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Evaluation of Roadway Level of Service for Pedestrian Movement: A Case Study on Katiadi Paurashava of Kishoreganj District

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Abstract

The Level of Service (LOS) has proved to be a practical and significant "quality of service" indicator for transportation facilities and is being widely used in the transportation and planning fields. The LOS rates these facilities' traffic operating conditions through the indicators (ordered from best to worst conditions): A, B, C, D, E and F. This LOS rating has its base on scientific measures of efficiency and on road users' perceptions. On the whole, these measures define a LOS based on acceptable traffic operating conditions for the road user. In short, Level of service is commonly used to assess the operational quality of transportation facilities in the roadway as well as roadside conditions. The primary objective of this study is to determine the Level of Service (LOS) of the primary, secondary and access roads for pedestrian movement in the study area. This study uses the average space occupied by the pedestrian as the main performance indicator for determining the pedestrian LOS. Pedestrian perception based LOS ratings are also evaluated about various roadway characteristics (e.g. traffic safety, sidewalk/road shoulder condition, road surface condition, pedestrian crossings/intersections, street lighting system etc.) for different types of roads

Introduction

Roads are the most fundamental way of communication on urban spaces. So the roadways must be efficient and well-functioning in order to meet the demand (Debnath and Islam, 2009). An efficient road network is very crucial for the rapid growth of the urban or rural areas and the effective road plan is considered as the base of urban planning. Nowadays, the road transport system is becoming more complex because of the population and automobiles increasing at a higher rate. The roadways and street systems are failing to accommodate the requirements of these increased automobiles and creating a number of traffic problems (Zaman, 2012).

All the cities and urban areas need to set new goals for the entire roadways and streets system in order to meet the needs of a vibrant and expanding city as well as to tackle the problems of traffic accidents, congestions, low-performing road networks, and to deal with environments that are uncomfortable for pedestrians (NYCDT, n.d). Road networks must be developed in such a way that the needs of the people are served most economically and efficient road network develops gradually. Efficiency evaluation of the existing road network is an imperative and crucial task for the road network planning. New roadway network development process must be emerged with due considerations

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of efficiency and Level of Service (LOS) evaluation of existing road network (Saha, 2009). For a consistent evaluation of the traffic flow within an urban road network, two elements are obligatory. Firstly, performance measures of traffic and pedestrian operational conditions have to be examined. The second one is to define different levels of service (LOS) for every road section as well as available roadway facilities (Axer, Rohde & Friedrich, 2012).

Level of Service (LOS) is a measure used to determine the effectiveness of elements of transportation infrastructure. The LOS indicators are (ordered from best to worst conditions): A, B, C, D, E and F. LOS is most commonly used to analyze roadways by categorizing traffic flow with corresponding safe driving conditions. When a road carries a traffic equal in volume to its capacity under ideal roadway and traffic conditions, the operating conditions become poor. Speed drops down and the delay and frequency of stops mount up. The service which a roadway offers to the road user can vary under different volumes of traffic. The concept of Level of Service (LOS) is used to denote the level of facility one can derive from a road under different operating characteristics and traffic volume (Kadiyali, 2006). Basically, level of service (LOS) ratings are more helpful to decision makers who are not methodically oriented to transport planning and often prefer to have a single number or letter to represent a condition (Chiguma, 2007). LOS ratings are easy to understand and utilize, and carry significant weight in decision-making (Litman, 2008).

In Bangladesh, roadway is the most significant means of communication and it has emerged as the most leading mode in surface (Debnath and Islam, 2009; Planning Commission, 2011). The urban centers in Bangladesh have grown in a disorganized manner and no proper thought has been given to the planning of the road network and transportation demands of these urban centers (Tamima, 2009). The road network has been developed mainly on the basis of short term need instead of long term planning. There is large scale deterioration of the network due to lack of appropriate maintenance, inadequate structural strength, vehicle overloading etc. Lack of adequate road safety has already arrived at a frightening level; faster movement along the highways is not possible due to the presence of large number of obstructions on the edge of roads (Planning Commission, 2011). Most of the roadway development and improvement efforts are mainly based on transit modes. There is usually none or little adjustment to reflect pedestrian comfort, convenience or efficiency (Litman, 2008). Most decision makers rely mainly on automobile transport and hardly ever obtain information representing the severity of problems facing mode users, especially the pedestrians. So evaluation of service levels of road network, which is received by the pedestrians, is also very important. Applying LOS ratings to walking environment can help consider an extensive range of impacts and alternatives in the transportation planning process. For example, it can be useful to identify roads and intersections, where pedestrian LOS ratings are of inferior quality, and to rank common destinations (such as commercial districts) according to their walking LOS ratings in order to categorize areas with poor service quality. Pedestrian LOS analysis can be used to prioritize investments, and designate trade-offs, such as where roadway widening will improve driving conditions, but worsen walking conditions (Florida Department of Transportation, 2009; Kadiyali, 2006; Litman, 2008; Singh and Singh, 2001).

