DECLARATION

I, the undersigned, declare that this thesis entitled "Causes and control mechanisms of road traffic accident: A case study from Shashemene to Adaba road." is my original work, and has not been presented by any other person for an award of a degree in this or other University, and all sources of material used for thesis have been duly acknowledged.

Candidate

Mr Deme Arega Dembi

Signature_____ Date _____

As Masters research advisors, we hereby certify that we have read and evaluated this MSc.

Research prepared under our guidance, by Deme Arega Dembi entitled: Causes and control mechanisms of road traffic accident: A case study from Shashemene to Adaba road.

We recommend that it can be submitted as fulfilling the MSc. Thesis requirements

Prof. Emer T. Quezon _____ _____

Main Advisor Signature Date

Tarekegn Kumela (MSc). _____ _____

Co-Advisor Signature Date

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ABSTRACT

The rate of road traffic accidents increase from time to time in Shashemene to Adaba road sections. In this study the aim is to identify the cause and control mechanisms of road traffic accident along Shashemene to Adaba.

The scope of the study was limited to Adaba Shashemene road, which starts from Shashemene municipal and point up to Adaba town which is 350 km from Addis Ababa with total length of 100km. The sample kebele/town, those with high traffic volume, for the study are taken using purposive sampling technique.

The general characteristics of road traffic accidents from Shashemene to Adaba road are identified and ranked blackspot locations according to priority values with corresponding cause of accidents. For the identified blackspot locations control mechanisms are provided.

In order to conduct the research, the data that were collected are accident records from 2012-2017 by each wereda police stations. Then these data were analyzed using priority value based on the severity of traffic accidents which takes into consideration the number of deaths and slight and serious injuries occurred for five years is used for Shashemene , Fejihursa, Kofele , Dodola and Adaba town while accident frequency is used for Ashoka and Wabe kebele to rank blackspot locations. Based on the analysis made, 25 top blackspot locations were identified.

Based on the results of the study in the year 2012 to the year 2017, it found out that there were 904 road traffic accidents have been occurring in the vicinity of the survey road sections. The percentage distribution of severity class comprised of about 25% of the fatal accident, 8.3% serious injury, 12.72% slight accident and 53.98% property damage, respectively. Properties damage during study period was about 26,697,236.00 Birr.

Finally, from the finding of the research the following control mechanisms were provided: speed breaker, provision of road side improvements, improvement of side walk, installation of traffic signs and pavement markings should be done.

Key Words: *Accident frequency, Control mechanisms, priority value, Road safety audit, Traffic accident*

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ACRONYMS

CSA	Central Statically Agency
EDRI	Ethiopian Development Research Institute
ERA	Ethiopia Road Authority
ERTA	Ethiopia Road Transport Authority
ETB	Ethiopian birr
OAU	Organization of Africa Union
PIARC	Permanent International Association of Road Congress
RA	Road Accident
RTA	Road traffic accident
RSDP	Road Sector Development Program
RAI	Road Accident Investigation
RSI	Road Safety Investigation
TRL	Transport Research Laboratory
TWLTL	Two-way left-turn lanes
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background

Road transportation provides benefits both to nations and to individuals by facilitating the movement of goods and people. It enables increased access to jobs, economic market, education, recreation and health care, which in turn have direct and indirect positive impacts on health of populations. However, the increase in road transportation has also placed a considerable burden on people's health in the form of road traffic injuries, respiratory illness, and the health consequences that ensure from a reduction in physical activity. There are also additional negative, economic, social and environmental consequences that arise from the movement of people and goods on the roads- such as air pollution, greenhouse gas emissions, and consumption of finite resources, community severance, and noise. For instance according to WHO's Global Burden of disease project for 2004, road traffic crashes caused over 1.27 million deaths that year which is a similar number to those caused by many communicable disease. While road traffic death rates in many high-income countries have stabilized or declined in recent decades, data suggest that in most regions of the world the global epidemic of traffic injuries is still increasing. It has been estimated that, unless immediate action is taken, road deaths will rise to the fifth leading cause of death by 2030, resulting in estimated 2.4 million fatalities per year Therefore, road transportation has a direct connection with the day-to-day activities of people, especially in large cities where the distance is too cover on foot or by bicycle within a reasonable time. According to WHO (2009), however, the increase in road transportation has placed a considerable burden on the people's lives. The fatality of road traffic deaths and injuries is the major one.

Even though the traffic accident rate is growing spontaneously from time to time in Ethiopia, the idea of road safety is applied lately throughout the country. It showed that lack of proper study on the accident suspected areas and also the absence of application of proper control mechanisms to be provided in order to mitigate the effects. In Ethiopia, the situation has been worsened as the number of vehicles has increased and consequently due to increased traffic flow and conflicts between vehicles and pedestrians. Despite government efforts in the road development, road crashes remain to be one of the critical problems of the road transport sector in Ethiopia (UNECA, 2009).

The road traffic accident hazard is believed to be much higher than the indicated statistics by the traffic police record because of under-reporting. The report of road traffic accident showed the occurrence of correct frequency in the study area was high from the other districts. The survey tracked the major road of Addis Ababa to Bale Robe passing the two districts of Shashamane and Adaba. The length of the path is about 100km. In addition to the traffic accident due to geometric design, this research also focused on assessing the general characteristics of road traffic accident, major causes and factors contributory to traffic accidents, its effect, and its control mechanisms to reduce the severity of road traffic accident.

In Ethiopia, road traffic accident is a perennial problem, specifically in Shashamane to Adaba road section. This incidence has long been affected the people and damages vast amount of property threatening the social- economic impact to the surrounding region in the country. In this research study, it was set out to assess the road traffic accident spatially and temporally considering its relevance to planners, policy makers, stakeholders and the community as a whole.

1.2 Statement of the problem

Over 90% of the world's road traffic fatalities occur in low and middle income countries, even though these countries have only about half the world's vehicle. Without action, annual road traffic deaths are predicted to increase to around 1.9 million by 2030 and to become the seventh leading cause of death.

Based on the study conducted by WHO regional office for Africa the rate of road traffic injury in 2004 was 2.2% (9th leading cause) and it is predicted to be 3.6 %(5th leading cause) in 2030.

