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EFFECTS OF HUMAN BEHAVIORS AND GEOMETRIC FACTORS IN ROAD TRAFFIC ACCIDENTS: A CASE STUDY ALONG SULULTA – FICHE ROAD, ETHIOPIA

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ABSTRACT

Road traffic accident was one of the severe problems which are affecting once's country and leading to death, injuries and property damage resulted in economic loss. The objective of this research was to investigate the effects of Human behaviors and Geometric factors in road traffic accidents along the road of Sululta-Fiche, which is located in Northern Shewa of Oromia region. Both probability sampling and non-probability sampling techniques were applied. The primary data were obtained from site observation of blackspot locations. While the secondary source of data was taken from records compiled by North Shewa traffic office and Oromia Special Zone Surrounding Finfinne traffic Office. A descriptive and analytical design methods were used in this research, while the results were displayed by graphs, tables and pie charts. From the study, the status of road traffic accident showed that there were dramatic increased of accidents every year within the study period. A total of 830 crashes occurred in the past three years. From this, 237 accidents happened in 2012, 279 accidents in 2013, and 314 accidents in 2015. From the traffic police report analysis, there were 41 locations in Sululta Town, and 70 locations in the Sululta Wereda, where those accidents happened. Based on the results of this research using priority value approach, there were 12 selected locations in Sululta Town and 10 chosen locations in Sululta Wereda. Therefore, it is concluded that the significant factor in traffic accidents along Sululta –Fiche road was the driver errors such as over-speeding, night driving and driving without attention, and it was followed by the geometric factors. These road deficiencies contributory to some errors of the drivers, were inadequate road width, insufficient sight distance, and narrow bridge at sag curves and improper intersection design. Based on the findings of the study, some of the countermeasures recommended to reduce the road traffic accidents are provision of speed limit signs to forewarn drivers, installation of speed barkers and rumble strips, widening the lane width of pavement, maintenance of deteriorated road, repair of the road signs and provision of adequate sight visibility for drivers.

Keywords: Countermeasures, Geometric factors, Human behaviors, Road traffic accident, Road safety audit.

1 INTRODUCTION

Road traffic accident occurs worldwide, but the incidence rate is higher in developing countries such as Ethiopia. The problem of road accidents in Ethiopia has reached an alarming proportion in such a way that the highways seemed like converted into dead zones, killing citizens daily. Road traffic accidents which are unintended and preventable are a common risk every day of life that can happen to almost everyone, anywhere [1]. Data from WHO shows the risk of dying from RTA is higher in Africa 24.1 per 100,000 [2] making it challenging in line with struggling to overcome the burden of infectious diseases and increasing number of non-communicable diseases. The alarming increase in morbidity and mortality owing to road traffic accidents over the past few decades is a matter of great concern globally. The issue of road safety has already become critical in Ethiopia- a country with low rates of motorization. The number of people killed and injured as a result of traffic accidents has been steadily increasing, and the country is experiencing a tremendous loss of life and property each year as one of the leading nations of the world with the worst accident record. Besides those that died in road traffic accidents there are many others who survived with residual disabilities of varying degrees of severity, who ends up as a burden to the society. The country itself suffers by losing its talented and productive workforce often in the prime of life. Even though the WHO and the Traffic Police Department of Addis Ababa have been working since 2002 to strengthen its road traffic injury data management capacity, the reports indicate that the trend of accidents is not in a state of decline; but rather has continued to rise enormously [1]. Considering the status road traffic accident happened on the Sululta – Fiche road from 2012 to 2015, there was the dramatic increment of the crashes from year to year. Therefore, this shows that there was a lack of proper study on the Sululta – Fiche road and need proper attention. In this research the accident, a hazardous location was intensely studied, and the possible countermeasure were provided by undertaking road safety audits and also by investigating the causes of the accidents. The objective of this research concerned with the effects of human behaviors and geometric factors in road traffic accident, establish remedial measures, and finally to suggest countermeasures to prevent the occurrence of traffic accidents on the Sululta - Fiche road. While the research questions were organized to seek for the answers of the current problem in the study area; as follows: (1) Which locations of the study area have the highest road traffic accidents and its contributing factors related to human behaviors and geometry of road that causes road traffic accidents? (2) Which causes are significant contributory factors to the occurrence of road traffic accidents? (3) What are the possible remedial measures that can be recommended to mitigate the road traffic accident in the study area?

