

Investigation of Pedestrian Safety - A Case Study

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ABSTRACT: The needs of the pedestrian should be considered in the design of the urban environment and transportation facilities. Since road infrastructure improvements and designed pedestrian environments are an important part of road safety enhancements that increase walking and decrease fatalities. This study was investigated the pedestrian safety problems and its countermeasures on road segments in Mizan city. This study investigated the existing problems affecting the safety of pedestrian movement, evaluates the service quality of walking facilities, and finally identified the most significant factors affecting pedestrian safety with engineering counter measures in the city. Four routes are selected based on different criteria. Those are Market area, Commercial area, Educational area, and Residential area. The primary and secondary data is used in this study. For the data analysis the study used both objective measurements and subjective assessments to model PLOS using Australian methods. As per field study indicates 60% of the respondents think the sidewalk is not user-friendly. The current sidewalk is encroached either by vendors, utility poles, parking carts or illegal construction materials in different places, and crosswalk facilities are not visible and not enough provided at a logical distant. As a result pedestrians are forced to walk on the carriageway due to these illegal obstructions. The Pedestrian LOS analysis indicates that poor pedestrian conditions exist and the factors that negatively affect pedestrian LOS are wide-ranging. Pedestrian comfort is minimal, and safety concerns within the pedestrian environment are evident in this city road segments. It was concluded that, the most significant factors affecting the pedestrian safety in the city are sidewalk surface quality/continuity, sidewalk environmental problems, crossing opportunity (crosswalk), supporting facility, personal security, sidewalk obstructions, and sidewalk widths. Pedestrian facilities and all the concerned factors should be well provided and maintained to more effective for both encouraging people to walk and improve pedestrian safety.

Key words: Pedestrian facility, Pedestrian Level of Service, Pedestrian safety, Pedestrian problems

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I. INTRODUCTION

Walking has been a traditional mode of movement between places, irrespective of towns and cities. People walk with different purposes and in large numbers especially in developing countries. A pedestrian-friendly environment plays an important role in encouraging walking as a mode of travel, and this will prove health and environmental benefits(Martin, 2006).

Improved pedestrian facilities enable greater access and mobility within the communities. This research was considered the various factors that influence people's willingness to walk, such as the sidewalk quality problems and obstructions, and other contributing safety issues in the area of a walkway. This research also investigated on pedestrians' perception of their environment and the expectations they have of pedestrian facilities and sought to identify the benefits that can result from improved pedestrian facilities. In situations where sidewalk facilities are either encroached or occupied by vendors and hawkers or are poorly maintained, the pedestrians are forced to walk on a portion of the carriageway or shoulders. Parking of vehicles in this area further pushes the pedestrians onto the lane, thus increasing their interaction with vehicles, and therefore their risk(Americans with Disability Act (ADA), 1990).

At present no proper methodology is available to evaluate Pedestrian Level of Service (PLOS) provided by urban streets in Ethiopia. Defining PLOS criteria is a module of a level of service analysis procedure for urban streets. As the pedestrian level of service is not well established for highly heterogeneous traffic flow condition on urban of Ethiopia, attention has given in this regard to defining one of the pedestrian levels of service criteria in this study(Asadi-Shekari, 2014).

Therefore, the purpose of this study was to focus on identifying those factors within the roadway that significantly influence the pedestrian's feeling of safety and comfort. The collection of these factors into a model provides a measure of the roadway segment's level of service to pedestrians. So, it is essential to develop suitable methodology for the pedestrian level of service analysis of urban walking facilities, and in this study, Mizan city is assumed to represent all towns in Ethiopia.

II. RESEARCH QUESTIONS

1. What are the existing conditions of pedestrian walking facilities?
2. What are the pedestrian facilities problems on road segments?
3. What are the most significant factors affecting pedestrian safety?
4. What are the remedial measures of the problem?

III. STUDY AREA

The study area is found in south region which is located around 600 Km from Addis Ababa, Ethiopia. The average geographical location of the study area is 9°5'N latitude, 36°33'E longitudinal and 2088 m elevation. The total population of the study area is around 117,077. Source: Mizan city administration office.