Road traffic accidents are the critical health problems all over the world increasing its severity from developed to underdeveloped countries. And it is more cause of death in sub Saharan Africa. Ethiopia is one of the member of this region were facing such a problem in our day to day activity. According to some studies conducted in the country 68% of the accidents involve innocent pedestrians including youth and children. This shows that the productive power and generation of the country is in danger due to the accident which also affects the economy of the country.

Generally, the central argument of the present study is to assess the status of Shashamane to Adaba in road traffic accident, causes of accident and reviewing different control/prevention ways taken by Shashamane to Adaba traffic bureau to reduce the accident rate. The researcher was motivated to carry out this academic research stemmed from the rise of RTAs on the highways of Shashemene to Adaba and its effect on the

lives and livelihood of individuals as road traffic accident has long claimed the lives of thousands of millions of fellow citizens.

1.3 Research Questions

1. What are the general characteristics of traffic accidents along Shashemene to Adaba Road?
2. Which location of Shashemene to Adaba road mostly affected by traffic crashes and it's corresponding causes of accidents?
3. How much deviation of existing geometric layout of the identified blackspots from ERA manual?
4. Which control mechanisms to possibly reduce occurrence of traffic crashes in the Shashemene to Adaba road?

1.4 Objective of the research

1.4.1 General Objective

The general objective of this study is to investigate the causes and its control mechanisms of road traffic accident.

1.4.2 Specific objective

- To identify and discuss the general characteristics of traffic accidents along Shashemene to Adaba Road,
- To rank and identify the blackspot locations according to priority values with corresponding cause of accidents identified,
- To compare existing geometric layout or condition with the ERA manual,
- To suggest control mechanisms at a hazardous locations.

1.5 Scope of the research

The scope of the study was limited to Shashemene Adaba road, which starts from Shashemene municipal which is about 250km's far from Addis Ababa and points up to Adaba town which is 350 km from Addis Ababa. The study area is with total length of 100km.

The study identifies the road stretch that is suspected to the occurrence of the accidents by applying suitable blackspot identification method, identifies the causes of the accidents based on the traffic data and finally states the proper control mechanisms that should be applied after undertaking road safety audit based on the prepared check list at the identified blackspot locations.

1.6 Significance of the study

Shashemene-Adaba road covers 100 km in length. Therefore, the significance of the study can be stated as follows:

- The findings obtained from the study would be helpful to gain information and knowledge about the patterns of road accidents, which in turn, could help to develop control mechanisms that could reduce the number and severity of accidents.
- It is important for the police for law enforcement and distribution of man power for surveillance;
- It is important by the government and municipal authorities to determine the need for road improvements, vehicle inspections and to initiate programs for educational purposes.
- It also helps as a source of information for those institutions concerned with road safety management and helps to improve the quality of decision-making in road transport safety planning.

1.7 Organization of the thesis

The report is organized in to five chapters. Chapter one is an introduction to the paper and contains back ground to the problem, statement of the problem, research questions, objectives, scope, and organization of the report and limitation of the research. Chapter two reviews prior studies under taken on the subject under study.

In chapter 3, the materials and method s are fully described. In this chapter firstly the study area is clearly explained and then study area map is drawn, secondly method to be used in order to collect the traffic data and road condition data is clearly stated ,and finally the method used in order to analyze the collected data is clearly described.

In chapter four results and discussion section, firstly the characteristics of road traffic accidents along the road were described, the fatal accidents, injury accidents are analyzed while property damage is analyzed based on cost of accidents. Secondly the accident prone areas were prioritized based on the priority value and accident frequency value. Thirdly the cause of the accidents was identified based on the traffic data. Finally the control mechanisms to be applied were identified by undertaking road safety audit and also by site visiting the black spot location.

The final chapter is chapter five. In this chapter conclusion and recommendation was made based on the analyzed result.

1.8 Limitation of the study

During the preparation of this document the main problem faced was the availability of well-organized data. The available data are only quantitative data which describes the number of fatality, injury (both major and simple), property damage and total number of road traffic accident.

Some of the traffic police officers found in respective Wereda were not responsive and were also not willing to give the accident data .In connection to this, most of the data obtained were blank or not filled with the required information. The result of the study showed that most of the cases were unidentified, so it creates an impact on the value of the analyzed variables

The road design data was not available in Ethiopian roads authority. This situation created difficulties for comparing the actual geometrical design characteristics with that of the as built data from the road.

The budget provided by ERA was not sufficient to fully pay the per time dues for the personal investigator and police inspectors, so it hinders from fully undertaking the research without budget shortage.

CHAPTER TWO

2. REVIEW OF RELATED LITERATURE

2.1 Introduction

One of the inputs for the economic development of a country is the development of road sector which is important for the transportation of peoples and goods from place to place.

Based on this truth our country Ethiopia is constructing many standardized roads and express ways throughout the country to boost the economy. Besides this as the coverage of road network increases the number of vehicles using the road also increase. Related to this as the number of motor vehicle and vehicle mile of travel increases within a given region or a country, the exposure of the population to traffic crashes also increase.

2.2 Road Traffic Accident (RTAs) Defined

The WHO (1977) defines a transport accident as, "any accident involving a device designed primarily for, or being used at the time primarily for, conveying persons or goods from one place to another". On the other hand, ABS (1990) classified road accidents on the basis of the following conditions: the death of a person within 30 days of the accident, or personal injury to the extent that the injured person was admitted to hospital, the accident occurred on any road, street, or any place open to public, the accident involved one or more road vehicles which were in motion at the time of the accident.

IRTAd (1992) stated that according to the Vienna Convention, the standard international definition of road crash involves a collision of a moving vehicle on a public road in which a road user (human or animal) is injured. Besides, the widely accepted definition of RTAs is given by the Economic commission for Europe (ECE). i.e. "road traffic accident (RTAs) are those accidents that occur on a way or street open to public traffic, result in one or more persons being killed or injured, and at least one moving vehicle was involved." Thus, RTA is collisions between vehicles, and pedestrians, between vehicles and animals, or between vehicles and fixed obstacles. For the purpose of this thesis, the definition of the economic commission of Europe is adopted.

2.3 Operational Definition of key concepts /words.

Road Traffic Accident: A collision involving at least one vehicle in motion on a public or private road that result in at least one person being injured or killed (WHO, 2004).

