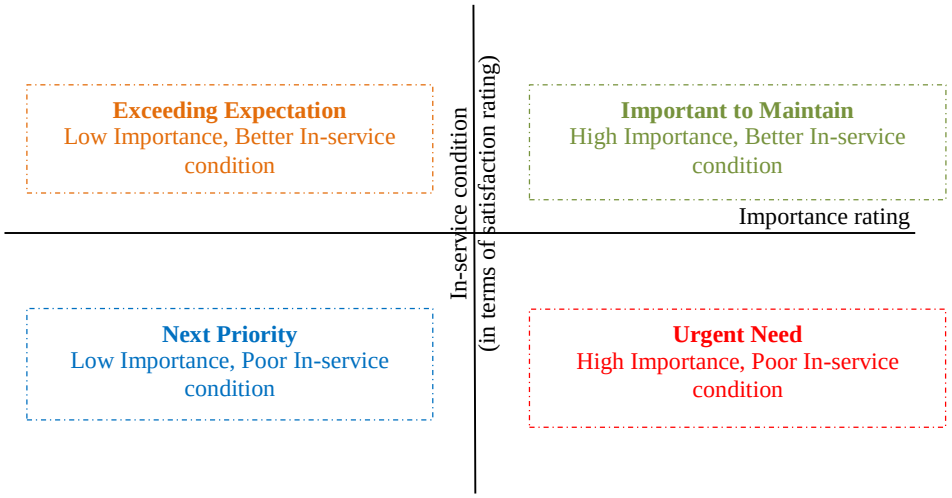

Figure 1. An integrated analysis of bus commuters' perception on in-service condition and importance towards various survey attributes

Such analysis may be carried out by investigating relative position of each of the survey attributes in a 2-dimensional plane (Fig. 1), where the in-service condition is represented by the ordinate of the survey attribute and the importance rating is represented by the abscissa. In order to determine the position of the survey attributes, the sample mean values of the satisfaction levels and importance ratings of each survey attribute over the population responses are estimated using the following set of equations.

$$I = \left\{\overline{i_k} : \overline{i_k} = \frac{\sum_{n=1}^{N} i_{kn}}{N}, k = 1, \dots, number\ of\ items, n = 1, \dots, number\ of\ respondents\right\} \quad (1)$$

$$S = \left\{\overline{s_k} : \overline{s_k} = \frac{\sum_{n=1}^{N} s_{kn}}{N}, k = 1, \dots, number\ of\ items, n = 1, \dots, number\ of\ respondents\right\} \quad (2)$$

In the above equations, the sets I and S represent the set of sample mean values of the importance ratings ($\overline{i_k}$) (which becomes the abscissa) and the satisfaction levels ($\overline{s_k}$) (which becomes the ordinate) respectively for the k th survey attribute. Furthermore, i_{kn} and s_{kn} represent the importance rating and the satisfaction level respectively as perceived by the n^{th} respondent on the k^{th} survey attribute.

Evidently, placement of the survey attributes on the 2-d plane reveals distinct four quadrants, which have much significance in the context of decision making. It is clear that the attributes falling in the bottom-right quadrant (or, the 4th quadrant in Cartesian coordinate system) labelled "Urgent Need", require the highest priority for improvement. This is because while the importance of these attributes are high according to the respondents, their in-service condition (in terms of satisfaction rating) remain quite low. The attributes falling in the 3rd quadrant labelled "Next Priority", warrant intervention next to the category of attributes under "Urgent Need", because even though their in-service condition remain quite poor, their importance to the respondents is also quite low. The attributes with low importance but better in-service condition (labelled "Exceeding Expectation") indicates a "possible overkill" and policy measures could be taken to reduce focus or investment on these attributes in view of economic feasibility. Finally, the attributes falling in the category labelled "Important to Maintain" indicate that the service quality of these are quite satisfactory and it is important to maintain their service condition as the importance of these attributes to the bus commuters is also very high.

In order to classify the attributes into the aforementioned 4 quadrants, it requires judicious placement of the axes of the 2-d plane. The placement of the axes however has been a subject of much debate in contemporary literature (Mount 2000). Often the position of the axes have been determined by aggregating the data in terms of arithmetic mean of the measures of in-service condition and the measures of importance ratings (Ortinau et al. 1989). Such choice of coordinates often leads to contradictions, non-intuitive results, subjective interpretations, and ambiguities etc. (Caber et al. 2012). In this regard, Ban et al. (2016) proposed that the application of a fuzzy C-means clustering algorithm could essentially resolved the ambiguity related to axis placement. In this study, a fuzzy C-means algorithm

is employed in order to rationally identify the 4 quadrants or categories of attributes as described above. The fuzzy c-means algorithm used in line with this study is illustrated by the following sets of equations.