2 RESEARCH METHODOLOGY

2.1 Study Area

The research was conducted on Sululta- Fiche main road which is found in the Northern part of Oromia regional state. The study area started at 7 km from Addis Ababa, which was the beginning place of Sululta wereda and ended at Fiche town which is about 115 km from Addis Ababa to North direction with the total length of 108 km. It is the part of the road that connects Addis Ababa to Bahir Dar and Gonder. North Shewa zone is approximately located between $9^{\circ}08'52''$ to $10^{\circ}35'17''$ North latitude and $37^{\circ}56'13''$ to $39^{\circ}34'47''$ East longitudes, and it is characterized by dissecting high plateaus and mountains associated with hills, valleys, and gorges. Its altitude extends from about 1000 located in the Abay gorge in the Wara Jarso district to over 3500m a.s.l. located in Degem district. In general, the study region is characterized by varying topographic features. The road passes through the principal towns of Sululta, Chancho, Muka Turi, Debra Tsige and end at Fiche town.



Figure 1: Map of study area: Sululta –Fiche road (Google map 2017)

2.2 Research design

A descriptive and analytical design method was used in this study. The descriptive type of research was considered to be an appropriate method to investigate the status, causes and remedial measures of road traffic and the analytical approach were used to analyze different traffic accidents occurred on the road.

2.3 Population

The population that was considered in the study are drivers driving along Sululta - Fiche road, North Shewa and Oromia Special Zone Surrounding Finfinne traffic police, pedestrian living within the range of study areas and traffic accident data of each of the North Shewa and Oromia Special Zone Surrounding Finfinne traffic police office.

2.4 Sample size & sampling technique

2.4.1 Sample size

The sample size was determined by a single proportion population formula taken with the assumptions of Z-value ($\alpha/2$) =1.96 (95%), confidence level for two sides), P= proportion expected prevalence of the problem (50 %), d = degree of accuracy desired to set at (5%), of which 385 sample population participated in the study.

$$\text{Sample size, SS} = \frac{z^2 X(p) x (1-p)}{d^2} \quad (1)$$

$$SS = \frac{1.96^2 x (0.5)x(1-0.5)}{0.05^2}; \quad SS = 384.16$$

2.4.2 Sampling technique

For this study, both probability sampling (simple random sampling, stratified sampling) and non-probability sampling (purposive sampling) techniques were utilized. For this research, the population was stratified into driver, traffic police and the pedestrians and traffic accident data were stratified based on an age of the driver, time of the day and vehicle type. Drivers and pedestrians were selected by simple random sampling (lottery method), and all traffic police are selected by a purposive sampling method.

2.5 Data collection process

2.5.1 Primary data collection

The primary data were obtained through site observation of the blackspot area and from questionnaires of pedestrians, drivers and traffic police.

2.5.1.1 The geometric data obtained on the blackspot area

The geometric road data gathered from site visit includes cross-sectional elements (lane width, shoulder width, climbing lanes and median barrier), road alignment (horizontal and vertical alignment) and sight distance. These were substantiated by actual measurements and visual inspection, which was made on the road site and it was checked using road safety audit checklist.

2.5.2 Secondary data collection

The secondary source of data was taken from recorded data compiled by North Shewa traffic office (Wucale wereda, Debra Libanos wereda, Girar Jarso wereda and Fiche town) and Oromia Special Zone Surrounding Finfinne Traffic Office (Sululta town and Sululta wereda). Those data were recorded by copying the original data and by taking pictures. The data applied to study were the accident data from 2012 to 2015.