IV. RESEARCH DESIGN

The methodology conducted in this study is statistical analysis; the data was used to show the present pedestrian level of services of the road segments in Mizan. The collection of data includes both quantitative and qualitative data. The subjective assessment is done by pedestrians’ perception over their safety whether the facility is environmentally friend or not which is collected by questionnaire. The objective measurement is implemented using pedestrian level of service to show the extent of the problems in qualitative aspect. The PLOS which is a qualitative measure is chosen as an overall approach to its ability to incorporate different methods and techniques in the collection and analysis of data that focuses on the various issues of the study.

SAMPLE SIZE AND SELECTION

In this study, the method of sampling to select the area used purposive sampling technique, and the selection will be based on their purpose. To represent sample size of the population; if it is more than 10,000 the precise magnitude is not likely to be very important, but if the population is less than 10,000 then a smaller sample size may be required. The required sample size was determined by using single population proportion formula by considering 50% estimated proportion of pedestrian safety problems because there is no such study conducted in the area before.

The sample size is calculated by

$$SS = \frac{Z^2 * P * (1-P)}{c^2} \dots \dots \dots \text{Equation.1}$$

Where; SS = Sample size

P = Proportion or percentage of population picking a choice, expressed as a decimal (50%=0.5)

Z = degree of confidence (e.g., 1.96 for a 95 percent confidence level)

C = degree of precision/confidence interval, expressed as decimal (e.g., 0.05 = +/- 5 Percentage points)

$$SS = (1.96)^2 * 0.5 * (1-0.5) / (0.05)^2 = 384$$

Taking 5% non-response rate = 5% of 384 becomes 19. Adding to the previous one it becomes 403 (pertinent sample size).

DATA SOURCE AND COLLECTION PROCESS

For this study, the primary and secondary data is used. The primary data was collected from the site using questionnaire, field investigation (roadway characteristics on the actual field observations) like quality and width measurement, and pedestrian count (volume) data. The secondary data was collected from Mizan city municipality and Police officers like standard master plan and accident data.

DATA PROCESSING AND ANALYSIS

After data was collected, the analysis and interpretations were done sequentially/accordingly. For data analysis, the collected data from users’ perception of the primary factors are evaluated using subjective assessment, and the objective measurements are processed using Australian PLOS calculation method, Excel, and some related tools, thus the organized data interpreted using descriptive methods in the form of tables, charts, and graphs.

V. RESULTS AND DISCUSSION

Pedestrian volumes were relevant to traffic and highway engineering practice. Also, other pedestrian volume influences the geometric features such as pedestrian over and under passes, elevated walkways, and crosswalks. Walking characteristics play a major part in the geometric design features and some of the controls devices. As I compare the walkway roadsides in the studied area with the standard highway capacity manual, they do not satisfy the criteria which indicate the sidewalk width need upgrading to accommodate the peak

pedestrian volume.

Table(1). Details of Existing conditions of the Sidewalk at Mizan

Study Area	Conditions of Sidewalk		
	Continuity of sidewalks	Illegal Occupancy	Remark
Market Area	Non-continuous	Vendors, building portions and parking Cart	Almost no curb ramps provided and uncovered or opened manholes at different locations present
Commercial Area	Non-continuous	Vendors, building portions and parking Cart	
Educational Area	Almost continuous	Almost None	
Residential Area	Almost continuous	Parking lot and building portions	

Table(2). Pedestrian Volume Study and Details of the Sidewalk at Mizan

Study Area	Sub-criteria				Remark
	Pedestrian count (peak/day)	Existing walkway width (m)	Master plan walkway width	Standard walkway width/from ADA/	
Market Area	1876	1.90	2.5	3.0	It doesn't satisfy the master plan and standards It needs upgrading
Commercial Area	1765	1.40	2.5	3.0	It doesn't satisfy the master plan and standards It needs upgrading
Educational Area	2,117	2.40	2.5	3.0	Almost it is enough to satisfy the master plan
Residential Area	1,246	2.10	2.5	3.0	Almost it is enough but needs to upgrade