The fuzzy c-means clustering is based on minimization of the following objective function

$$J_m = \sum_{k=1}^{N} \sum_{j=1}^{C} u_{kj}^{m} \, (x_{isk} - c_{isk})^2 \quad (3)$$

In the above equation, m is any real number greater than 1, u_{kj}^{m} is the degree of membership of x_{isk} in the category j, x_{isk} is the k^{th} element (or, attribute) in the 2-dimensional measured data, c_{isk} is the 2-dimension centre of the generated category. Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership u_{kj}^{m} and the cluster centers c_{isk} by

$$u_{kj}^{m} = \frac{1}{\sum_{p=1}^{C} \left(\frac{x_{isk} - c_{isk}}{x_{isk} - c_{isp}} \right)^{\frac{2}{m-1}}} \quad (4)$$

$$c_{isk} = \frac{\sum_{k=1}^{N} u_{kj}^{m} \times x_{isk}}{\sum_{k=1}^{N} u_{kj}^{m}} \quad (5)$$

4. Results and discussion

As described in the previous sections, the bus commuters' perception on the selected survey attributes have been collected in terms of satisfaction towards both their in-service condition and their importance levels. In order to place the survey attributes in a 2-dimensional analysis plane, the sample mean values of the importance ratings and satisfaction levels on each survey attribute are estimated (Table 2). It is evident that most of the survey attributes have recorded a relatively low value of satisfaction rating (below 4), indicating that the bus commuters in Bhubaneswar are mostly dissatisfied with the infrastructural facilities present currently on the walk-access feeder paths. Specifically it is found that bus commuters are mostly dissatisfied with the lack of sitting or resting places along the sidewalk and the lack of public awareness and knowledge based messages on access path. However, the importance of the said attributes is also found to be low according to the perception of the bus commuters.

Table 2. Mean perception ratings towards in-service condition (in terms of satisfaction) and importance of the survey attributes

Attribute Code	Survey Attributes	Mean Satisfaction Rating (S)	Mean Importance Rating (I)
P1	Presence of dedicated sidewalk facility for access path	2.84	5.26
P2	Provision of adequate width for sidewalk or right-of-way i.e. RoW	2.49	5.15
P3	Crosswalks are present at frequent intervals along the access path	2.54	5.50
P4	Presence of traffic calming measures like bollards/rumble strips on access road	4.68	3.55
P5	Presence of kerb ramp	2.44	3.14
P6	Presence of sitting facility like benches on access path	2.20	2.64
P7	Presence of temporal shelter from natural elements (sun, rain etc.) on access path	4.74	2.87
P8	Quality of road surface of the Sidewalk/access path	2.76	5.87
P9	Presence of street lights on access path	3.06	5.36
P10	Presence of pedestrian way-finding sign boards	4.86	4.76
P11	Presence of public awareness and knowledge based messages on access path	2.20	3.87
P12	Presence of regulatory and informatory signs near schools, offices, hospitals, etc. on your access path	4.49	5.12

The two aspects which bus commuters are found to be relatively more satisfied (rating more than 4) are the presence of traffic calming measures and the presence of regulatory and informatory signs near schools, offices, etc. However, while the importance of the latter remains high (i.e., 5.12 importance rating), the importance of the former seem to be quite less (importance rating less than 4). This may be indicative of the fact that traffic movement on the feeder routes used by bus commuters to access city bus stops is quite low, and therefore the requirement of traffic calming measures on these feeder paths is not realized by the survey respondents.