Road Traffic Management: It is planning, coordinating, controlling and organizing traffic to achieve efficiency and effectiveness of the existing road capacity (World Bank, 2004).

Traffic Accidents: are defined as major problems in both developed and developing countries, albeit related to different historical reasons and circumstances. The single, clear, common feature is the impact caused by the automobile. Or traffic accident are major public health problems which are leading causes of death for males aged 15-44 and fifth greatest cause of death for women of the same age group. (Eduardo, 2001).

Road Traffic: A Movement of people, animals and vehicles from one place to another along roads and streets. (World Bank Encyclopedia)

Road**:** Is defined as a good network for rapid growth of the city for its existence. As parks, gardens, open space are "lungs "so also roads are arteries of the city.(Solomon, 2000)

Road Traffic Management System**:** Road traffic Management system is defined as a system or plat forms which has innovative solution for the dynamic supervision, regulation and control of traffic on motor ways, high ways, in tunnels and at junctions. (From website for traffic industry (http;//www road traffic. technology 2014).

Traffic Composition**:** form and structure of different modes of transport which are motorized and non-motorized, that share the same road network, (World Bank),2004).

Transport: It is a means of moving people and goods from place to (World Bank, 1999). It is understood that transport systems are rail, road, metros, air etc.
But in this study, the term transport is used to denote the road transport (World Bank, 1999).
Road Traffic injuries: fatal or non-fatal injuries as a result of road traffic crash (World Bank, 2004).
Road Traffic fatality: A death occurring within 30 days of the road traffic crash (WHO, 2004).
Vulnerable Road Users: Road users most at risk in traffic, such as pedestrian, cyclists and public transport passengers, children, old people, and disable people are also included in this category.
Traffic Mix: Form and structure of different modes of transport, motorized and non-motorized, that share the same road network (World Bank, 1999).

Transportation System: It is defined as a system consisting of the fixed facilities, the flow of entities and the control system that permits people and goods to overcome the fraction of geographical space efficiently in order to participate in timely manner in some desired activity (Zelalem, 2006)

2.4 Definitions of traffic accident black spots

One of the definition for highway accident black spots is they are highway or road locations where the potential for accident is unacceptably high. According to this definition repetition of accidents on a road section result the section of the road with the accident black spot location .Others define traffic accident black spot in terms of accident rate (accident per vehicle kilometers or per entering vehicles), some use accident frequency (accident per kilometer year) and some use the combination of the two.

In addition to the above definitions hazardous locations are sites where crash frequencies, calculated on the bases of the same exposure data are higher than the expected value for other similar locations or conditions. In this explanation hazardous locations are located based on comparison of different sites

In each of the definitions stated above traffic accident black spots are defined in relation to the number of accidents happening on a road sections. They are dealing with the highest number or rate of accident happening in a certain location. Thus we can conclude that in road safety management, an accident black spot is a section of a road or highway where road traffic accidents have historically been concentrated.

2.5 Approaches for the identification of road traffic accident black spots

Improving road safety is not a single activity and cannot be attained within a short period of time. There are different stages to be performed to achieve the goal, safety for road users. The procedure in improving road hazardous locations includes identification of accident black spots, diagnosis, finding control mechanisms, estimating effects, prioritizing, implementation, and follow up and evaluation of measures taken.

Thus identification of black spot is a key for the whole component of the process in attaining the safety of road users. Thus the correct location for the occurrence of road accident black spot must be properly identified. And this stage is an important phase as it is a prerequisite for the improvement of road safety using identification of road hazardous location. Different methods are applied in different countries and by different researchers for the identifications of road accident black spots. And there are also different manuals prepared which guides for the identification of road traffic accident black spots. But the problem or limitation is the manuals are prepared based on the standards of the countries and defines their own criteria's for the locations of the accident spots.

One of the method used for the identification of road traffic accident black spot is a statistical method called Rate Quality Control method. This method consists of computing three different parameters for each road sections. The three parameters include accident rate, accident frequency, and severity index. And the logic of this method is a location or section of the road is road traffic accident black spot if the parameter gives high values than the other similar sites.

On the other hand the accident black spot can be identified by using a conventional method in which it relies on fixed length of road sections, where the total length is divided into 300, 500, and 1000m road sections. Based on fixed length of road sections divided the number of accident happened with in each road section is calculated and compared to the black spot criteria defined.

Related to the above conventional method there is a manual method used in which road inspectors travel along a highway and inspect all accident records. The method is a sequential pacing data analysis technique, and accidents within 100m of distance are grouped together as an accident black spot location. Any accident located farther will be grouped as another black spot location. Both of the methods explained above uses fixed methods and both of them are inaccurate because the section length is fixed where accidents within each section may be related to each other.

Methods discussed in the above sections are using historical data accidents for the identification of the hazardous locations. The limitation of these methods is thus they require well recorded data for analysis. And this will be impacting the developing countries in improvement of road safety as they are poor in traffic accident data recording.

Besides this there is another method can be used when such limitations occur, it is public participation approach. This method is important when accident data are limited or not available on site. It uses public input locations to identify the road traffic accident black spot locations.

All of the above methods discussed are important in identifying accident black spots.

Different researchers use different types of methods for the identification of road traffic accident black spots. The application of the methods depends on the availability of recorded accident data and on the standards designed by the countries as it is explained earlier.

In different countries there are different criteria's for the analysis and identification of road traffic accident black spots. For instance in Australia at least 3 causality crushes in 5 years, in England with in 300m road section 12 crashes in 3 years, in Germany with the same road section in England 8 crashes in 3 years, in Norway with in 100m road section 4 crashes in 3 years and in Thailand with varying road section length at least 3 crashes in 1 year defines the sections as road traffic accident hazardous locations.

2.6 Comparison between Black Spot Identification Methods

First and for all there is no integrated crash, road and traffic data in Ethiopia, and in connection this when the road under consideration is assessed, the traffic data collected from the respective police station is not full enough to apply model based method.