2.6 Data processing and analysis

The quantitative data processing and analysis are displayed by graphs, tables and pie charts. In this study, blackspot location analysis was made using the Flemish government analysis method. First, each site within the last three years, three or more accidents have occurred have selected. Then, a site is considered to be dangerous when its priority value (P) equals 15 or more [3]:

$$P = X + 3*Y + 5*Z, \quad (2)$$

Where:

P = priority value

X = total number of light injuries

Y = total number of serious injuries

Z = total number of deadly injuries

After the analysis and identification of blackspot locations, the site observations were followed. From here, the cause of accidents at the location concerning geometric factors are identified by using Safety Audit Checklist of Existing Road.

3 ANALYSIS, RESULTS, AND DISCUSSION

3.1 General characteristic of respondents

The research questionnaire was distributed to 250 pedestrians, 100 drivers and 36 traffic police in the study area.

Table 1: Characteristics of Respondents

Respondents		Pedestrians		Drivers		Traffic police	
		No.	%	No.	%	No.	%
Sex	Male	159	63.6	100	100	34	94.4
	Female	91	36.4	0	0	2	5.56
Age	< 18	2	0.8	0	0	0	0
	18-24	41	16.4	17	17	8	22.2
	25-34	135	54	70	70	14	38.9
	35-44	52	20.8	5	5	10	27.8
	45-54	18	7.2	8	8	4	11.1
	>=55	2	0.8	0	0	0	0
Level of Education	Illiterate	0	0	0	0	0	0
	Primary school	6	2.4	25	25	0	0
	Secondary school	37	14.8	59	59	21	58.3
	Diploma	52	20.8	16	16	13	36.1
	Degree	143	57.2	0	0	2	5.56
	Above degree	12	4.8	0	0	0	0

From table 1, the pedestrians composed of about 63.6% male and 36.4% female pedestrians, while 100% drivers were male, and the majority of the traffic police were male which accounted for 94.4%. Also, as far as the educational status of the respondents is concerned, 57.2% of the pedestrians were degree holders, 59% of drivers and 58.3 percent of traffic police were not degree holders (e.g., below grade 12). The questionnaire survey of the researcher conducted depicts the question that relates to: "Rank the causes of road traffic accident on Sululta on Fiche road according to their severity." Based on the results from respondents, driver factor ranked 1st on causing road traffic accidents. Further analysis, it showed that the geometry of the road was ranked 2nd, road condition ranked 3rd, carelessness of pedestrians ranked 4th, and the negligence of road safety rules ranked last from the identified causes of road traffic accidents in the study area.

3.2 General characteristic of road traffic accidents

From the study period of 2012-2015, a total of 830 accidents occurred, out of which 325 were injuries, and 505 were property damages. From a total of 325 accidents, 95 were fatal, 81 were severe, and 149 were slight injuries. Thus, the distribution of crashes, 46.17 % of the crash happened in Sululta wereda, 37.61% in Sululta town and 16.22% happened in Wucale, Debra Libanos, Girar Jarso wereda and Fiche town. This indicated that the majority of the road traffic accidents happened at Sululta road.

