Khulna University Studies, 8(1): 13-19, 2007

RESEARCH ARTICLE **ENGINEERING & TECHNOLOGY**

MODELING SYSTEM COHERENCE TO KNOW THE PEDESTRIAN'S LEVEL OF SERVICES IN DHAKA CITY

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KUS –06/26-200806

Manuscript received: August 20, 2006; Accepted: April 03, 2007

Abstract: Walking is by far one of the most egress modes of transport. At the same time, pedestrians are the most vulnerable road users in the world because of their openness to the accidents with other motorized modes of transport. However, system coherence is a very important aspect to know the pedestrians' level-of-service in a city so that the policy makers among the engineers can understand the problems of the walkers for specific road way design considerations and maintenance. This paper tries to focus the issues that are very much related with system coherence as a major part of pedestrian's level-of-service assessment technique for Dhaka case as well as put a model so that several data can be analyzed in a single platform to know the relations among several variables. Ordered probit model has been used to make such platform for establishing the relations among several variables. Lastly, some policy options have been proposed to increase the safety of the walkways along with interventions needed for a better walkway design.

Key words: Pedestrians, system coherence, Dhaka, Bangladesh

Introduction

Walking is by far the most important mode of transport, as it not only acts as a crucial link for inter-modal transfers in major activity centers, but also helps to fulfill recreational and utilitarian trips (Sarkar *et al*., 2004). When designing circulation systems, it is important to recognize that walking is not only an integral part of the network, but that it can also fulfill many activities in an environmentally sensitive way. A comfortable environment makes a journey by foot pleasant and enjoyable (Sarkar and Sheila, 2000). However, in Dhaka city, about 60% trips are being made on foot but the pedestrians are facing many problems while using walkways. A lot of research works are going on for assessing the pedestrian's level of services in the developed nations but in developing countries like Bangladesh, it is yet not a very significant one for the transport planners. It is because; the transport planners or researchers are always emphasizing the problems of the motorized vehicles. Besides, budget allocation is not sufficient to continue research in the field of pedestrians. However, the pedestrians are not well aware of their comfort level as well as safety issues. They don't have any place to complain nor even any instructions available for them to use the walkways properly. For instance, the pedestrian's response to this present study regarding their

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DOI: https://doi.org/10.53808/KUS.2007.8.1.0626-E

opinions about safety, security, convenience and comfort, continuity of the walkways, system coherence and the attractiveness of the walkways in Dhaka city and their choices. This study shows an analytical way to summarize their responses so that the planners, engineers, professionals and researchers can understand the present situation of the walkway environment in Dhaka city. Besides, some necessary measures to be taken immediately for combating the possible problems are also suggested in this study.

System coherence is a criterion that can help assessing the walkway condition by offering three sub-criteria. Street type, connectivity and visibility are three sub-criteria that have been fixed here in this paper to evaluate the pedestrian LOS (Level-of-services) in Dhaka City. In some previous studies, it has been noticed that walkers are very much interested to see the present activities just besides the walkways (DCC, 1998). Some rigid walls just beside walkways decrease the LOS and less connectivity with some basic services like: shopping centers, schools and shades of buses (passengers waiting place for buses) also decrease the evaluation of walkways in American and European cities (Sarkar *et al*., 2004). The situation is not likely the same for Dhaka Case as some previous study show that walkers in Dhaka City are very much aware about the social security instead of thinking about design or system coherence (Rahaman, 2004). However, the model proposed in this study can surely help the decision makers to provide the better connectivity of different services from the walkways as well as better facilities to improve visibilities of different activities just beside walkways in Dhaka city.

Present paper tries to investigate two principal objectives- (1) to know the criteria that are responsible for assessing the system coherence of walkways in Dhaka city and, (ii) to estimate a suitable model for better pedestrian level-of-service assessment techniques in Dhaka city.