The present research targets to perform the measurement of urban road efficiency for pedestrian movement in the context of its capacity and current demand of movement. This measurement performs a comparison between the current demand and the standard pedestrian space capacity of a road. Pedestrian perception based Level of Service ratings is also evaluated about various roadway characteristics (e.g. traffic safety, sidewalk/road shoulder condition, road surface condition, pedestrian crossings/intersections, street lighting system etc.) for different types of roads in the study area.

Objectives of the Study

The objectives of this research are as follows:

- To evaluate Pedestrian Level of Service (PLOS) of primary, secondary and access roads in the study area based on pedestrian space criterion.
- To evaluate Pedestrian Level of Service (PLOS) of primary, secondary and access roads in the study area based on pedestrian perception regarding different walkway facilities and characteristics.
- To rank different types of the selected road sections in a order of worst to good condition based on PLOS analysis
- To identify the factors affecting roadway Pedestrian Level of Service (PLOS) in the study area

Conceptual Framework

Pedestrian Level of Service (PLOS)

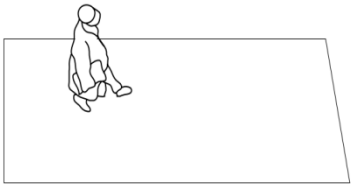
The measurement of PLOS depends on a number of factors, such as the presence of sidewalks, separation between pedestrians and motor vehicle traffic, crossing widths, comfort, average pedestrian crossing delay and travel time, convenience and freedom to maneuver etc. (Azlan, 2010; TRB, 2000; VTPI, 2013).

Characteristics of Different Pedestrian Levels of Service (PLOS)

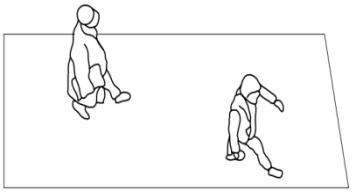
The Characteristics of Different Pedestrian Levels of Service can be described as following (TRB, 2000):

Pedestrian Level of Service "A": At this level, pedestrians move in desired paths without changing their travels in response to other pedestrians. Walking speeds are liberally selected, and conflicts between pedestrians are very unlikely (TRB, 2000).

Pedestrian Level of Service "B": At this level, there is adequate area for pedestrians to select walking speeds freely, to avoid other pedestrians, and to bypass crossing divergences. Pedestrians begin to be aware of other pedestrians at this level, and to respond to their presence when selecting a walking pathway (TRB, 2000).



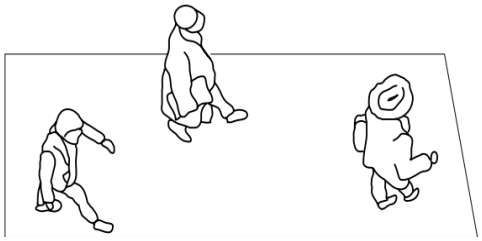
Source: TRB, 2000
Figure 1: Pedestrian Level of Service "A"



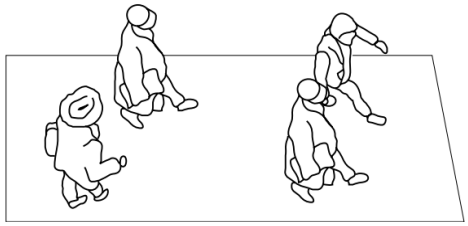
Source: TRB, 2000
Figure 2: Pedestrian Level of Service "B"

Pedestrian Level of Service "C": At this level, space is adequate for regular walking speeds, and for bypassing other pedestrians in mainly unidirectional flows. Crossing movements or reverse-direction can cause minor conflicts; flow rate and speeds are fairly lower (TRB, 2000).