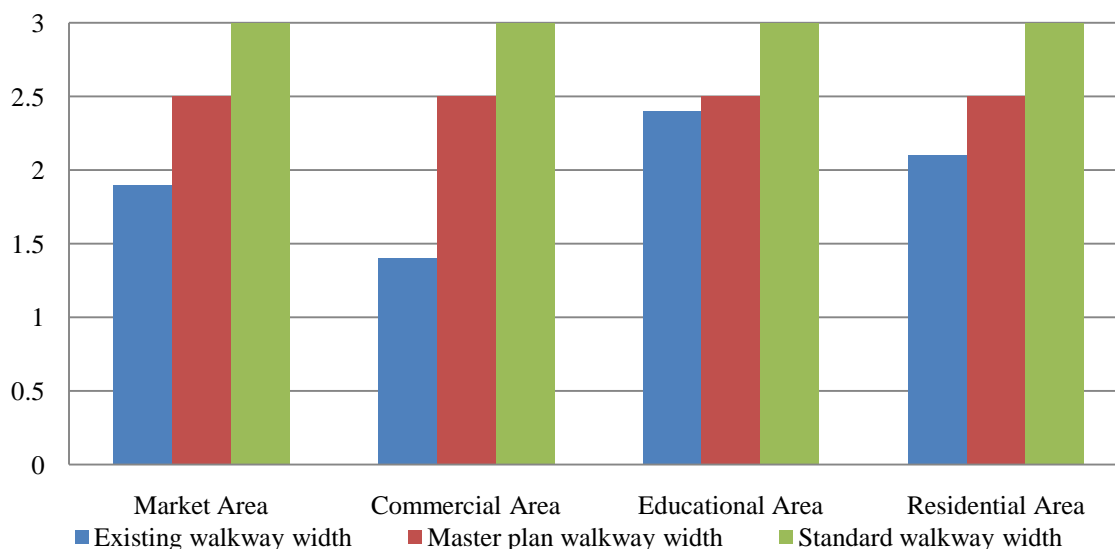


Fig. 1 Comparison of Existing, Master Plan and Standard Walkway Width

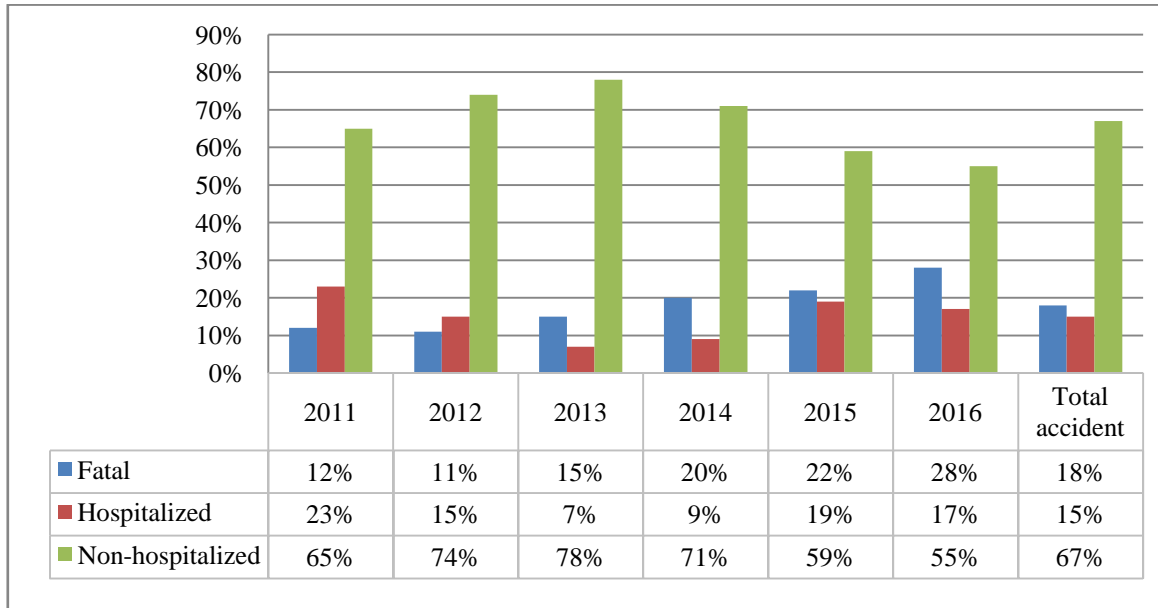


Fig. 2 Pedestrian Accident Severity in Mizan city (2011 - 2016)