Materials and Methods

This study is completed with a series of methods that have been applied to estimate the output model. Following figure will show the methodology in brief here in the following figure:

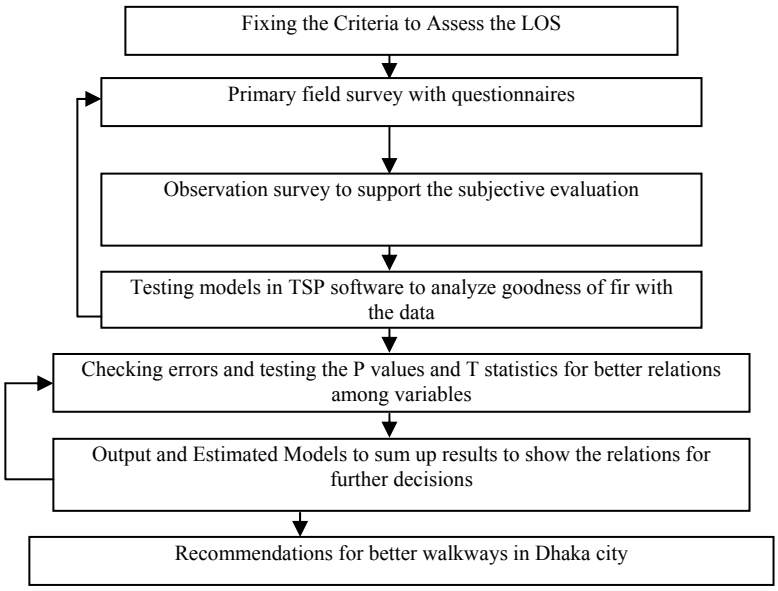

Fig. 1. Flow Chart of the methodology in brief.

First of all, some criteria have been fixed to know which factors are mostly important for assessing the system coherence of pedestrians in Dhaka City as a technique of LOS assessment. Primarily, 4 criteria have been fixed. After the first field investigation, one criterion has been eliminated from the four as that one was quite negligible for further considerations. Afterwards, three criteria: Street Character, visibility and connectivity of the walkways among different services have been included for further proceedings. Primary questionnaire survey was conducted in the month of March, 2005 for the first time to get the socio-economic character of the road users in Dhaka City. Second questionnaire survey was conducted three months later to know the pedestrians' impression for assessing system coherence at a scale of 1 to 5. In that scale, 1 means the best evaluation and 5 means the worst case. However, pedestrians may not consider many aspects that the planners or engineers can consider. For supporting the data, an observation survey with video capturing and photographs in digital modes have been conducted to know the real situation of Dhaka case. After reviewing the observation survey (here named as objective evaluation), a suitable model was identified so that it can incorporate all the data in a single platform for further investigation. Ordered Probit model was found to be more suitable to test the field data with the outcome model by using simple computer algorithm. Lastly, some recommendations have been included to check the evaluation. This will also open up new windows in some other fields of urbanization and transportation to build new models with the help of present one.

Study area: Dhaka, the capital of Bangladesh is located at the central part of the country with having a 10 million population (DCC, 1998). This city is now called one of the mega cities of the world. The urbanites of the city are depending on foot for 60% of their daily trips (DCC, 1998). The figure 2 below shows 5 different blocks that have been selected for the present study. Five blocks offer five different characteristics. For this, the pedestrian's level of service expected to be different. Mohakhali is a transit area for the daily commuters. Here people are coming from the hinterland by bus and then walk for changing to another mode of transport. Farmgate is located at the central part of the Dhaka city area which offers commercial and transit areas for the urbanites and for the commuters as well. Malibagh is a mixed use area with many residential buildings and many shopping areas.

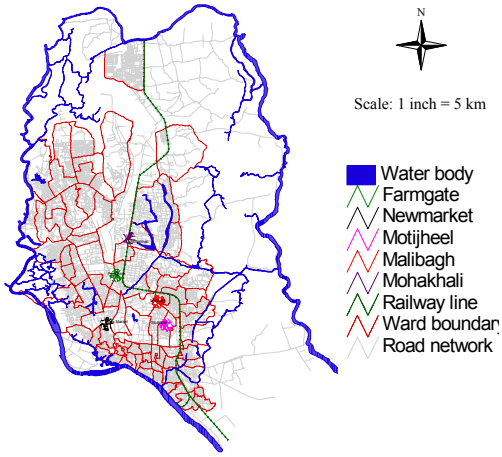

Fig. 2. Road map of Dhaka city with the 5 study blocks

New Market area is composed with some institutional land use and with some shopping centers. Well known Dhaka University campus is very close to this area and some other institutions are at a walking distance. However, Motijheel, the CBD area is fully composed with the service area and commercial district of the city.