Pedestrian Level of Service "D": At this level, there is restriction in freedom for selecting individual walking speed as well as to cross other pedestrians. Reverse-flow movements and crossing face a high possibility of conflict and as a result require frequent alteration in position and speed. The pedestrian flow is practically fluid flow, but interaction and friction between pedestrians is likely (TRB, 2000).



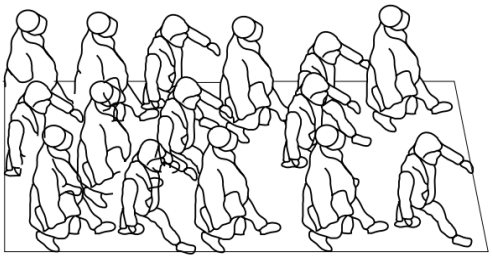
Source: TRB, 2000
Fig 3: Pedestrian Level of Service "C"



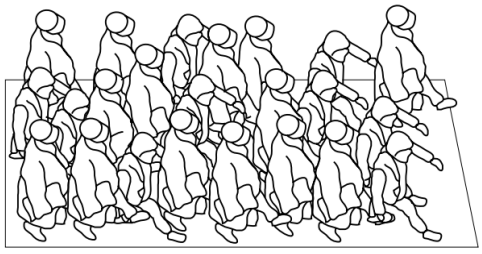
Source: TRB, 2000
Fig 4: Pedestrian Level of Service "D"

Pedestrian Level of Service "E": At this level, all pedestrians confine their normal walking speed practically, regularly altering their footsteps. Frontward movement is possible only by shuffling at the lower range. Space is not adequate for passing slower pedestrians. Reverse-flow movements and crossing movements are possible only with severe difficulties. Design volumes approach the limit of walkway capacity; interruptions to flow are very common (TRB, 2000).

Pedestrian Level of Service "F": At this level, all walking speeds are rigorously limited, and forward progress is made only by shuffling. There is recurrent, inescapable conflict with other pedestrians. Reverse-flow movements and crossing movements are almost impossible. Flow is irregular and unbalanced. Space is more typical of queued pedestrians than of moving pedestrian streams (TRB, 2000).



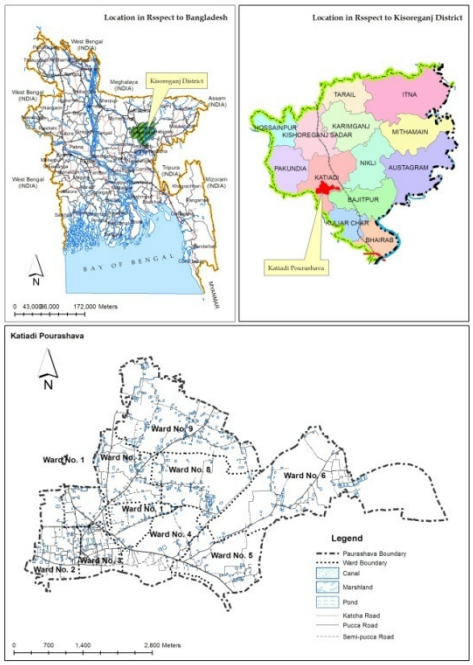
Source: TRB, 2000
Figure 5: Pedestrian Level of Service "E"



Source: TRB, 2000
Figure 6: Pedestrian Level of Service "F"