Because of this, it is not applicable to apply model based method. So that in this study non -model based method is used for study. From non-model based method the accident severity will be used in order to determine the hazardous location. So that in this study three different countries are selected in order to decide the formula for the accident severity determination. The first is turkey the revised KGM method being used, the second one is Belgium and the third is TRL method. While comparing these three different black spot identification methods the Belgian method is more preferable in order to select the sites with highest accident occurrence. So that in this study Belgian method is used.

To determine the most „dangerous" accident sites, the Flemish government analyses the accident data that are obtained from the Belgian "Analysis form for Traffic Accidents" ,This form should be filled out by a police officer for each traffic accident that occurs with injured or deadly wounded casualties on a public road in Belgium. Based on these data, the following criterion is used. First, each site where in the last five years or more accidents have occurred is selected. Then, a site is considered to be dangerous when its priority value (P), calculated using the following formula, equals 15 or more.

$P = X + 3*Y + 5*Z$, where

X = total number of light injuries

Y = total number of serious injuries

Z = total number of deadly injuries

In Ethiopia there are also researches conducted related to the identification of road traffic accident black spots. One of these researches had been conducted in Addis Ababa- Shashemene road for the identification of road traffic accident black spots with their causes and proposing low cost engineering measures. Based on the study conducted nine accident black spots were identified in which six of them are on scheme roads and three of them are on intersection. Based on the findings the researcher identified the main causes of the accidents at black spots as unavailability of proper pedestrian facility, high volume of pedestrian traffic, drivers fatigue's, lack of awareness of traffic rules and finally proposed low cost engineering solutions to improve the safety of the road.

In addition to the research conducted on Addis Ababa-Shashemene road there is research conducted on identification of road accident black spots in Addis Ababa the capital city. The method used in conducted

the findings are based on the frequency of occurrence of road crashes in each sub city. Based on these findings the first ten hazardous locations are identified. Some of them includes according to their order is Kirkos, Bole, Arada, Yeka, Lideta, Nifas Silk/Lafto, Addis Ketema, Akaki, Kolfe, and
Gulele sub city. From this finding we conclude that there is an initiation of identifying road traffic accident black spot in Ethiopia. And this must be developed to the other regions and cities of the country as road traffic accident is not a problem of a capital city only.

2.7 Definition of Geometric Design

The geometric design of highways deals with the dimensions and layout of visible features of the highway. The emphasis of the geometric design is to address the requirement of the driver and the vehicle such as safety, comfort, efficiency, etc. The features normally considered are the cross section elements, sight distance consideration, horizontal curvature, gradients, and intersection. The design of these features is to a great extend influenced by driver behavior and psychology, vehicle characteristics, traffic characteristics such as speed and volume. Proper geometric design will help in the reduction of accidents and their severity. Therefore, the objective of geometric design is to provide optimum efficiency in traffic operation and maximum safety at reasonable cost. The planning cannot be done stage wise in this case like that of a pavement, but has to be done well in advance.

2.8 Road Environment

Road environments have impacts on occurrences of road traffic accidents. In developed countries, there are continuous efforts to meet the safety standards of roads through safety audit during the planning, designing, and operation stage. Terje's, A (1998) indicates that, in Africa road network is expanding fast, maintenance standards have started improving lately, and there is potential for improving the safety standards of the roads. However, Berhanu, G. (2000) reports that, in Ethiopia, the police have limited road and traffic engineering skill in general and thus the under estimate the contribution of roads and environments to traffic accidents and especially they lack trainings on subject area.

2.8.1 Road Alignment

An important factor, which affects the occurrence of road traffic accidents in terms of frequency and severity, is road alignment. Inconsistent horizontal alignments of roads, sharp curves and grades are known for their substantial and adverse safety impacts.

i) Horizontal Alignments

A recent study shows that accidents on horizontal curves for concern in all countries. A study in Denmark has found that about 20 per cent of all personal injury accidents and 13 per cent of all fatal accidents occur on curves in rural areas; and in France, over 20 per cent of fatal accident occur on dangerous curves in rural areas. Accidents on bends are major problems in many developing countries, although the proportion of such accidents is dependent on both topography and demography of each country.

Table 2.1 Casualties at Bends in Developing Countries

Country	Proportion of casualties in Rural Areas	Casualties at Bends	
		Rural	Urban
Botswana		19.6%	8.6%
Zimbabwe		25.0%	5.0%
Papua New Guinea		46.9%	16.1%

Source: Highway design note 2/01, TRL, old Wokingham Road, Berkshire, UK RG45 6AU.

Choueiri, R(1998) reviews a number of studies, which generally has shown that sharp curves result in much higher crash rates than more gentle curves, section with curvature of between 5 and degrees have at least twice the crash rate of sections with curvature of 1 and 5 degree, and sections with curvature of between 10 and 15 degrees have crash rates four times as great. In terms of curve radius, 200 m seems to be the point below which crash rate greatly increases. The evidence suggests that curve flattening is highly effective in reducing crashes.

Numerous have been reviewed by Leisch & Associate confirming that there are several elements of horizontal alignment which are associated with horizontal curve safety. The safety of a horizontal curve-its accident frequency and severity- is party determined by features internal to it (radius or degree of curve, super elevation, etc.) and partly by features external to it (density of curves upstream, length of the connecting tangent sections, sight distance, etc.) that influence driver expectation and curve approach speed.

ii) Vertical Curve

There are three main effects of vertical road alignments, which are closely associated with the occurrences of traffic accidents. These are excessive speeds and out –of-control vehicles on down grades, differential

speed between vehicles created on both down and upgrades, and low range of visibility that often occurs in the immediate vicinity of steep grades at the crest of vertical curves.

Ross Silcock Partnership (1994) indicates that it may be difficult for driver to appreciate the sight distance available on crust curve and he may overtake when it is insufficient for him to do so safely.

This can be extremely expensive to provide safe overtaking sight distances on crust curves. However a complete ban on overtaking would be difficult to enforce because of the presence of very slow moving vehicles, the lack of driver discipline in selecting places, poor maintenance of road marking and signs. Successive short vertical curves on straight section of road may produce misleading forward visibility.

Behanu, G. (2000) summarizes the effects of vertical curve in such a way that steep grades have higher accident rates than mild ones. He extends that grades of less than 6 per cent have little effect, but grades steeper than this are associated with higher accident rates. Down grades are greater problems, particularly for truck safety than upgrades. A combination of horizontal curves under 450m and grades over 4 per cent are not recommended. Poor condition of the horizontal and vertical alignments of a road can result in visual effects, which contribute to accidents and are detrimental to the appearance of the road.