By considering all the 5 blocks different types of pedestrians were observed. This data is very important to focus the total impression of Dhaka city and its walkway environment indeed.

Using ordered probit model: Ordered probit models were calibrated for investigating factors affecting the socio-economic as well as the observation data for getting the relevant output. Probabilities of dependent variables (for example *Y*) are formulated as follows:

$P(y=1) = \Phi(-\beta x)$

$P(y=2) = \Phi(\mu_1-\beta x) - \Phi(-\beta x)$

$P(y=3) = \Phi(\mu_2-\beta x) - \Phi(\mu_1-\beta x)$

$P(y=4) = \Phi(\mu_3-\beta x) - \Phi(\mu_1-\beta x)$

……

$P(y=n) = 1 - \Phi(\mu_n-\beta x)$

The μ's are unknown threshold parameters to be estimated with β. Explanatory variables x were identified by both observation and questionnaire survey conducted in the field. Based on this analysis, 25 output models were calibrated in this study. But all of them are not included here in this part to explain the effects of different variables rather they are placing in the appendix for further discussions. However, the important variables and the relationships with other dependent variables and estimation of those models are included in this study only to explain the present situation of Dhaka City. Besides, the most suitable models are included in this study for assessing the system coherence of pedestrian's level-of-service in Dhaka city.

Explanations of procedures: First of all, three different types of data have been extracted as: socio-economic data of pedestrians, subjective evaluation from pedestrians and objective data from the experts. These three types of data have influences on the total evaluation of system coherence mainly on: street characteristics, visibility and connectivity of the walkways. A simple one page questionnaire first was given to the walkers to know their impression on three aspects of system coherence. Then the following algorithm was developed in a manner like:

LOS of Street Character = f {(socio-economic influences), (subjective evaluation from the walkers), and (observation survey)}……Equation 1

With this notion, output model was calibrated in a single table. Some dummy variables and some constant variables were used to assess the situation in a simple but fruitful computer program to estimate the probit model. In this procedure, pedestrians' age, sex and monthly income have been considered as the basic socio-economic variables. Subjective evaluation at a 1 to 5 scale is considered as the subjective evaluation from the walkers too. Objective variables considered the observation of the present walkway condition as well as presence of rigid walls just beside the walkways, characteristics of the roads like whether the adjacent road is used for both motorized and non-motorized vehicles in the respective areas.

Results

Some basic facts: Pedestrians are using walkways for their regular life in Dhaka city for several reasons. Both male and female walkers can be seen on Dhaka's street and on the foot paths. The following figure 3 shows the distance traveled by different sex group of walkers.

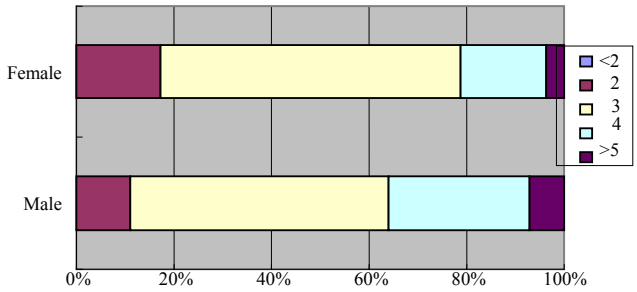

Fig. 3. Distance (km) traveled by walkers in Dhaka city by sex.

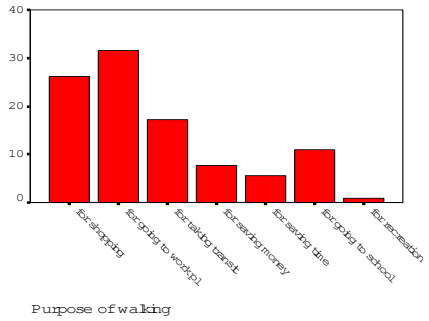

Figure: 4. Purpose of walking for pedestrians in Dhaka city.

From the Fig. 3, it can be observed that female walkers are used to walk shorter distance than male walkers. Male walkers are traveling almost twice for more than 5 kilometers a day than female walkers for going to work place or for other reasons. Figure 4 shows the different reasons why the pedestrians are using the walkways regularly. In some developed nations, people are walking for recreation or for good health. But in the case of Dhaka, only a little portion of walkers are using walkways in this purpose. However, people are walking for going to work place at most in Dhaka.