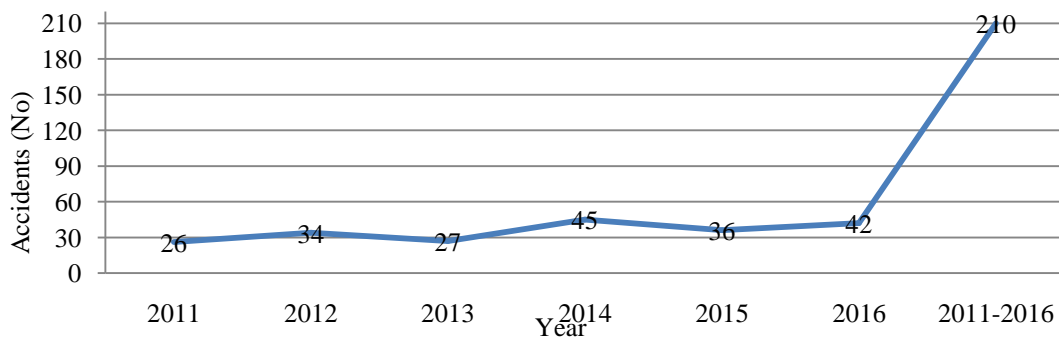


Fig. 3 Pedestrian Accident Trends in Mizan city (2011 - 2016)

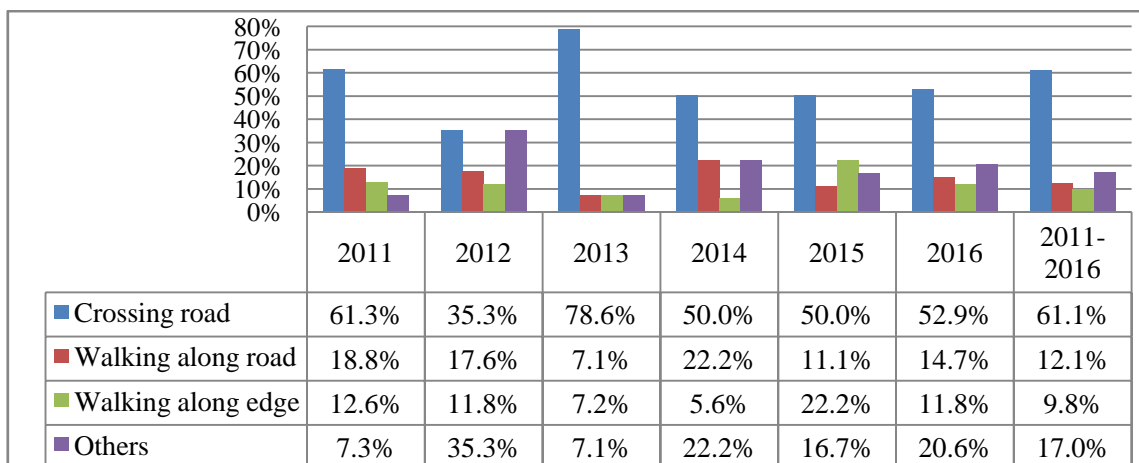


Fig. Error! No text of specified style in document. Pedestrian Behavior and Casualty Location in Mizan city (2011-2016)