2.8.2 Sight Distance

This is the ability to see ahead in order to stop safely or overtake vehicle or view approach intersection. Sight obstructions on the road; generally occur due to the presence of deep cuts, embankments, vegetation, walls and the like on the inside of the horizontal curves and intersection quadrants, and sharp crest vertical curves themselves. Types of sight distances are: stopping sight distance, passing sight distance, intersection sight distance, and decision sight distance. Berhanu, G.(2000) reviews various studies that value and consider uses of the above sight distance. However, there are variations among different design standards. These sight distances vary with design or operational speeds of road section, perception/ reaction time, eye, height, object and pavement friction.

Choueiri, k. (2001) reviews studies which suggest that inadequate sight distance may be a factor in 20 to 25 percent of rural accidents resulting from overtaking man oeuvres. The actual percentage of crashes in which sight distance has a role clearly be related to the extent of overtaking man oeuvres, which in turn is related to traffic flow. Most studies appear to indicate that crash rates are higher with low sight distances, but they change little when the sight distance is 150-200 m or greater.

Berhanu, G. (2000) reviews studies in Sweden that a decrease of accident rates with increasing sight distance was observed, especially single-vehicle accidents at night. In British study, it was reported that on rural roads sight distances shorter that 200m were relatively more likely to be found at accidents sites through their association with horizontal curves.

The TRB study in the USA for which accident data were collected for carefully matched sites with and without sight-distance restrictions due to vertical curvature, found accident frequencies to be 52 per cent greater than overall at sites with sight restrictions than at control sites.

2.8.3 Road Cross-Sectional Elements

Various studies revealed that road cross sectional elements are the most important road related features which affect road safety. Road cross—sectional elements comprise lanes, shoulder, side slope, back slope, and clear zone.

i) Lane and shoulder width

According to Roadrigues, J(1998) lane width of 3 4-3.7 meters have been shown to have the lowest accident rate on rural roads. Lane widths of less than 3m have been shown to contribute to multi-vehicle accidents. Berhanu, G(2000) reviews numerous studies that lane and shoulder width affects run off the road and opposite direction accidents. The rates of these accidents decrease with both increasing lane and shoulder width, but the marginal effect of increasing width on accident rates decrease as either the base lane width or the base shoulder width increases. Lane width of 3.4 to 3.7 meters has the lowest accident rate and represents the balance between safety and traffic flow. For 3.0 meters lane a shoulder of 1.5 meters or greater, and for 3.3 to 3.6 meters lanes shoulders of 0.9 or greater reduces the accident rate significantly. Choueiri et al review that widening narrow lanes bring safety benefits up to a width of 3.7 meters, with little benefit beyond that unless the road carries large volumes of trucks. Other studies carried out in the USA shows that there were safety benefits in sealing shoulders and suggested 1.5m as the optimum width for sealed shoulders. This finding was broadly confirmed by Swedish study which found that accidents decrease with shoulders up to 2 meters wide, but there is little additional benefit obtained with shoulders greater than 2.5 meters. Generally, lane width has greater effect on accident rates than shoulder width.

ii) Road side features and side slopes

Roadside encroachments begin when the vehicle inadvertently leaves lanes, veering toward the roadside. Most encroachments are quite harmless: the driver is able to regain control of the vehicle on the shoulder and safely return to the travel lanes. When coupled with nearby roadside hazards, however, encroachments

can result in roadside accidents. Such accidents comprise a significant number involve single vehicles running off the road.

The transport Research Board Report reviews past research on the safety of the roadside environment has produced important improvements to roadside hardware; including, for example, the development of barriers that better contain and more safety redirect vehicles,, sign and luminaries supports that break away on impact, causing little damage to the striking vehicle and its occupants. In addition, design standards occasionally provide for clear recovery areas- boarders beginning at the edge of the travel lanes with travel lanes, traversable slopes and free of hazardous obstacles. Improved designs for drainage structures such as culvert headwalls reduce hazards posed by unforgiving obstacles.

Entry of an errant vehicle on to the roadside border does not in itself mean that an accident is inevitable. Although some dangers always exist, the chances of recovery are excellent if the border is reasonably smooth, flat, and clear of fixed objects and other non-traversable hazards. The chances of successful recovery diminish as the ground slope within the border. Safety researchers generally agree that art speeds of approximately 55mph, safe clear zones should have side slopes no steeps than about 6:1 and should extend outward at least 30ft from the edge of the travel lanes. When the border is flat, unintended encroachments on tangent alignments seldom extend beyond the 30-ft range.

2.9 Access Management

Access management is a new response to the problems of congestion, capacity loss, and accidents along roadways. Koepke and Lavinson call for significant improvements in access control, spacing, and design to preserve the functional integrity and operational viability of the road system.

Constantly growing traffic congestion, concerns over traffic safety, and the ever increasing costs of upgrading roads have generated a new interest in managing access to the highway systems. Access management is the process that provides access to land development while simultaneously preserving the flow of traffic on surrounding roadways. Three issues kept in the forefront of access management are: safety, capacity, and speed. Fewer direct accesses, greater separation of driveways, better driveway design and location are the basic element of access management.

Many studies over the past 40 years have shown that accident rates rise with greater frequency of driveways and intersection. Each additional driveway increases accident potential. Roughly 240 roadway segments in the USA, involving more than 37,500 accidents, were analyzed in detail.

According to this study, for example, a segment with 60 access points per mile would be expected to have an accident rate 3 times higher than a segment with 10 access points per mile. In general, each additional access point per mile increases the accident rate by about 4 percent.

In urban areas, undivided high ways had 9.0 accidents per million vehicle miles as compared with 6.9 for two-way left-turn lanes (TWLTL2) and 5.6 for non-traversable medians. In rural areas, undivided highways had 3 accidents per million vehicle miles as compared with 1.4 for TWLTLs and 1.2 for non-traversable medians.