An interesting matter can be observed here as the walkers in Dhaka are walking for saving money and time too. This is because; Dhaka is a city with almost 60% people who are considered to be very low income group at the moment (Mannan *et al.,* 2001). For instance, people try to save money by not using the other modes of transports rather walking regularly to their workplace of to the necessary trips.

Table 1. Model estimation for street types

Variable	Coefficient	T - Statistics
Constant	-0.135034	-0.386087
Sex	-0.060952	-0.54016
Age group 0 to 15	-1.73E-01	-0.933982
Age group 15 to 46	-0.053785	-0.356791
Income less than 1500 taka	1.08409	3.37249
1501 to 3000 taka	1.08744	3.38046
3001 to 5000 taka	0.885858	2.72819
5001 to 7501 taka	8.37E-01	2.50507
7501 to 10000 taka	0.277878	8.18E-01
Street Type MT + Walkers	0.710368	6.94E+00
L(c)	-659.66	
L(θ)	-623.29	
Sample Size	500	

Output results of estimated models: Three different models have been built to get the relationship among socio-economic, observation and subjective data to know the influences of system coherence. System coherence actually refers to the well maintained walkway that ensures good visibility of services in different places so that pedestrians can see the facilities very well from the walkways. It also refers to well street characteristics that offer both motorized and non-motorized transports in the adjacent road ways along with the walker's way. At the end, system coherence also ensures well connectivity of walkways with the specific facilities. For example, in some transit places, the walkways are not well connected so that the bus passengers can easily walk through on it to take their desired bus easily. Even if there is some degree of connectivity, often, the connectivity does not allow proper spaces. As a result, walkers must come to the carriage way for going to the desired facilities. Pedestrians often do not notice these facilities and problems as they do not care about such things. But when this research work continued, many pedestrians thought of the problems and they even replied to the questions satisfactorily to express their views. To understand the problems and to express the views of the pedestrians regarding system coherence, we have created three different models by taking age, sex and walker's income as fixed socio-economic variable in all the given study blocks. In three models, for street type, connectivity and visibility of services, we used same data from the pedestrian's impression but we changed the observed variables with some specific facilities. Dummy variables were used in all the places to ensure better result and to compare the situation with the constant variables.

In Table 1, it can be seen that the model has been estimated for the street type and impression of walkers to analyze system coherence as a broad criteria. From the results, it can be seen that female walkers gave poor value for the assessment of street type in compare to male walkers. At the same time, higher income group has given poorer evaluation of the sub-criteria in compare to low income groups. This is because; high income group always expects better service as they are paying higher tax indeed.

Table 2. Model estimation for connectivity of walkways with different services.

Variable	Coefficient	T - Statistics
Constant	9.31513	13.9407
Sex	0.127325	1.0013
Age group 0 to 15	-0.384527	-1.85791
Age group 15 to 46	-0.102543	-0.604801
Income less than 1500 taka	-0.086643	-0.252467
1501 to 3000 taka	-3.40E-02	-0.098421
3001 to 5000 taka	-0.1225	-3.53E-01
5001 to 7501 taka	-0.061221	-1.71E-01
7501 to 10000 taka	0.182561	0.508087
Connectivity with services at a distance of 20 feet	-5.555	-16.5049
Connectivity with services at a distance of 40 feet	-4.531	-12.6821
Well connected with the footpath alignment	0.067054	0.390012
Not well connected with the footpath alignment	-2.29051	-8.08789
L(c)	-381.63	
L(θ)	-666.60	

At the same time, variables from observations were

here; street with motorized traffics only and streets with both motorized and non-motorized traffics. Only motorized streets with walkway facilities got better evaluation from the walkers in comparison with both motorized and non-motorized streets. This is also an interesting point to be noted that pedestrians feel well to walk on the streets where only the motorized vehicles are plying.

In Dhaka City, some major intersections offer both motorized and non-motorized vehicles to ply. As a result, in maximum cases of small injuries, pedestrians are very much susceptible to injuries by non-motorized rickshaws. For this, pedestrians have given poorer evaluation at a 1 to 5 scale in total system coherence while assessing street characteristics. On the other hand, we considered explanatory variables as a factor of assessment. Values of L(c) and L(θ) reflects the explanation power of explanatory variables. Explanatory variables are important if the differences of L(c) and L(θ) is within a range of 100. In this case, the difference is lower than 100. So, it can be concluded that explanatory variables have sufficient power to explain the variations assumed in the model. Further study can be formulated with some of these explanatory variables to assess further evaluation of walkway's system coherence.