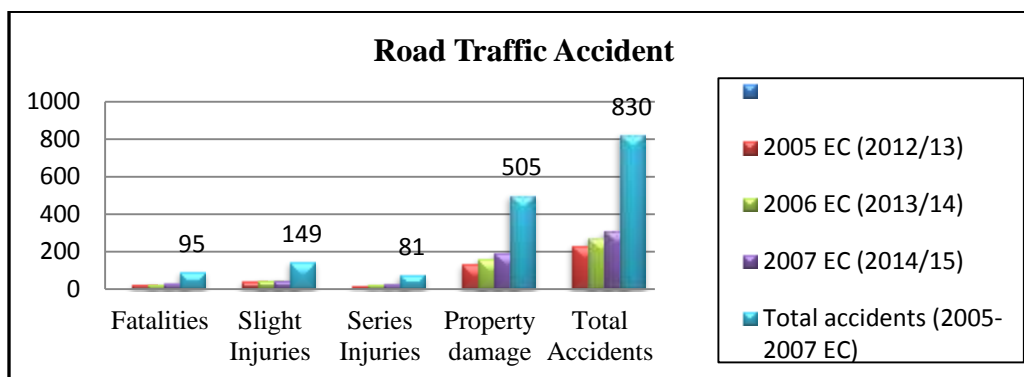


Figure 2: Road Accidents from 2012-2015

3.2.1 Accident Variation by months of the year

Figure 3 Shows the occurrence of the monthly variation of an accident. There were more accidents happened during the

wet season than the dry season of the year. For instance, the highest number of accidents occurred in February, May, June, and August. February is the time at which farmer products are being brought to market areas. Due to this, there was a high number of traffic movements. While, during May, June, and August the weather condition is not good (i.e. rainy and foggy) which was contributory to the driver errors.

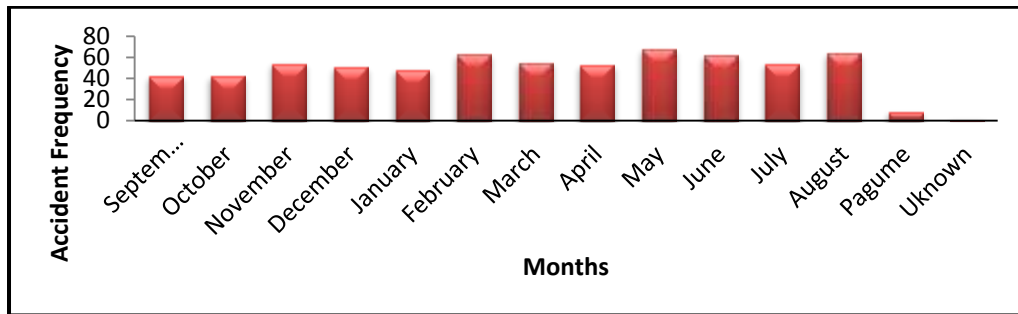


Figure 3: Accident variations by months

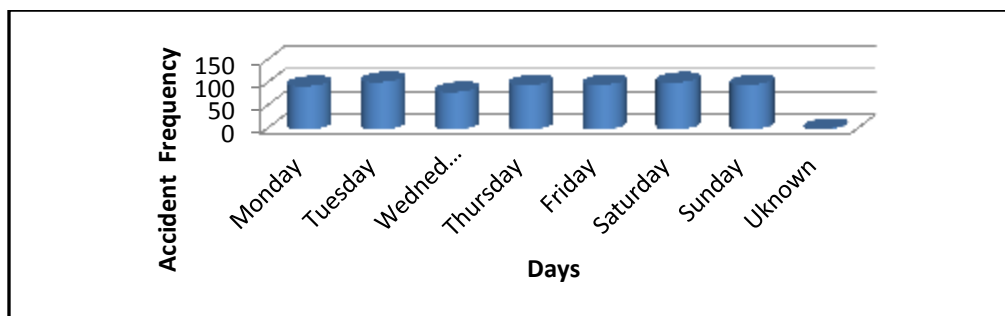


Figure 4: Accidents variations by days

On the hand, figure 4 Shows the daily variation of accident happened within the day. The results indicated there was no significant variation between the days. However, the highest number of accidents occurred Tuesday and Saturday. These days are the market days in the study area, and there were a lot of movements for both vehicles, pedestrians and animals. In addition, drivers or businessmen were importing products to the study area, coming from Bahir Dar and Gonder.