In urban and suburban areas, each access point (or driveway) added would increase the annual accident rate by 0.11 to 0.18 per million vehicle miles on undivided highways and by 0.09 to 0.13 per million vehicle miles on highways with TWLTLs or non-traversable medians. In rural areas, each point (driveway) added would increase the annual accident rate by 0.07 per million vehicle miles on undivided highways and 0.02 per million vehicle miles on highways with TWLTLs or non-traversable medians.

On two-lane rural highways, intersections are ranked together with horizontal curves and bridges as the most likely locations for accident concentration. According to the national Safety Council estimates in USA, 56 per cent of all urban accidents and 32 per cent of all rural accidents occur at intersection. Although the average accident occurring at intersection is not as severe as the one occurring on the open road, there is nonetheless, a concentration of severe accidents at intersection. Of all the fatal accidents in the United State, 29 per cent of those that occur on urban highways and 16 percent of those that occur on rural highways are intersection related. It is logical to concentrate on such types of high accident record areas. For safety and traffic management reasons, selection of intersection design depends on the AADT of the major and minor road. Roundabouts have the least accident rate as observed in developed countries and best countermeasures from safety of intersection point of view.

2.9.1 Narrow bridges

Bridges are often location on sag vertical curves where approach traffic is on down grades and a factor responsible for increasing speed which contributes to the losing control of vehicles. Bridges are also more

dangerous when located on bend road sections. Berhanu, G (2000) notes that bridges are over represented in accidents relative to the total length of the road system. Traffic accidents are also severe at bridges. An extensive review of literature on the safety effects of bridges by Mak in Berhanu points out feature including bridge width, curved bridge, approach roadway alignment and adverse surface condition as the most prevalent factors of bridge accidents. Based on the findings of the cited studies, mak in Berhanu suggests that at least the bridge shoulder be 1.8 m wider than the approach traveled way width on rural two-lane highways (i.e. 0.9m shoulder width on each side should be carried across the bridge). Besides, frequency and severity of traffic accident at bridges can be reduced through the provision of adequate visual information to enable the driver control and navigate safely on bridges.

Run-off-the-road crashes and head-on collisions are frequently associated with narrow bridges. Such crashes are related to lack of maneuvering room because of narrow lanes, shoulders and roadside hazards or curbing. Combining these factors with excessive speed might end in deadly results.

Crashes involving narrow bridge are often fatal. The crash rates may be lowered by increasing lane and shoulder width or completely replacing bridges.

Other study made by the transport research Board indicates that hazards associated with bridges can be significant. Roadway constriction at narrow bridges reduces the opportunity for safe recovery by out-of-control vehicles and can result in end-of-bridge collisions. Furthermore, bridge approaches are often on a downward grade, a factor responsible for increase in speed, and, particularly in the case of older spans, are often sharp-curved.

2.10 What causes car accidents?

The dictionary defines accident as “an unexpected and undesirable event, a mishap unforeseen and without apparent cause.” Strictly speaking, most accidents are not accidents at all: they are collisions that could and should have been avoided. The association between the factors that contribute to accidents and accident occurrence is irreducibly statistical. By studying accidents without having any idea of how frequently various hazards occur in traffic, no conclusions what so ever is drawn concerning the relative importance of factors contributing to accidents (Benedetto, 2008).

McMahon and ward (2005) identified three major classes of causes of vehicle accidents; road user’s errors/human factors, vehicle defects and road condition or environment. Among the most prominent

factors is the human factor of which drivers' errors takes the lion's share of the blame. Drivers are carelessness that is pretty hazardous resulted from driving too fast, failing to give way, improper over taking and following too close. All of which could result from aggressive or irresponsible behavior, deficient actions, perceptual errors or impairments.

Nonetheless,, Van Elslandeet al (2008) said in the field of road safety research, most accident analysts tend to conclude by considering "human error" as the main cause of accidents. The problem behind such a statement is that, itt leads to oversimplification of the problem.

On the other hand, Salmon et al (2005) stated that there are two theoretical approaches to human error. The "person approach" which focuses upon the last step of system operation and by so treats human error as the cause of most of the accidents, and the "safe system approach" which looks further in the accidents process considering the role of the various organizational levels that contribute to the production of system outputs (rules, design, management, etc) and looking for the "holes' or 'weaknesses' in the various defense layers which are supposed to constitute a safe system, well adapted to its users.

Elslande et al (2008) argued that most safety studies have been based upon a person approach and stress the role of human error in the production of 75-90% of accidents. But it would be wrong to regard this 'error' as the primary cause of accidents. A safe system approach will rather consider it as a consequence of malfunctions further upstream, so that human error is only a link in the chain of events leading up to an accident. And it is a necessary link as far as the driving system which is unable to function without drivers is concerned.

The so called human error may be explored in many different approaches on the basis of how it is perceived (Van Elslande et al, 2008). The common sense of using human error in the framework of everyday life and in safety research gives the rise to an oversimplified conception of how events occur. Such an outlook neglects the complexity of accident phenomena which are the result of an amalgamation of factors. This affects the way to manage the root causes of accidents (Hollnagel and Amalberti, 2001. RTAs are the results of a combination of factors and undesirable result of interaction between an operator and a task, arising from interaction between internal and external determinates (Van Elslanded, et al 2007).

The traditional view of road safety considers road crashes are usually the sole responsibility of individual road users. Despite the fact that many other factors beyond their control may have come into play, such as

the poor design of roads or vehicles. But human error does not always lead to disastrous consequences. Human behavior is governed not only by the individual's knowledge and skills, but also by the environment in which the behavior takes place (Rumar, 1999). Indirect influences, such as the design and layout of the road, the nature of the vehicle, and traffic laws and their enforcement affect behavior in important ways (Nantulya and Reic, 2002).

Moreover, traffic volume, traffic speed and traffic compositions have adverse effect on the frequency and severity of RTAs. As the volume of traffic grows, opposing vehicle increases, intervals for passing vehicles are less available, the accidents due to improper Passing become frequent, and the frequency of accidents grows approximately in direct proportion to the average traffic volume (ibid). Hijar et al (2003) asserts that as the volume of traffic increases, the speed of vehicles drops and the main kind of accident becomes a nose-tail collision.