In the same way, Table 2 and Table 3 express the models for connectivity with different facilities with the walkways and the visibilities of different activities beside the walkway surface for Dhaka city. Sometime it was observed that the difference between L(c) and L(θ) was greater than 100. It concludes with the notion that explanatory variables will not be suitable in building this model.

Table 3. Model estimation for visibility from the walkways.

Variable	Coefficient	T - Statistics
Constant	4.61103	8.64565
Sex	0.144932	1.20926
Age group 0 to 15	-3.25E-01	-1.65986
Age group 15 to 46	-0.059234	-0.369777
Income less than 1500 taka	0.154873	0.466816
1501 to 3000 taka	0.762716	2.29524
3001 to 5000 taka	0.219058	0.656993
5001 to 7501 taka	1.89E-01	0.548788
7501 to 10000 taka	0.188021	5.40E-01
Clear Visibility of services	-1.26584	-7.49E+00
Moderate Visibility with services	-0.125914	-0.823792
Presence of rigid wall beside walkway	-0.281642	-9.15874
L(c)	-537.01	
L(θ)	-451.32	

Discussion

A series of analysis have been conducted to assess the walkers view regarding problems of walkways in Dhaka city. Field survey and observation surveys have given the primary idea to fix up some criteria for further analysis. It has been observed that in Dhaka City, almost 40% people walk to go to workplace everyday from higher to lower income category. Besides, a very good portion of the women walkers can be found (almost 30%) in Dhaka City. At the same time, it has been observed that female walkers are walking for shortest distance in most of the time. A significant observation from the finding was that pedestrians often feel insecure on walkways because of social problems and crimes at a regular interval. For instance, problems with security are one of the major issues in case of Dhaka City. The analyzed results also show that among social security problems, passing bad comments to the women walkers is very new and uncommon with other cities of developing countries. However, illegal vendor's occupancy on the walkway is also one of the major responses from the pedestrians at Dhaka city. Significant differences have been observed among different observation locations. From the walker's point of view, New Market, Farmgate and Motijheel (CBD) are the worst areas due to illegal occupancy of vendors. Whereas, in Malibagh and in Mohakhali the problem seem to be different as break of continuity and presence of construction materials get the highest rating respectively.

After identifying the composition of walkers and their problems, another series of analysis were taken under consideration to build up some models. Itemized data have been collected for the second survey considering satisfaction level of the walkers. At the same time, observation survey was carried out to get the related information for estimating the model. The ordered probit model used in this study, helped understanding the relations among socio-economic compositions of the walkers, subjective evaluation through the questionnaires and the observation survey from the field. Influences of the respondents can be observed through proposed model for what exact objective value influenced more for subjective evaluation.

Conclusion

In spite of the serious problem of pedestrian safety and security the number of pedestrians is increasing in Dhaka city. In this regard an integrated approach of response modeling can be introduced by using ordered probit model. Using this approach, following recommendations can be made to change the situation so that walkers can feel more comfortable while using the walkways.

- Continuity of the walkway surface should be well maintained among different connections of bus stops, shopping centers and especially to the school gates as lots of school going children use the walkways everyday,
- Pedestrians feel better with the roads that do not offer non-motorized vehicles like rickshaws, rickshaw vans etc. Policy makers can bring some policies to impose ban on non-motorized vehicles in the peak hours in some selected major intersections so that the walkers can easily cross it.
- Rigid walls can be replaced with some fences so that pedestrians can see their desired spots easily through the fences.

This research paper discusses the techniques of assessing walkway's condition in respect to some given criteria. It also opens up new windows in urban planning so that other facilities can be examined in the light of this model. It not only gives quantitative assessment result but also help the policy makers or other researchers to understand the present scenario in a simple method. At the end, it can be said that this research is an attempt to make people aware about the importance of walkways and about the problems at the same time. This research can be further useful for more research and the data will surely help stakeholders to identify new areas that need to be focused for research and interventions.

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