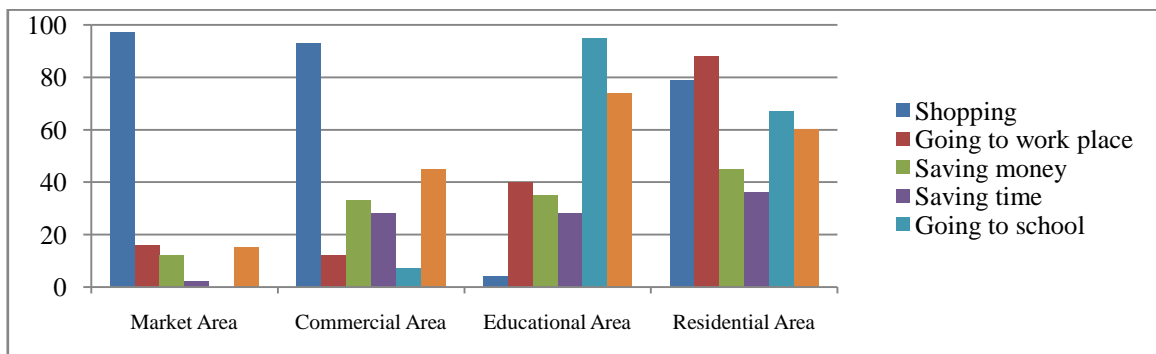


Fig. 5 Pedestrians Purpose of Walking in Mizan City (source: Field survey)

Table(2). Pedestrians’ view about the user friendliness of sidewalks

Location	Sidewalks are user-friendly	
	Yes (%)	No (%)
Market Area	12	88
Commercial Area	34	66
Educational Area	58	42
Residential Area	54	46
Total respondents	40%	60%

Table(3). Pedestrians’ preference for using the sidewalk

Location	Pedestrians’ Preference for Using the Sidewalks	
	Yes (%)	No (%)
Market Area	8	92
Commercial Area	48	52
Educational Area	83	17
Residential Area	90	10
Total respondents	57	43

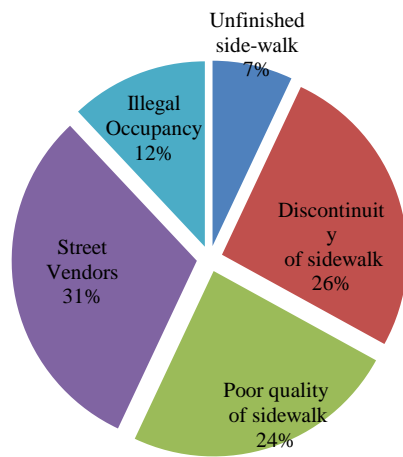


Fig. 6 Reasons for not preferring the sidewalk

Table(4). Pedestrians’ feeling about the sidewalk environment

Location	Pedestrians feeling about the sidewalk environment (%)					Result
	Very Bad	Bad	Good	Very good	Excellent	
Market Area	34	29	25	8	4	Unpleasant
Commercial Area	14	30	22	18	16	Poor
Educational Area	9	12	36	21	22	Acceptable
Residential Area	10	34	22	14	20	Poor

Table(5). Pedestrians’ perception on assessment of effective measurement of pedestrian walking facilities

Extent of requirements for effective measurement of pedestrian walking facilities							
User’s perception (%)	Geometric, location and user factors						
	1	2	3	4	5	6	7
	78.7	97.6	63.8	81.6	42.3	43.2	86.5
1 = Enhancing the width of the sidewalk				5 = Providing support facilities			
2 = Improving the surface quality				6 = Improving sidewalk environment			
3 = Removal of street hawkers/obstructions				7 = Improving personal security/lighting			
4 = Providing cross-walks							

Table(6). Objective and subjective results investigated for each factors affecting PLOS in Mizan city (Gallin's Method)