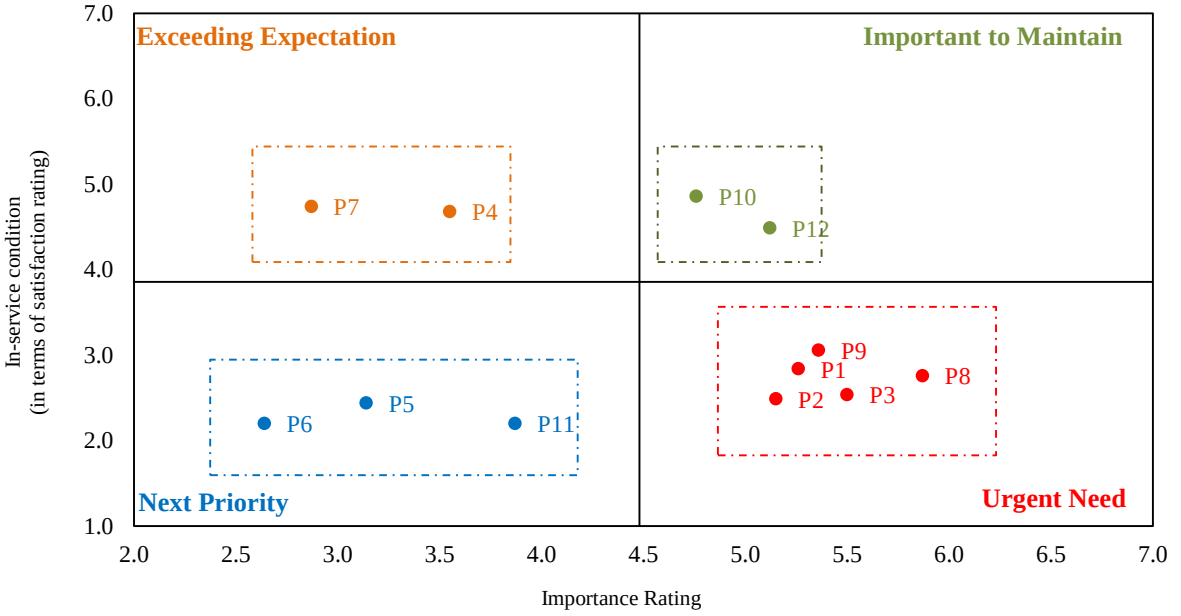

Figure 2. Intervention areas identified for improvement of walk-access infrastructure

Table 3. Fuzzy membership degree for each of the survey attributes

Attribute Code	Survey Attributes	Urgent Need	Next Priority	Imp. to Maintain	Exceeding Expectation
P1	Presence of dedicated sidewalk facility for access path	0.89	0.05	0.03	0.03
P2	Provision of adequate width for sidewalk or right-of-way i.e. RoW	0.92	0.01	0.02	0.05
P3	Crosswalks are present at frequent intervals along the access path	0.94	0.01	0.04	0.01
P4	Presence of traffic calming measures like bollards/rumble strips on access road	0.03	0.05	0.02	0.90
P5	Presence of kerb ramp	0.06	0.79	0.04	0.11
P6	Presence of sitting facility like benches on access path	0.01	0.95	0.02	0.02
P7	Presence of temporal shelter from natural elements (sun, rain etc.) on access path	0.01	0.08	0.07	0.84
P8	Quality of road surface of the Sidewalk/access path	0.85	0.06	0.07	0.02
P9	Presence of street lights on access path	0.83	0.02	0.03	0.12
P10	Presence of pedestrian way-finding sign boards	0.02	0.01	0.91	0.06
P11	Presence of public awareness and knowledge based messages on access path	0.02	0.89	0.05	0.04
P12	Presence of regulatory and informatory signs near schools, offices, hospitals, etc. on your access path	0.06	0.02	0.91	0.01

Fuzzy partitioning of the mean perception ratings towards in-service condition (in terms of satisfaction) and importance of the survey attributes reveals that the optimum axes position for the classification of the 4 categories is at the Cartesian coordinates (4.48, 3.86), as shown in Figure 2. The fuzzy partition matrix is illustrated in the Table 3, which shows the fuzzy membership degree of each survey attribute to the identified 4 categories. The results (refer Fig. 2) indicate that 5 attributes such as presence of dedicated sidewalk facility (P1), width of sidewalk (P2), presence of crosswalks (P3), quality of road surface (P8), and presence of street lights on access path (P9) have the most urgent