MCMahon and ward (2005) and Hobbs (1979) claimed that vehicle defects lead significantly to accidents which are mainly those related to the lack of regular maintenance, of which defective tries and brakes failure most frequently. Vehicle defects contribute to less than 5% of crashes, The rise in the number of motor vehicles and the amount of motorized traffic along transport with economic development are key determinates of risk of road crashes. The quality of road network, vehicle compositions, increase in car ownership and the extent of public transport and facilities for more venerable road users such as pedestrians and cyclists, all contribute to the level of risk. In low income countries, rapid growth in motorization has not been accompanied by sufficient improvement in the road design to allow for such growth to take place without an increase in the rate of road traffic crashes.

2.11 Top 10 causes of car accidents

Every year, car accidents result in hinders of thousands of injuries and loss of human life around the world. In fact, traffic collisions are the leading causes that can be preventable. Thus, it is important to have an understanding as to the leading factors contributing to car accidents. A list of the leading causes of traffic accidents is provided below.

1. **Speeding while driving and Reckless Driving:** Failing to follow the speed limit is the most common cause of traffic accidents.
2. **Use of Mobile Phone:** Texting While Driving: The proliferation of mobile phone use has resulted in an increased level of danger on the roads. In response national and state legislatures have passed strict

anti-texting laws, while the judicial system has begun to charge individuals whose texting while driving resulted in deaths, with manslaughter.

3. **Other forms of Distracted Driving:** There are numerous types of distracted driving. Some of the most common types of distractions resulting in high incidences of traffic accidents include, eating, smoking listening to loud music or changing the dial, reaching for objects in the vehicle, and looking or talking with other passengers in the vehicle.
4. **Driver fatigue- Falling asleep on the Wheel:** According to recently published data driver fatigue is the cause of 2.5-3.0 percent of all roadway related fatalities. Individuals who have a history of falling asleep at the wheel should be prosecuted for a criminal offense.
5. **Drunk Driving and Driving While under the influence of a Narcotic Substance:** According to studies driving while under the influence of alcohol results in a 90% increase in the probability of an accident.
6. **Rubber-necking:** Rubbernecking is another type of distracted driving and takes place when drivers look at other things on the road not linked to their driving.

   Examples include watching other accidents, looking at sunsets, and nice views.
7. **Defective Automobile and Automobile Parts:** Common auto defects that can cause severe injuries to occupants include, tire defects, defective design of Sport inutility Vehicles resulted in vehicles being more prone to rollovers, seatbelt defects and defective airbags.
8. **Defects on Roadway Construction:** The improper design of roadways result in hundreds of auto accident fatalities each year. Liable parties can include Caltrans and construction contractors for improper installment of traffic lights and roadway signals.
9. **Poor Weather Condition:** Examples of weather condition posting the greatest dangers to motorists on the road includes icy ready, high winds and rain after a prolonged drought resulting in oily surfaces.
10. **Improper Coning off Construction Zones:** Road is needed to maintain and built the countries transportation infrastructure. However in many cases road construction crews fail to safely cordon off construction zones resulting in an increased probability of auto accident. (http:www.losangelespersonalInjurylawyers.co/top-10-causes-of-car accidents/accessed on 04,2014 at 9.32pm

    Generally, every accident is not usually attributable to a single cause but to a chain of unique multiple factors or failures associated with the road design deficiencies, vehicle defects, and road user errors. In

most cases, the traffic police associate traffic accident with a single most important cause on the spot of accident and do not list the multiple factors.

The road traffic system has four main physical components; namely the road user (human factor), the vehicle, the road and the environment. The key contributory factor of road accident are driver, vehicle, road, pedestrians and animals (Hick ford and Hall, 2004 66). Then these factors are considered as prime actors of the roads that need a proper management to mitigate a range of road traffic accidents.

2.12 Road Traffic Management system

Road traffic may be considered as a system in which humans, vehicles and the road interact with each other. This implies that the efficiency and safety of road traffic depends on the performance and interaction of these components. Road traffic accident may thus be regarded as an event caused by a failure in one of the components or in the system of inerter action between these components, (Girma, 2000)

According to (Ogaden, 1996), road traffic accident is a rare, random, multiple factor event, always preceded by a situation in which one or more road users have failed to cope with the road and its environment. It is a random event from time and location (space) aspects or it is impossible to predict actually where or when the next road accident will occur. By contrasting the above concepts, many leaders do not consider road traffic management problems as accidents. Therefore everybody in the world should have to consider the road traffic management problem.

2.13 Road Traffic Factors

The prominent which affect the frequency and severity of road traffic accidents are mainly traffic volume, traffic speed and traffic composition. As the volume of traffic grows, the increase of opposing vehicle increases, intervals for passing vehicles are less available, the accidents due to improper passing become frequent, and the frequency of accidents grows approximately in direct proportion to the average volume of traffic increases, the speed of vehicles drop and the main kind of accident becomes a nose-tail collision.

According to Ross Silcock partnership (1991) Ogden (1996) cited in Girma(2000), greater hazard occurs at higher speeds for the fact that vehicles become less stable and the driver and other road users have less time to react. Hence, as the speed of the vehicle increases the severity of accident increases. The survival rate also decreases as the collision speed of the vehicle increases. And the death risk of pedestrians is much higher than for a vehicle user according to Gunnarsson (1999). Gunnarsson cited results of studies that indicate that 90% of pedestrians survive at a collision speed of 30km/h, and 40% at 50km/h. Another study made in Norway as summarized by Sakshaug (1989) showed that when the speed limit was lowered from

60 to 50, 70 to 60, and 80 to 60 km/h serious accidents were reduced by 40-50%. On the other hand, the number of serious accidents increased by about 50% where the speeds limit was raised from 80 to 90 km/h. Another factor which affects the frequency and severity of road traffic accidents is composition of traffic.

There are different types of vehicles in a traffic stream. And different type of vehicles has different physical geometric, and performance characteristics. Speed and Acceleration can vary greatly from on vehicle type to another. High differential speeds in traffic streams result in more overtaking maneuvers and more probable danger of accidents. In support of this view, Ogden (1996) showed that the speed differential between heavy and other vehicles is often the basic argument for higher involvement of trucks in accidents. Therefore, speed volume and composition of traffic are most important factors in accident prevention (safety), which needs more attention.

2.14 Check Lists for Inspection of Hazardous Sites

According to road safety audit for existing roads, ERA Road safety audit manual uses the following parameters used in order to undertake road safety audit.