S N	Geometric, Location and User Factors	Locations (measurement/current value)			
		Market Area	Commercial Area	Educational Area	Residential Area
1	Average sidewalk Width (m)	1.90	1.40	2.40	2.10
2	Average Surface Quality	Poor quality; Non-continuous, some opened manholes and drainage pipes, fixed objects	Poor quality; Non-continuous, some opened manholes and drainage pipes, fixed objects	Moderate quality i.e., almost continuous, some opened drains/ fixed objects, etc.	Moderate quality i.e., almost continuous, some opened drains/ fixed objects, etc.
3	Number of Obstructions (per Km)	11 (Utility Poles, illegal construction materials) and full of Vendors	5 (Utility Poles, illegal construction materials) and some vendors at evening	8 (Illegal construction materials and some of the utility Vendors)	3 (Utility Poles and illegal construction material)
4	Crossing Opportunities	None provided no crossing facilities which is risk to cross	Some provided but poorly located	Some provided but poorly located	Some provided but, not enough
5	Support Facilities	Non-existent	Non-existent	Non-existent	Non-existent
6	Connectivity of roads	Good	Good	Good	Good
7	Sidewalk Environment	Unpleasant environment, close to vehicular traffic and with a bad odor from vendor wastes	Poor environment, closer to vehicular traffic and shopping homes	Acceptable environment, No closer to vehicular traffic	Poor environment, close to vehicular traffic with bad odor from homeless road side living wastes
8	Potential for vehicle conflict	Nine conflict points, i.e., 1-three leg junction on the path segments (both side of the road)	Eighteen conflict points, i.e., 2-three leg junction on the path segments (both side of the road)	Eighteen conflict points, i.e., 2-three leg junction on the path segments (both side of the road)	Nine conflict points, i.e., 1-three leg junction on the path segments (both side of the road)
9	Pedestrian Volume	Assumed 1876 per day	Assumed 1765 per day	Assumed 2,117 per day	Assumed 1,246 per day
10	Mix of path Users	Mostly pedestrians, assume approximately 80%	Mostly pedestrians, assume approximately 80%	Mostly pedestrians, assume approximately 80%	Mostly pedestrians, assume approximately 80%
11	Personal Security	Unsafe, limited street light and poor inadequate security	Poor, limited street light and poor inadequate security	Good, but needs maintenance street light and work on security	Unsafe, limited street light and poor inadequate security

Table(7). Pedestrian LOS Grade Scale (Gallin, 2001)

LOS Grade	Range of Scores
A	132 or higher
B	101 to 131
C	69 to 100
D	37 to 68
E	36 or lower

Table(8). Pedestrian Rating and criteria of the PLOS factors in Market area road segment, between Mizan Red Cross society and Mizan Hospital

SN	Geometric, Location and User Factors	Measurement/value	Weight	Score	Weighted Score	Ranking Affecting Factors
1	Average sidewalk Width (m)	1.90	4	3	12	5
2	Average Surface Quality	Poor quality	5	1	5	3
3	Number of Obstructions (Per Km)	Full of Vendors, utility Poles, illegal construction materials	3	0	0	1
4	Crossing Opportunities	None provided, no crossing facilities which is risk to cross	4	0	0	1
5	Support Facilities	Non-existent	2	0	0	1
6	Connectivity of roads	Good	4	3	12	5
7	Sidewalk Environment	Unpleasant environment, close to vehicular traffic and with a bad odor from vendor wastes	2	0	0	1
8	Potential for vehicle conflict	Reasonable, nine conflict points, i.e., 1-three leg junction on the path segments (both side of the road)	3	3	9	4
9	Pedestrian Volume	Assumed 1876 per day	3	0	0	1
10	Mix of path Users	Mostly pedestrians, assume approximately more than 80%	4	3	12	5
11	Personal Security	Unsafe, limited street light and poor inadequate security	4	0	0	1
Total Weighted Score					50	
LOS result						D

Table(9). Rating and criteria of the PLOS factors in Commercial area road segment, between Mizan Auditorium and Anwar Mosque

S N	Geometric, Location and User Factors	Measurement/value	Weight	Score	Weighted Score	Ranking Affecting Factors
1	Average sidewalk Width(m)	1.40	4	2	8	7
2	Average Surface Quality	Poor quality	5	1	5	5

3	Number of Obstructions (Per Km)	5 (Utility Poles, illegal construction materials) and some vendors at evening	3	2	6	6
4	Crossing Opportunities	Some provided, but poorly located	4	1	4	4
5	Support Facilities	Non-existent	2	0	0	1
6	Connectivity of roads	Good	4	3	12	8
7	Sidewalk Environment	Poor environment, closer to vehicular traffic and shopping homes	2	1	2	2
8	Potential for vehicle conflict	Poor, 18 conflict points i.e. 2- three leg junction on the path segments (both side of the road)	3	1	3	3
9	Pedestrian Volume	Assumed 1765 per day	3	0	0	1
10	Mix of path Users	Mostly pedestrians, assume Approximately more than 80%	4	3	12	8
11	Personal Security	Poor, limited street light and poor inadequate security	4	2	8	7
Total Weighted Score					60	
LOS result					D	