need for improvement. It may be intuitively realized that these aforementioned attributes constitute the basic walk-infrastructural requirements considered by commuters undertaking walk-mode to access bus service. The attributes which are found to have the next priority of improvement are presence of kerb ramps (P5), presence of sitting or resting places (P6), and presence of public awareness and knowledge-based messages (P11). These aspects may not be the basic infrastructural requirements for walk-accessibility, but are found to increase the attractiveness of the sidewalk facilities significantly (Seattle DoT 2011). Apart from this, the results indicate that the importance of pedestrian way-finding signboards (P10) and regulatory and informatory signs near public places such as schools, offices, etc. (P12) is not only found well realized by the bus commuters in the city, but their in-service condition is also deemed satisfactory. This suggests that policy decisions should be targeted at maintaining the service condition of these infrastructures, and also possibly implement more of these at other strategic locations on the feeder paths. The in-service condition of the attributes such as presence of traffic calming measures (P4) and presence of temporal shelter from natural elements (P7) are found to be quite satisfactory, even though their importance to the bus commuters is quite low. Even though some literature (Pasanen and Salmivaara, 1993; Sisiopiku and Akin, 2003) highlight the importance of these said attributes, it is also realized that presence of a well-serviced infrastructure often undermines its perceived importance to the end users (Yin et al., 2016). Overall, the study identifies major 5 attributes such as presence of dedicated sidewalk facility, width of sidewalk, presence of crosswalks, quality of road surface, and presence of street lights on access path which need to be improved for the wholesome development of walk-access infrastructural facility on the feeder paths to urban local bus stops in Bhubaneswar.

5. Closure

The success of bus transport service depends not only on urban transportation network being served by it and its service quality; but also depends to a large extent on accessibility to this service by walk-mode and its related infrastructural facilities. In mid-sized urban areas in India, poor infrastructural service condition of walk-access feeder paths to local bus service invariably leads to diminishing propensity of the bus commuters to access bus service by walk mode. In view of this, it becomes imperative to carry out a rational evaluation of the existing infrastructural facilities for walk mode on feeder paths to urban local bus stops in order to identify the requirement for their improvement as per bus commuters' preferences. In order to carry out the work, the evaluation is done by jointly considering their perceived service condition and relative importance to the bus commuters, who access the bus stops by walk-mode. The intervention areas are identified based on the fact that bus commuters' satisfaction towards in-service condition of a particular attribute is low, but its importance is high. The work has been carried out with reference to the existing infrastructural facilities of walk-access feeder path to urban local bus stops in Bhubaneswar city, India.

In order meet the objective, a total of 12 survey attributes were selected, which were found to be existing in the geographical area of the study. A fuzzy c-means partitioning algorithm is employed on stated perception data towards in-service condition of the selected attributes and their importance. The analysis reveals that presence of dedicated sidewalk facility, width of sidewalk, presence of crosswalks, quality of road surface, and presence of street lights on access path are found to be basic infrastructural requirements, which need to be looked upon for overall improvement of feeder paths to urban local bus stops in Bhubaneswar. Apart from these, presence of kerb ramps, presence of sitting or resting places, and presence of public awareness and knowledge-based messages are also found to taken as key consideration, which could increase attractiveness of the sidewalk facilities. As a future scope of the study, the key attributes revealed could be used for carrying out a stated preference study in order to estimate the bus commuters' willingness to pay for improvement of the said infrastructural attributes. Overall, the work provides valuable insights into the infrastructural requirements on walk-access feeder paths in a mid-sized urban area.

Acknowledgements

The database of the current study is developed using funds received from the project grant under the IMPRINT-India initiative Project code # 7094. The fund is jointly supported by the Ministry of Human Resource Development

(MHRD), Govt. of India and the Ministry of Housing and Urban Affairs, Govt. of India. The authors convey their sincere thanks to the supporting Ministries.

References

Agarwal, O. P., 2001. Towards a national urban transport policy. Indian Journal of Transport Management 25.6, 593–616.

Araujo, G., and Braga, M., 2008. Methodology for the qualitative evaluation of pedestrian crossings at road junctions with traffic lights, Transportation, 539-557

Ban, O.I., Ban, A.I. Tuşe, D.A., 2016. Importance–performance analysis by fuzzy C-means algorithm. Expert Systems with Applications 50, 9-16.

Caber, M., Albayrak, T., Matzler, K., 2012. Classification of the destination attributes in the content of competitiveness (by revised importance–performance analysis). Journal of Vacation Marketing 18, 43–56.

Cao, X., Handy, S., Mokhtarian, P., 2006. The influences of the built environment and residential self-selection on pedestrian behavior: evidence from Austin, TX. Transportation 33.1, 1-20.

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.

Handy, S., Cao, X., Mokhtarian, P., 2005. Correlation or causality between the built environment and travel behavior? Evidence from Northern California. Transportation Research Part D: Transport and Environment 10.6, 427-444.