Study Area

The small urban centers of Bangladesh are not still ready to accommodate population with all the basic urban services. Due to absence of planned development, the condition of basic urban services, especially the roads and transportation sector of the small urban centers of Bangladesh are deteriorating day by day. Katiadi Paurashava of Katiadi Upazila at Kishoreganj District is one of the typical examples of secondary towns in the country having road transportation and traffic related problems. Kishoreganj-Katiadi-Bhairab Highway, a regional highway of RHD, passes through the middle of the Paurashava and acts as a corridor for connectivity among different wards of this Paurashava and as well as with the Kishoreganj District and Bhairab. Besides this, another regional highway of RHD namely, Katiadi-Mothkhola-Itakhola road is passing through this Paurashava. Highest percentages of trips are distributed to different wards of Katiadi Paurashava. People coming from long distance for different commercial, business or educational purposes also generates significant amount of trips. Therefore, development of internal road network of the Paurashava is gaining appreciable importance. There is no traffic and transportation management system in the area. Development of all transport related infrastructures are without any specific plan and priority basis. There is no system of evaluating the roadway and traffic performance measures in the area (LGED, 2011). With the above requirements, the present study is undertaken to evaluate the Level of Service (LOS) of different types of roads at Katiadi Paurashava of Kishoreganj District to deal with the above challenge through measuring the existing efficiency level of the road network, finding out the major problems and their corresponding solutions regarding preferred Level of Service of roads.



Source: LGED, 2011, Modified by the Author.

Figure 7: Location and road network map of Katiadi Paurashava

Research Design

The present research work was conducted by using the mixed method research design approach. A series of field observations, surveys and interviews has been conducted in order to collect information from the primary sources to identify the existing roadway conditions of the study area and collect necessary data required to evaluate the PLOS of the roads. The detailed research methods are described in the following sections.

Data Collection Procedure

Selection of Sections of Road Network: The selection of road sections was deemed important, because the results based on them were expected to represent the whole study area. Roads were selected based on the presence of a wide range of traffic flow conditions, such as flow intensity (volume/capacity ratio), directional distribution, traffic mix, percentage of heavy vehicles, and their physical and geometric quality that could support this kind of study. The only arterial road in the area i.e. Kishoreganj-Katiadi-Bhairab road was selected as primary road, and based on the traffic pattern, functional characteristics and importance of accessibility, five secondary roads were selected through simple random sampling method for this research (Table 1).

Table 1: Selected primary and secondary roads of the study area

Road classification	Name of the selected road
Primary road	Kishoreganj-Katiadi-Bhairab road
Secondary roads	Hospital road
	College road
	Upazila road
	Mothkhola road
	Post Office road

The access roads were selected from three wards of the Paurashava. The wards are selected through area sampling system and the access roads are selected through simple random sampling system. The ward numbers and the corresponding Mahallas from where the access roads are selected are given in Table 2.

Table 2: Selected access roads of the study area

Ward No.	Mahalla name	Name of the selected road
01	Vogpara	Vogpara access road
	Kamarkona	Kamarkona access road
02	Katiadi Poschim Para	Puran (Old) Bazar access road
	Bir-Noakandi	Bir-Noakandi access road
03	Katiadi Purba Para	Purbapara access road

Reconnaissance Survey and Inventory Survey: In order to familiarize with the field conditions to know about the traffic and transport situations, a reconnaissance survey was conducted to Katiadi Paurashava. Information about the congestion points,

important road way links, intersection points, causes of traffic delay, intra and inter travel network, local transport modes etc. were collected through reconnaissance and inventory surveys. On the basis of the inventory surveys, detailed traffic surveys have been planned.

Pedestrian Volume Survey: Pedestrians were counted separately for 12 hours at peak (8.00 am-13.00 pm, 16.00 pm-18.00 pm) and off peak (7.00 am-8.00 am, 13.00 pm-16.00 pm, and 18.00 pm-19.00 pm) times of a weekday. Manual count method has been adopted for conducting this survey.

Pedestrian Questionnaire Survey: A questionnaire was prepared considering various aspects of the pedestrians of the study area**.** The questionnaire survey has been conducted on the pedestrians moving on different types of roads to evaluate pedestrian LOS for each type of road.

Sampling Design: The sample size of the questionnaire and the respondents has been selected through simple random sampling system. The sample size for different road types is given in Table 3.

Table 3: Sample size for pedestrian questionnaire survey

Road classification	No. of selected road	Size of sample
Primary road	01	50
Secondary road	05	125 (25 from each road)
Access road	05	100 (20 from each road)
Total sample size		**275**

Interview of the Authority: Interview of the road related authorities in the study area has been conducted to collect information about various aspects of the road networks and transport system of the study area.