Table(10). Rating and criteria of the PLOS factors in Educational area road segment, between Mizan round about and Mizan University

SN	Geometric, Location and User Factors	Measurement/value	Weight	Score	Weighted Score	Ranking Affecting Factors
1	Average sidewalk Width(m)	2.40	4	4	16	9
2	Average Surface Quality	Moderate quality	5	2	10	7
3	Number of Obstructions (Per Km)	8 (Illegal construction materials and some of utility Vendors)	3	3	9	6
4	Crossing Opportunities	Some provided, but poorly located	4	1	4	3
5	Support Facilities	Non-existent	2	0	0	1
6	Connectivity of roads	Good	4	3	12	8
7	Sidewalk Environment	Acceptable environment, No closer to vehicular traffic	2	2	4	3
8	Potential for vehicle conflict	Poor, 18 conflict points i.e. 2- three leg junction on the path segments (both side of the road)	3	1	3	2
9	Pedestrian Volume	Assumed 2,117 per day	3	0	0	1
10	Mix of path Users	Mostly pedestrians, assume Approximately more than 80%	4	3	12	8
11	Personal Security	Reasonable, but needs maintenance street light and work on security	4	2	8	5
Total Weighted Score					78	
LOS result					C	

Table(11). Rating and criteria of the PLOS factors in Residential area road segment, between Mizan Museum and Mizan Stadium

SN	Geometric, Location and User Factors	Measurement/value	Weight	Score	Weighted Score	Ranking Affecting Factors
1	Average sidewalk Width(m)	2.10	4	4	16	8
2	Average Surface Quality	Moderate quality	5	2	10	6
3	Number of Obstructions (Per Km)	3 (Utility Poles and illegal construction material)	3	3	9	5
4	Crossing Opportunities	Some provided but, not enough	4	2	8	4
5	Support Facilities	Non-existent	2	0	0	1
6	Connectivity of roads	Good	4	3	12	7
7	Sidewalk Environment	Poor environment, close to vehicular traffic and with bad odor from homeless road side living wastes	2	1	2	2
8	Potential for vehicle conflict	Reasonable, nine conflict points, i.e., 1-three leg junction on the path segments (both side of the road)	3	3	9	4
9	Pedestrian Volume	Assumed 1,246 per day	3	0	0	1
10	Mix of path Users	Mostly pedestrians, assume Approximately more than 80%	4	3	12	7
11	Personal Security	Unsafe, limited street light and poor inadequate security	4	1	4	3
Total Weighted Score					82	
LOS result					C	

VI. CONCLUSION AND RECOMMENDATIONS

CONCLUSION

Nowadays, in the development of one's country, both urban economic activities and safe movements of peoples and goods are measured through its basic transport system. For safety and comfort purposes, pedestrians need facilities that are safe, attractive, convenient, and easy to use especially appropriate walking facilities in any city. Poor design of pedestrian facilities can lead to perpetual problems and can discourage use if pedestrians are made to feel unsafe, unprotected, or uncomfortable. So, the needs of the pedestrian should be considered in the design of urban environment and transportation facilities.

In Mizan city about 210 traffic accidents were recorded in the last six years and in this, more than 20% of pedestrians have resulted in death. The report indicates that majority of the casualties were located away from a pedestrian crossing, at the non-designated midblock crosswalk, when they cross a road and share the carriageway for walking purposes. When they were asked about why they do not use safer means crossing on a zebra, they replied that the crossing facilities are not provided at a logical distant and are preferable on crossing the road directly is quicker. Analysis of pedestrian road crossing behavior showed that 47% of pedestrians use crosswalks correctly while 53% of pedestrians cross at non-designated locations. As the study indicates on all segments the available type of facility is a zebra, but it is not visible even for pedestrians on many places and needs maintenance which is functional in all seasons.