3.2.2 Accidenst Variation by time of a day

Figure 5 indicates the highest number of accidents occurred during 3:01-6:00 PM. The traffic volume was high while the existing roadway width from 6 m to 6.5m (less than the standards) was inadequate to accommodate the traffic. Record also showed that Sululta area was the residence for most of the workers from Addis Ababa, during this time they traveled way to their home.

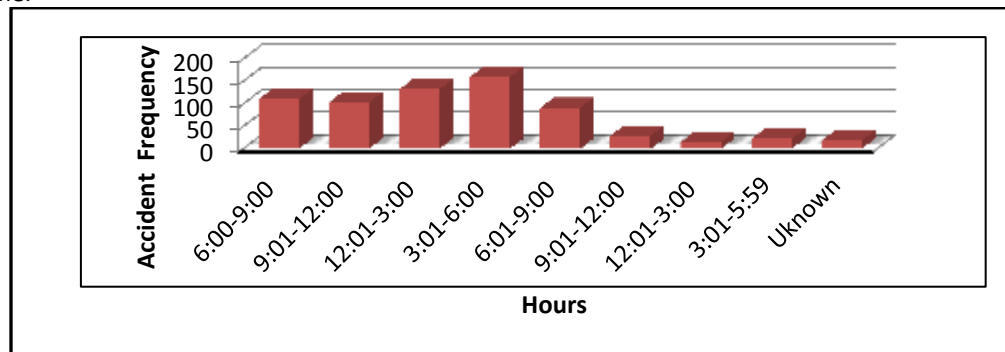


Figure 5: Accident variations by hours

3.2.3 Accident distribution of vehicle types

Different vehicles category was involved in these road accidents. Figure 6 indicated that vehicle category involved in road traffic accident. The vehicles category most frequently involved in crashes were trucked 41-100 quintals (26%), and minibus up to 15 seats (23%) were the second most vehicle categories involved in traffic accidents.

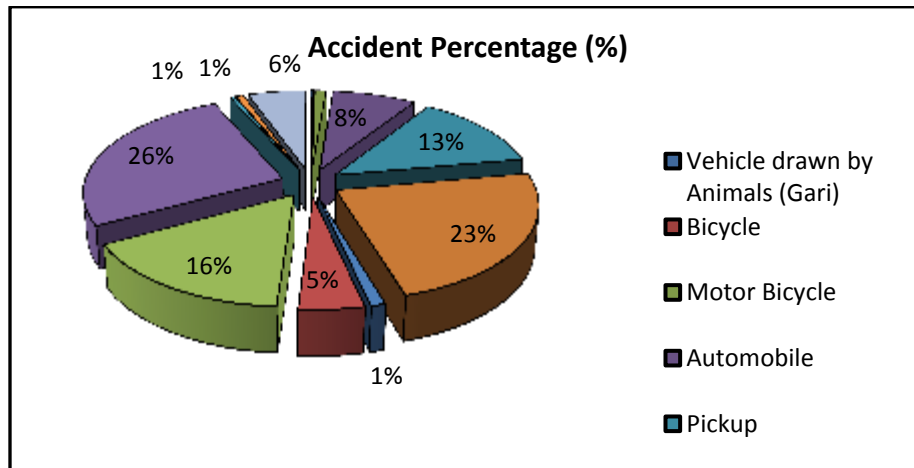


Figure 6: Accident distributions by vehicle category

The involvement of vehicles types in causing fatalities, injuries and property damage, the minibus shared the highest (18.07%) and Isuzu were registered as the second vehicle types (15.42%) causing fatalities, injuries and property damage during the 3- year period. It was also observed that most drivers used these kinds of vehicles, exceeded the maximum speed required, and they were also driving without taking the rest.

3.2.4 Accident by vehicle collision types

The majority of accident incurred by the vehicle of about 42% collision type, 28% by vehicle out of road (rollover), and 16% by the vehicle with the pedestrian. From these analysis and site observation, the researcher observed that the caused of these accident's related geometric such as; inadequate road width, worn of road marking and high traffic volume.