Secondary Data Collection: In this step, all necessary secondary information and data have been collected from the related authorities and organizations, particularly dealing with road network and transportation sector throughout the Paurashava level as well as other relevant agencies and organizations that work for this sector. The other secondary information has been collected from various literatures (Dissertations, Journals, Books, and Research Papers etc.) and internet sources relating roadway, transport system and the LOS.

Data Analysis Procedure

The PLOS Evaluation Criteria

The roadway (Pedestrian) LOS has been evaluated based on two criteria:

(i) **Pedestrian Space:** The pedestrian space for each road has been calculated and then compared to the standard value (as in Table 4) to determine respective LOS.

(ii) Pedestrian Perception Basis

Pedestrian Space Calculation: The primary performance measure for walkway is space.

It is the average area provided for each pedestrian in a walkway or queuing area, expressed in terms of square meters per pedestrian (m^2/p) (TRB, 2000). This is often a more practical unit for analyzing pedestrian facilities and can be directly observed in the field by measuring the walkway sample area and determining the maximum number of pedestrians at the walkway at a given time (usually peak periods) in that area. The average area occupied by the pedestrian can be computed by dividing the square area of the effective walkway width with the peak hour pedestrian volume. The formula is as follows (Azlan, 2010):

$$\text{Pedestrian Space} = \frac{\text{Area of the effective walkway width } (m^2)}{\text{Peak hour pedestrian volume } (V_P)} \qquad \text{[Equation: 1]}$$

As there is no designated sidewalk beside the primary and secondary roads in the study area, the effective walkway width is measured through field observation, usually the shoulder width plus the maximum width of carriage way used by the pedestrians. For the access roads, average width of the roads is taken. The selected length of all roadway sections is 100 meters.

Table 4: Average pedestrian space and relevant PLOS criteria for walkways and sidewalks.

Pedestrian Space (m^2/person)	**LOS**
> 5.6	A
3.7-5.6	B
2.2-3.7	C
1.4-2.2	D
0.75-1.4	E
≤ 0.75	F

Source: TRB, 2000.

For design purposes, a level of service of C is suitable for urban streets (Kadiyali, 2006).

Pedestrian Perception Evaluation: Pedestrian opinion based LOS is also determined for each type of road. The perception of the pedestrians about the selected qualitative characteristics of the roads is collected through questionnaire survey. Then specific score, corresponding numerical grade and PLOS was selected for every opinion (as in Table 5). The total numeric grade for every opinion regarding each characteristic was computed. Then average grade was computed for each characteristic by dividing total grade by total number of respondents for every road and from that average grade corresponding characteristic LOS is determined.

Participant Perception Based Pedestrian LOS Evaluation Criteria: A Level of Service represents a numerical score as a grade, in a similar manner as a student might be marked on an exam i.e. a C or above signifies a pass of varying quality, and a D or below signifies a fail of varying quality. Typically, Level of Service is defined in details for each grade. For Walkability, this is not possible given the differences between Participant's perceptions of "very good", "Good", "Slightly Good", "Bad", "Slightly Bad" or "Very Bad". For simplicity, an 'A' is considered 'Very Good' and similarly, F 'Very Bad'.

Similar to the student grade example, "Neutral" represents the bound between C and D and neither represents a pass or fail (NZTA, 2009). Given the above, the conversion between the participant perceptions and level of service is shown in Table 5.

Table 5: Conversion between the participant perceptions and Level of Service comparisons

Opinion	Score	Numerical Grade	Level of Service
Very Good	7	≥ 6	A
Good	6	≥ 5 and < 6	B
Slightly Good	5	> 4 and < 5	C
Neutral	4	4	N
Slightly Bad	3	≥ 3 and < 4	D
Bad	2	≥ 2 and < 3	E
Very Bad	1	< 2	F

Source: NZTA, 2009, modified by the author.

Analysis: **Evaluation of Pedestrian Level of Service**

The Level of Service (LOS) of primary, secondary and access roads of the study area in terms of pedestrian movement is evaluated in the following sections. The pedestrian space per person (m^2/p) is selected as major criterion for evaluating pedestrian LOS. Pedestrian LOS is also evaluated based on the perception of the pedestrians about some selected qualitative characteristics of each road.

Pedestrian LOS Evaluation of the Primary Road (Pedestrian Space Basis)

Table 6 shows pedestrian volume at primary road at different time periods.