The users' perception revealed that 60% think the sidewalk is not user friendly. The sidewalk quality and continuity of the facility is very important for the pedestrian with disability and of old age. Since the walkways in Mizan city, in general, have almost the same problems like non-continuous, crack, and non-covered manholes which is difficult especially for pedestrians with disabilities and also risky at night time for all the users. Frequent ups and downs make the footpath uncomfortable to use and force the pedestrian to share the carriageway along with the vehicles. Since, the reason behind not preferring the walkway indicates that street vendors, discontinuity of sidewalk and surface quality are affecting the pedestrian safety.

In Mizan city the study observes, almost more than half, feel threatened at night due to inadequate security. As on the areas observed the lighting facilities are available in the night time while walking on the walkways. Unfortunately, most of them are not working properly due to lack of proper maintenance at a regular interval. In the four studied routes, most of the case there is no lighting opportunities on both sides, and this leads presence of the illegal pick pocketing and the snatch bags.

This research is tried to aware the transportation planners and nearby authorities on the existing problems related to the safety of pedestrians in Mizan city. Hopefully, this study contributes much in enhancing the safety of pedestrians by identifying the affecting factors studied through the investigation of existing problems in the areas of pedestrians and indicated that improving the road infrastructure can increase walking and decrease fatalities in the city. Pedestrian facilities such as sidewalks, crosswalks, Curb ramps and the like should be well designed and maintained to be effective for both encouraging people to walk and improve pedestrian safety along certain routes.

Finally, a model for the assignment of an LOS grade to the road segments was developed based on identified factors, liaison with Stakeholders and a best practice review of available literature. Therefore, based on this method the study was identified the most significant factors affecting pedestrian safety in Mizan city. Among the identified safety factors mainly sidewalk environment, crossing opportunity, support facility, personal security, obstructions, surface quality, and sidewalk width indicates the most affecting factors that need consideration for necessary improvements to make a more pedestrian friendly environment for each segment in the City.

RECOMMENDATIONS

Good design and construction of a pedestrian facility is an important factor in incorporating pedestrians into Mizan transportation system, but it can't be expected to solve all pedestrian related problems. Therefore, education and enforcement are other important tools that heighten awareness of pedestrians.

The concerned government offices for transport infrastructure have to work together to enhance the pedestrian safety in the city.

The qualities of sidewalk at all studied sites are poor with almost the same problems such as non-continuous and non-covered manholes which are difficult especially for pedestrians with disabilities. It is economical that covering the manholes and ditches with the nearby covers available on the place.

Sidewalk environment is affected by the urban noise pollution due to different waste materials in the side drainage ditches in market area. The study identified from the respondents that this markets should be changed to other places to minimize the environmental problems in the segments.

In Mizan city, the current sidewalk is fully encroached either by vendors, utility poles, parking carts or illegal construction materials in different places. It is possible to remove idle utility poles placed on sidewalk, and enforce street shopping, cart drivers and neighbor stores not to sell or place some goods on the sidewalks.

Additionally, to improve safety and minimize accidents educating the peoples on the safety benefits of zebra/designated crosswalk use and a review of crosswalk operations can enhance the safety of pedestrians in Mizan city municipality.

Researches on pedestrian safety must be conducted in the city to improve the comfort of pedestrians on sidewalk facilities and to minimize the accident risks in related to road users in future works.

To summarize, the following recommendations should be implemented Transport and infrastructure related offices especially Mizan municipality should work periodic maintenances for necessary improvements on pedestrian walking facilities. Raised Zebra crossing should be provided specially in front of schools and churches. Zebra crossing should be marked with vertical signs and horizontal marking. Preparation and construction of separate parking areas for the church followers either by church or by any concerned government bodies should be made. Provide and properly constructed side walkway. Provide fence/supporting facilities to lead the pedestrian. Prohibition of on walkway parking vehicles. On the segments with security problems, strict police attendants. Enforce street shopping and neighbor stores not to sell or Place some goods on the sidewalks. Provide street lighting, and pedestrian crossing lighting.

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