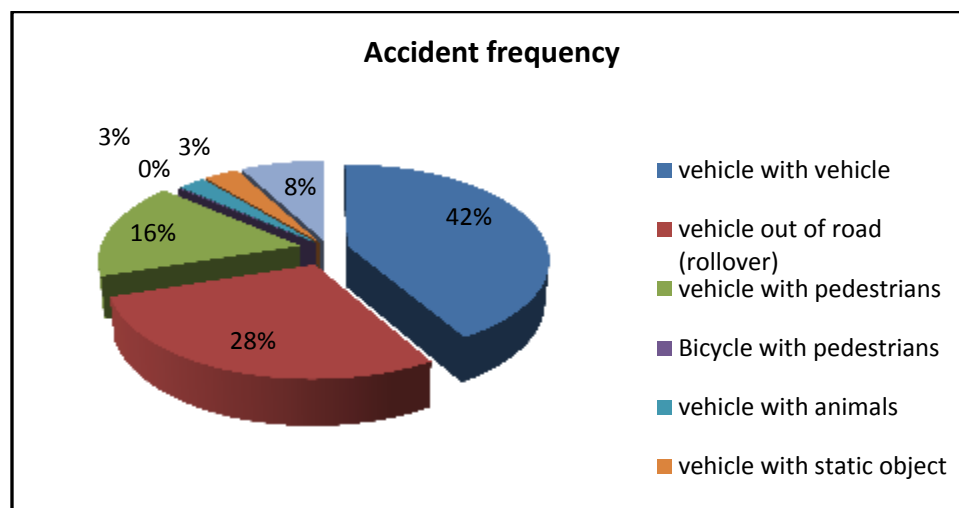


Figure 7: Accident by vehicle collision types

3.2.5 Causes of road traffic accidents

In table below indicated the following causes of the accident along Sululta - Fiche road. The major causes of accidents were: speeding composed of 36.75%, driving without attention of 16.51% and failure to give way to pedestrians of 12.29%. Thus, the highest fatalities were caused by speeding and failure to give-way to pedestrians and also the highest by

causing fatalities, injuries and damage to properties.

Table 2: Causes of road traffic accident on the road

Sno.	Causes of Accident	Fatalities	Injuries		Damage to Property	Total	(%)
			Slight	Series			
1	Driving without attention	14	16	8	99	137	16.51
2	Drunk driving	0	1	0	0	1	0.12
3	Failure of vehicle	4	5	3	4	16	1.93
4	Failure to give way to animals	1	0	1	10	12	1.45
5	Failure to give way to Pedestrians	29	37	23	13	102	12.29
6	Failure to give way to vehicles	1	1	0	10	12	1.45
7	Improper Loading	0	0	0	1	1	0.12
8	Improper Overtaking	3	3	4	43	53	6.39
9	Improper Turning	0	1	0	6	7	0.84
10	Lack of Experience	0	1	0	1	2	0.24
11	Road condition	0	0	0	1	1	0.12
12	Speeding	22	62	31	190	305	36.75
13	Weather condition	1	0	0	1	2	0.24
14	Unknowns	20	22	11	126	179	21.57
	Total	95	149	81	505	830	100.00

3.3 Blackspot identification

3.3.1 Calculating of accident frequency

According to criteria stated by Flemish government in Belgium, each site within the last three years, three or more accidents have occurred. These were the basis for further black spot investigation. Reviewing the record a few times, a total of 41 locations in Sululta town, and 70 in the Sululta wereda identified accident locations. From here, there were 19 hazardous locations, and 26 hazardous areas which fulfilled the first criteria respectively. These areas had found out 3 and more accidents during the study period of 2012-2015.