Table 6: Pedestrian volume at different time periods at primary road

Time period	Period type	Pedestrian volume
7am-8am	Off-Peak	19
8am-9am	Peak	23
9am-10am	Peak	35
10am-11am	Peak	62
11am-12pm	Peak	67
12pm-13pm	Peak	43
13pm-14pm	Off-Peak	37
14pm-15pm	Off-Peak	32
15pm-16pm	Off-Peak	36
16pm-17pm	Peak	52
17pm-18pm	Peak	41
18pm-19pm	Off-Peak	33
Total		**480**

Source: Field Survey, 2017.

Calculation

We know,

$$\text{Pedestrian Space} = \frac{\text{Area of the effective walkway width } (m^2)}{\text{Peak hour pedestrian volume } (V_P)}$$

Again, Area of the walkway = Walkway length × Walkway width

Here, effective walkway width = 2.44 m
Selected section length of the walkway = 100 m
∴ Area of the effective walkway width = 100 m × 2.44 m
= 244 m^2
Peak hour pedestrian volume, V_P = 323 pedestrians
∴ Pedestrian space $= \frac{244}{323}$
= 0.76 m^2/p
Pedestrian Level of Service, PLOS = **E [**Refer to Table: 4**]**

The pedestrian LOS of primary road is E that means almost all pedestrians restrict their normal walking speed, frequently adjusting their way of walking. At the lower range, forward movement is possible only by shuffling. Space is not sufficient for passing slower pedestrians. Cross or reverse-flow movements are possible only with extreme difficulties at this road.

PLOS Evaluation of the Selected Secondary and Access Roads (Pedestrian Space Basis)

The PLOS of the selected secondary and access road sections according to pedestrian space basis were calculated by following the similar procedure of PLOS calculation of the primary road, which are summarized in Tables 7 and 8.

Table 7: Pedestrian level of service calculation of the selected secondary roads (pedestrian space basis)

Name of the road	**Area of the effective walkway width (m^2)**	**Peak hour pedestrian volume (V_P)**	**Pedestrian space (m^2/pedestrian) (Refer to Equation:1)**	**Pedestrian Level of Service (Refer to Table: 4)**
Hospital Road	152.4 m^2	311 pedestrians	0.49	F
College Road	183 m^2	248 pedestrians	0.74	F
Mothkhola Road	183 m^2	189 pedestrians	0.97	E
Upazila Road	152.4 m^2	198 pedestrians	0.77	E
Post Office Road	183 m^2	128 Pedestrians	1.43 m^2/p	D

Source: Computed and summarized by the Author.

Table 8: Pedestrian level of service calculation of the selected access roads (pedestrian space basis)

Name of the road	Area of the effective walkway width (m2)	Peak hour pedestrian volume (VP)	Pedestrian space (m2/person) (Refer to Equation 1)	Pedestrian Level of Service (Refer to Table: 4)
Vogpara access road	210 m2	141 pedestrians	1.98	D
Kamarkona access road	240 m2	141 pedestrians	1.7 m2/p	D
Puran (Old) Bazar access road	150 m2	167 pedestrians	0.9 m2/p	E
Bir-Noakandi access road	180 m2	113 pedestrians	1.6 m2/p	D
Purbapara access road	180 m2	176 pedestrians	1.02 m2/p	E

Source: Computed and summarized by the author.

Pedestrian LOS Evaluation of the Primary Road (Pedestrian Perception Basis)

Table 9: Pedestrian LOS of the primary road based on the pedestrian opinion

Characteristics	Grade to the Opinion (No. of Response to the Opinion × Corresponding Opinion Score)							Total Grade	Average Grade (Total Grade/50)	LOS
	Very bad	Bad	Slightly bad	Neutral	Slightly good	Good	Very good			
Safe from traffic	14	34	18	40	15	0	0	121	2.42	E
Obstacle free	12	36	21	36	20	0	0	125	2.5	E
Sidewalk/Shoulder/ Surface condition	22	28	24	24	0	0	0	98	1.96	F
Pedestrian crossings/Intersections	21	26	39	12	0	0	0	98	1.96	F
Street lighting	3	14	12	92	30	42	0	193	3.86	D
Amount of vehicles	16	46	27	8	0	0	0	97	1.94	F
Parking system	18	36	33	12	0	0	0	99	1.98	F
Drainage system/Water removal from roads	15	40	27	24	0	0	0	106	2.12	E
Overall Walkability	13	34	30	28	15	0	0	120	2.4	E

Source: Computed by the author based on field survey, 2017.