Iseki, H., Taylor, B.D., 2010. Style versus service? An analysis of user perceptions of transit stops and stations. Journal of Public Transportation 13.3, 40-63.

Jiang, Y., Zegras, P.C., Mehndiratta, S., 2012. Walk the line: station context, corridor type and bus rapid transit walk access in Jinan, China. Journal of Transport Geography 20.1, 1-14.

Lovasi, G.S., Schwartz-Soicher, O., Neckerman, K.M., Konty, K., Kerker, B., Quinn, J., Rundle, A., 2012. Aesthetic amenities and safety hazards associated with walking and bicycling for transportation in New York City. Annals of behavioral medicine 45, S76-S85.

Luk, J. Y. K., 2003. Reducing car travel in Australian cities: Review report. Journal of Urban Planning Development, ASCE 129:2(84), 84–96.

Maitra, B., Dandapat, S., Chinakayala, P., 2015. Differences between the perceptions of captive and choice riders toward bus service attributes and the need for segmentation of bus services in urban India. Journal of Urban Planning and Development 141.2, 10.1061/(ASCE)UP.1943-5444.0000205.

Maitra, B., Sadhukhan, S., 2013a. Public transport in the context of urban mobility in India. SHELTER14.2, 52-56.

Maitra, B., Sadhukhan, S., 2013b. Urban public transportation system in the context of climate change mitigation: Emerging Issues and research Needs in India, Mitigating Climate Change. A. Khare and T.Beckman (eds.) Springer Environmental Science and Engineering, 75-91.

Matzler, K., Sauerwein, E., 2002. The factor structure of customer satisfaction: An empirical test of the importance grid and the penalty-reward-contrast analysis. International journal of service industry management 13.4, 314-332.

Mount, D. J., 2000. Determination of significant issues: applying a quantitative method to importance–performance analysis. Journal of Quality Assurance in Hospitality and Tourism 1.3, 49–63.

Ortinau, D. J., Bush, A. J., Bush, R. P., Twible, J. L., 1989. The use of importance–performance analysis for improving the quality of marketing education: Interpreting faculty-course evaluations. Journal of Marketing Research 11, 78–86.

Parida, P., Parida, M., 2007. Development of qualitative evaluation methodology for sidewalks in Delhi, ITPI Journal 4, 27-33.

Pasanen, E., Salmivaara, H., 1993. Driving speeds and pedestrian safety in the city of Helsinki. Traffic Engineering and Control 34, 308–310.

Rahul, T. M., Verma, A., 2014. A study of acceptable trip distances using walking and cycling in Bangalore. Journal of Transport Geography 38, 106-113.

Rastogi, R., Rao, K.V.K., 2003. Defining transit accessibility with environmental inputs. Transportation Research Part D 8, 383-396.

Roy, S., Basu, D., 2017. An approach of examining service condition of sidewalk facility in urban area, 12th Eastern Asia Society of Transportation Studies (EASTS) Conference, 18-21 Sep, 2017, Ho Chi Minh, Vietnam

Seattle Department of Transportation, 2009. Seattle Pedestrian Master Plan, Seattle, USA. http://www.seattle.gov/transportation/pedestrian_masterplan/docs/PMP%20Summary_High%20Res.pdf

Sisiopiku, V.P., Akin, D., 2003. Pedestrian behaviors at and perceptions towards various pedestrian facilities: an examination based on observation and survey data. Transportation Research Part F 6, 249-274.

Srinivasan, M., Rogers, P., 2005. Travel behavior of low-income residents: studying two contrasting locations in the city of Chennai, India. Journal of Transport Geography 13, 265-274.

Stoker, P., Garfinkel-Castro, A., Khayesi, M., Odero, W., Mwangi, M.N., Peden, M., Ewing, R., 2015. Pedestrian safety and the built environment: a review of the risk factors. Journal of Planning Literature 30.4, 377-392.

Thompson, G., Brown, J., Bhattacharya, T., 2012. What really matters for increasing transit ridership: Understanding the determinants of transit ridership demand in Broward County, Florida. Urban Studies 49.15, 3327-3345.

Tilahun, N., Li, M., 2015. Walking Access to Transit Stations: Evaluating Barriers using Stated Preference, TRB 94th Annual Meeting 15-5667.

Yin, J., Cao, X.J., Huang, X., Cao, X., 2016. Applying the IPA–Kano model to examine environmental correlates of residential satisfaction: A case study of Xi'an. Habitat International 53, 461-472.