3.3.2 Priority Value of Hazardous locations

According to the priority, criteria developed by the Flemish government, road sections which have greater than or equal to 15 of priority value considered for further blackspot investigation. Equation (2) was used to compute for P.

3.3.2.1 Sululta Wereda

A total of about 26 hazardous locations that fulfilled the first criteria which have 3 or more accidents within the last 3 years of study period of 2012-2015 of those ten hazardous locations were identified as black spot location in Sululta Wereda. Table below shows the calculated values of priority value based on fatalities and injuries for each blackspot location.

3.3.2.1 Sululta Town

A total of 19 hazardous locations fulfilled the first criteria which has 3 or more accidents within the last 3 year of study period of 2012-2015 of those 12 dangerous areas were identified as blackspot location in Sululta town. Also in table below shows the calculated values of priority value based on fatalities and injuries for each black pot locations.

Table 3: Identified Blackspot locations in Sululta Town

Sululta Town Hazardous Location							
SNo.	Location name	Fatalities	Injuries		Damage to Property	Priority Value(P)	Accident Frequency
			Slight	Series			
1	01 kebele sululta	3	8	4	31	35	40
2	Ashewa	1	4	4	8	21	15
3	Asir kilo	2	1	2	10	17	10
4	Doro Irbata	2	0	2	7	16	9
5	Hotel	2	0	2	18	16	18
6	Kajima	1	1	3	5	15	8
7	Kimbire	1	1	3	9	15	11
8	Lether industry	2	2	2	11	18	15
9	Mizan	1	2	3	11	16	15
10	Pirayim milk industry	2	1	2	7	17	10
11	Shufune	2	0	3	8	19	12
12	Wasarbi	2	5	2	22	21	26

There were a total of 22 blackspot locations identified in Sululta town and Sululta wereda which fulfilling the condition using the priority value formula. Hence, the locations have 3 or more traffic accidents within the last 3 years of the study period, and the locations priority value were more significant and equal to 15.

3.3.2.2 North Shewa zone

For the case of Wucale, Debra Libanos, Girar Jarso wereda and Fiche town, there were no specified locations of accidents recorded by traffic police. In this study, the blackspots were identified based on the interviews conducted with traffic police officers. Based on those interviews, the places having more traffic accident were considered as the blackspots for further investigation.

3.4 Road geometric factors related effects on road traffic accidents

Geometric design elements play an essential role in defining the operational traffic efficiency of any roadway. Key geometric design elements that influence traffic operations include number and width of lanes, the presence and widths of shoulders and highway medians, and the horizontal and vertical alignment of the highway [4].

In the study period different accident happened at the different section of road. Some of the roads problems observed during the audit were improper designs of the roadway. Because almost all the sections of the road found during the safety audit are: road markings were wholly worn out, no shoulder, insufficient sight distance due to existence of trees and topographic feature of the road, narrow lane width, narrow bridge, bridge around sag and sharp curves, damage guardrails and the road signs such as warning signs were also completely worn out, and some were improper placement at some sections of the road.

The existing values of crosssection elements for the audit road have been measured and compared with ERA geometric design manual as shown in the table below. In order to check the design standard of the cross-section of the road of the study area, the researcher should have to know the standard design of the road.

Table 4: Comparison of road cross section of existing road with ERA standards

SNo.	Roadway Element	ERA Standard Values	Observed Values
1.	Design speed	30 – 85 km/hr depending on the terrain of the roads	Mostly 80 km/hr and above
2.	Lane width	6.7-7 m	5 -6.5m
3.	Shoulder width	0.5-1.5m	0-1m
4.	Number of lanes	Two lane	One and two-lane
5.	Bridge Width	At least full approach traveled width or plus 0.6 m clearance way width on each side	Less than travel way width
6.	Pedestrian crossing	Controlled	Uncontrolled

In addition to the above listed geometric related factors, some of the elements were discussed under road safety audit checklist prepared for evaluations of identified blackspot locations.