Table 9 demonstrates that according to the pedestrians' point of view the Level of Service of the Primary road, in terms of the condition of road shoulder and road surface, pedestrian crossings/intersections, vehicle volume at the road and road side parking system, falls at 'F' category. That means the primary road falls to maintain the desired service level of the pedestrians in case of above options, because there is no designated sidewalk alongside the road, the road shoulder is not well defined and continuous, surface of the road is not smooth and pit holes exist, the intersection at the primary road is not channelized and no provisions for safe pedestrian crossings, too many vehicles moving on the road causing conflicts with the pedestrians and creates congestion, road side illegal parking occupies the shoulder and carriage way of the road which impedes pedestrian movement at primary road. According to the participants the condition of the road in terms of traffic safety, obstructions and drainage system is in bad condition (LOS E) and approaching to the failure condition. Street lighting provision of the road is slightly bad (LOS D). The overall walkability of the primary road is in bad condition (LOS E) as per the pedestrians' opinion.

PLOS Evaluation of the Selected Secondary and Access Roads (Pedestrian Perception Basis)

The PLOS of the selected secondary and access road sections according to Pedestrian perception basis were calculated by following the similar procedure of PLOS calculation of the primary road (Table: 9), which are summarized in Tables 10 and 11.

Table 10: Pedestrian level of service calculation of the selected secondary roads (pedestrian perception basis)

Roadway Characteristics	**PLOS**				
	Hospital Road	**College Road**	**Mothkhola Road**	**Upazila Road**	**Post Office Road**
Safe from traffic	F	F	D	F	D
Obstacle free	E	E	D	E	D
Sidewalk/Shoulder/ Surface condition	F	F	E	F	E
Pedestrian crossings/Intersections	F	F	D	F	E
Street lighting	D	D	C	D	E
Amount of vehicles	F	F	E	F	E
Parking system	F	F	E	E	F
Drainage system/Water removal from roads	E	F	D	E	F
Overall Walkability	F	F	D	E	E

Source: Computed and summarized by the Author.

Table 10 presents that according to the pedestrians perception most of the selected roadway facilities are far below (PLOS E or F) the acceptable PLOS limit (PLOS C) in regarding most of the secondary roads in the study area.

Table 11: Pedestrian level of service calculation of the selected access roads (pedestrian perception basis)

Roadway Characteristics	PLOS				
	Vogpara access road	**Kamarkona access road**	**Puran (Old) Bazar access road**	**Bir-Noakandi access road**	**Purbapara access road**
Safe from traffic	D	E	E	D	E
Obstacle free	D	E	E	D	E
Sidewalk/Shoulder/ Surface condition	F	E	E	F	E
Pedestrian crossings/Intersections	D	E	D	N	E
Street lighting	E	D	D	F	D
Amount of vehicles	D	E	E	D	E
Parking system	C	D	E	C	E
Drainage system/Water removal from roads	D	E	E	F	F
Overall Walkability	D	E	E	E	E

Source: Computed and summarized by the Author.

Table 11 presents that according to the pedestrians perception most of the selected roadway facilities are far below (PLOS E or F) the acceptable PLOS limit (PLOS C) in regard to most of the access roads in the study area.

Key Findings of the Research

The main problem of present road network in the Paurashava is that there is no systematic planning of the roads, whether major or local roads. As a result, the level of service of the important roads falls below the acceptable limit (LOS C). The ranking of the selected roads (ordered from worst to good condition) based on the pedestrian LOS calculation is summarized in Table 12 and 13.

Table 12: Ranking of the selected roads (worst to good) in terms of Pedestrian Space Based PLOS evaluation

Road Name	Road Classification	PLOS (Space Basis)	Remarks
Katiadi-Bhairab Road	Primary Road	E	Space is not sufficient, very difficulties in cross or reverse movement
Hospital Road		F	Sporadic and unstable flow, all walking speeds severely restricted, unavoidable contacts with others
College Road		F	

Road Name	Road Classification	PLOS (Space Basis)	Remarks
Mothkhola Road	Secondary Road	E	Space is not sufficient, very difficulties in cross or reverse movement
Upazila Road		E	
Post Office Road		D	Freedom to select walking speed and bypassing is restricted, high probability of conflict
Puran (Old) Bazar Road	Access Road	E	Space is not sufficient, very difficulties in cross or reverse movement
Purbapara road		E	
Vogpara Road		D	Freedom to select walking speed and bypassing is restricted, high probability of conflict.
Kamarkona road		D	
Bir-Noakandi road		D	

Source: Developed by the author based on the pedestrian space based LOS analysis.

Table 12 presents that during the planning phase for the pedestrian facilities; the roads with PLOS F (Hospital road and college road) must be given first priority, because the pedestrian flow of these roads is completely unstable. Then priority should be given to the roads with PLOS E and PLOS D respectively.

Table 13: Ranking of the selected roads (worst to good) in terms of pedestrian perception on overall walkability.

Road Name	Road Classification	PLOS (Pedestrian perception basis)	Remarks
Katiadi-Bhairab Road	Primary Road	E	Roadway facilities are in acute shortage and the overall roadway walking environment is far below than the acceptable level (PLOS C)
Hospital Road	Secondary Road	F	Roadway completely fails to maintain the desired service level of the pedestrians regarding different walkway facilities
College Road		F	
Upazila Road		E	Roadway facilities are in acute shortage and the overall roadway walking environment is far below than the acceptable level (PLOS C)
Post Office Road		E	
Mothkhola Road		D	Roadway facilities are in slightly bad condition and gradually approaching to the failure condition.

Road Name	Road Classification	PLOS (Pedestrian perception basis)	Remarks
Kamarkona access road	Access Road	E	Roadway facilities are in acute shortage and the overall roadway walking environment is far below than the acceptable level (PLOS C)
Puran (Old) Bazar access road		E	
Bir-Noakandi access road		E	
Purbapara access road		E	
Vogpara access road		D	Roadway facilities are in slightly bad condition and gradually approaching to the failure condition.

Source: Developed by the author based on the pedestrian perception based LOS analysis.

Factors Affecting Pedestrian Level of Service in the Study Area

The factors affecting pedestrian level of service in the study area can be summarized as follows**:**

- **Increasing traffic volume:** When traffic volume increases the PLOS accordingly decreases. During heavy traffic generation, the pedestrians are more anxious of their safety than other time.
- **Walkway/Sidewalk width:** Greater the width of sidewalk greater is the level of safety being perceived by pedestrians as they feel more comfortable which results in a higher PLOS.
- **Roadway width :** With increasing in the roadway width the pedestrians feel it more difficult to cross the road from one end to another thereby decreasing the PLOS.
- **Speed limits:** With increasing in vehicular speed, there is a radical decrease in the PLOS. It is because at higher speeds, the pedestrians recognize higher threat levels to their life and so resulting in a decrease in PLOS.
- **Comforting factors:** These factors include climate control, weather protection, passage shelters, arcades, and other pedestrian facilities.
- **Convenience factors:** These factors include pathway directness, walking distances, surface grades, walkway ramps, directional signing and symbols, directory maps, and other features making pedestrian travel easy and simple.

Conclusion

Levels of Service criteria are important factors in roadway planning and design process. The pressure on urban transport systems in Katiadi Paurashava has been increasing as a consequence of rapid urban growth of the area. As part of the sustainable transportation planning process in the study area, actions are required to address congested and most vulnerable roadways (exceed LOS thresholds). PLOS evaluation reveals the deficiencies

of each category of road regarding pedestrian facilities in the study area. It is imperative to monitor the quality of transport supply in terms of level of service in all categories of roads for evaluating various transport improvement programs on short term and long term basis. Although the efficiency of the selected roadways is not at satisfactory level (which is the representative scenario of road network in the study area), the opportunities is not exhaustive. If the Paurashava road development and management plan is taken according to LOS ranking of all the roads, then the present as well as future demand of road users can be met in a reasonable way.

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