3.5 Identification effects of human behavior and geometric factors and countermeasures of accidents in black spot locations

Road safety audit checklist was prepared to collect road condition data on blackspot locations. The blackspot locations were evaluated using road safety audit checklist criteria, and the criteria were based on ERA road safety audit checklist for existing road guideline manual. The corresponding countermeasure was provided by site visiting blackspot locations with traffic polices, and it was produced based on the road safety audit checklist provided. Hereunder are the three major areas identified as the blackspot locations.

3.5.1. Sululta Town Black Spot Locations- Asir Kilo (Around 7+000 from Addis Ababa)

The blackspot location was found at the entrance of Sululta town, and it was located around 7 km from Addis Ababa.

Table 5: Asir kilo Road Safety Audit Checklist

SNo.	Observed problems at the black spot locations	Countermeasures for black spot location
1	Inadequate road width (6 - 6.5m)	Increasing/ widening the road width
		Providing climbing lane in upgrades direction
2	The edge of the road and road surface was damaged	Maintaining deteriorated/ damaged road surface
3	The shoulder was unpaved, and the width of the shoulder was less than 0-1m	Paving and increasing of shoulders
4	The area has inadequate site visibility (sight distance) due to the existence of trees and terrain of the area.	Removing of trees that obstruct sight visibilities.
5	The location has no road marking	Renewing damaged road signs and road markings

3.5.2. Wasarbi (Around 8+500 from Addis Ababa)

Table 6: Wasarbi Road Safety Audit Checklist

SNo.	Observed problems at the black spot locations	Countermeasures for black spot location
1	Inadequate road width (6 - 6.5m)	Increasing/ widening the road width
2	There was improper intersection (intersection at sharp curve)	Correcting the intersection
3	The shoulder was unpaved, and the width of the shoulder was less than 0-1m	Paving and increasing of shoulders
4	There were no pedestrian or zebra crossings	Providing pedestrian or zebra crossing
5	The location has no road marking	Renewing damaged road signs and road markings
6	The area also has straight road section and at this location the possible cause was driver factors (speeding and overtaking) Since most of the time (3:00-7:00 Pm) the location has traffic congestion that causes collisions of vehicles with a vehicle.	Controlling the traffic flow during this time by providing enough traffic police Providing speed hump and speed breaker to control over speeding

3.5.3 Mizan (Around 10+500 from Addis Ababa)

Table 7: Mizan Road Safety Audit Checklist

SNo.	Observed problems at the blackspot locations	Countermeasures for blackspot location
1	Inadequate road width (6 - 6.5m)	Increasing/ widening the road width
2	This location is found around Ethiopian road authorities size and weight control station. Around this, there were a high number of Parked vehicles and there was a taxi station in the area.	Changing taxi station from weight area and controlling vehicle parking around the areas.
3	The shoulder was unpaved, and the width of the shoulder was less than 0-1m	Paving and increasing of shoulders
4	The area has improper intersection since there was sight obstruction by trees.	Removing of trees that obstruct sight visibilities and changing intersections
5	The location has no road marking	Renewing damaged road signs and road markings

4 CONCLUSION

Based on the findings of the study, the status of road traffic accident showed that there was a dramatic increment of the crashes from year to year during the study period. The traffic police report analysis, there were 41 locations in Sululta Town and 70 locations in Sululta wereda in which accidents occurred. From here, using priority value, it was found out 12 locations in Sululta Town and 10 locations in Sululta wereda identified as hazardous locations. The results from this study, indicated that the highest number of accidents happened during 3:01-6:00 PM of the day. These accidents were due to high number of vehicles during this time. The respondents agreed that human factors take the highest rank for the occurrence of traffic accidents, referring to drivers. It is therefore concluded that over speeding, driving without attention, failure to give-way to pedestrians, night driving and lack of experience, were the major reported driving factors causing traffic accidents within the study area, in addition with the geometric factors mentioned in the previous discussion.

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