A. Vertical and Horizontal Alignment

Place where the alignment standard changes abruptly will be checked and also the curve with speed value of more than 10km/hr. will be identified for control mechanism.in connection to this, Place where there is prevalence of inadequate stopping sight distance and also any location with inadequate overtaking sight distance at which "double lines" have been marked will be checked and recorded.

B. Cross-Section

The following points are checked:- Any location where the cross-section standard changes abruptly along the route, or is otherwise inconsistent with driver expectations and also location where the capacity of the roadway is restricted will be checked, locations of regular traffic congestion is recorded, location with inadequate shoulder width and also the correct type of kerb to be used will be checked, the provision of Pedestrians paved footpaths, adequate refuge width on median and islands, and proper ramps up and down kerbs and location where there is regular pedestrian traffic, Bicyclists-segregated areas (e.g., paved shoulders) where numbers are significant location where the cross section does not allow the development of appropriate access control.

C. Traffic Signal Installations

Traffic signals are provided only where warranted for safe, efficient, and equitable management of traffic flow along or across main roads, and also it is provided for the safe crossing of pedestrians.

Provision, location, and spacing of traffic signals reflect a sensible traffic management strategy along the route, so that while under taking road safety audit already existing signals are checked whether they are operating effectively or efficiently, simultaneously the positioning and visibility of signal faces are recorded where visibility of signals is obstructed by tree foliage, traffic signs.

D. Traffic Signing

For cases of unauthorized traffic signs and use of non-standard signs (color and shape)signs is inadequate, bearing in mind the speed of vehicles and the amount of information displayed, For instances where signs contain too much information to be capable of being read by drivers travelling at normal operating speed ,The effectiveness of traffic signs by observing them at night and identifying any lack of reflectorization, The type of signposts used where sign posts constitute a fixed roadside hazard or where the use of frangible signposts should be considered, For case where there is a lack of (vertical) clearance to traffic signs ,For situations where traffic signs are obstructing essential "lines of sight" for drivers and pedestrians.

E. Pavement Marking

Under pavement marking the following thing are checked:-the general adequacy and visibility of pavement marking both at night and in wet weather, the correct type of line marking has been used in the various situations, e.g., "continuity lines" at merge and diverge sections, "double (Barrier) lines" where overtaking is to be prohibited, etc. , any deficiency in the delineation of merge and diverge areas, including situations where through traffic may inadvertently lead into auxiliary and turn lanes, locations where there is a lack of "hazard marking" at approach ends of islands and medians, locations where auxiliary "turn lanes" have been designated with appropriate pavement arrows and locations where the wrong type of arrow has been used, locations where pavement arrows and other markings are confusing to drivers, particularly where "old incorrect" markings have not been properly removed , The effectiveness of road markings at night and in wet weather and also the need for retro reflective pavement markers or road studs to supplement line and hazard markings is considered, simultaneously inadequacy of provision of these devices and in the use of non-standard arrangements of them will be checked.

F. Roadside Safety and Landscaping

Under this the following points are checked: - The "clear zone width" generally available along both sides of the road, and comment on this aspect in the RSA report, The "fixed roadside object" that occur within the "clear zone width" and comment on the need to treat them in the interests of road safety, The provision of guardrail along the road, consider whether it is really justified and identify locations where it is not justified and locations where it has not been provided where it is warranted, That the correct treatment has

been applied to the ends of guardrail sections, including "soft" end treatments and end anchorage, For the adequacy of "bridge railing" systems on all bridges. Take particular note of inadequate railings that will not restrain an impacting vehicle-this is often the case with bridges, The treatment of "approach guardrail" to bridges; record situation, where there is no "strong" anchorage of the approach guardrail to the bridge railing system and/or no proper transition of the rigidity of flexible or semi rigid approach guardrail as it approaches and meets the rigid bridge railing, The extent to which trees and other vegetation obstruct driver and pedestrian sight lines, which are essential for safe traffic operation, The existence of poles of various kinds along the road and comment on whether some or many can be removed, relocated to less hazardous positions, The degree of hazard associated with large trees, boulders, etc. and whether these can be treated to improve roadside safety.

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1 Study area

Shashemene- Adaba Road plays a vital role in inter-district as it connects the Western and Eastern part of Ethiopia. The commencement and the completion date of this Asphalt road project was 1998 and 2000 E.C respectively. The total length of the road under consideration is 100Kms.

Shashemene, Oromo is a town and a separate woreda in West Arsi Zone, Oromia Region, Ethiopia. The town lies on the Trans-African Highway 4 Cairo-Cape Town, about 150 miles (250 km) from the capital of Addis Ababa. It has latitude of 7° 12' north and a longitude of 38° 36' east. The 2007 national census reported a total population for this town of 100,454, of whom 50,654 were men and 49,800 were women. A plurality of the inhabitants practiced Ethiopian Orthodox Christianity, with 43.44% of the population reporting they observed this belief, while 31.15% of the population said they were Muslim, 23.53% of the populations were Protestant, and 1.3% was Catholic.

Adaba is one of the woredas in the Oromia Region of Ethiopia; it shares the name of its administrative center, Adaba. Part of the West Arsi Zone, Adaba is bordered on the southwest by Nensebo, on the west by Dodola, on the northwest by the Shabelle River which separates it from the Gedeb Asasa, and on the east and south by Bale Zone. The 2007 national census reported a total population for this woreda of 138,717, of whom 68,775 were men and 69,942 were women; 12,099 or 8.72% of its population were urban dwellers. The majority of the inhabitants were Muslim, with 84.39% of the population reporting they observed this belief, while 14.46% of the population said they practiced Ethiopian Orthodox Christianity. The research will be conducted on cause and control mechanisms of road traffic accident from Shashamane to Adaba road projects that are completed and substantially completed during the road sector development stages and executed by different contractors in central and Eastern parts of Ethiopian regions.

These studies identify various causes and its control mechanisms of road traffic accident along Shashemene to Adaba road section. From the statement of the problem point of view we can understand that the issue is common in all part of the country wide. As a result, the study also deals with different areas facing

different problems. Therefore, to make the research feasible the study area will be set on cause and control mechanisms of road traffic accident.

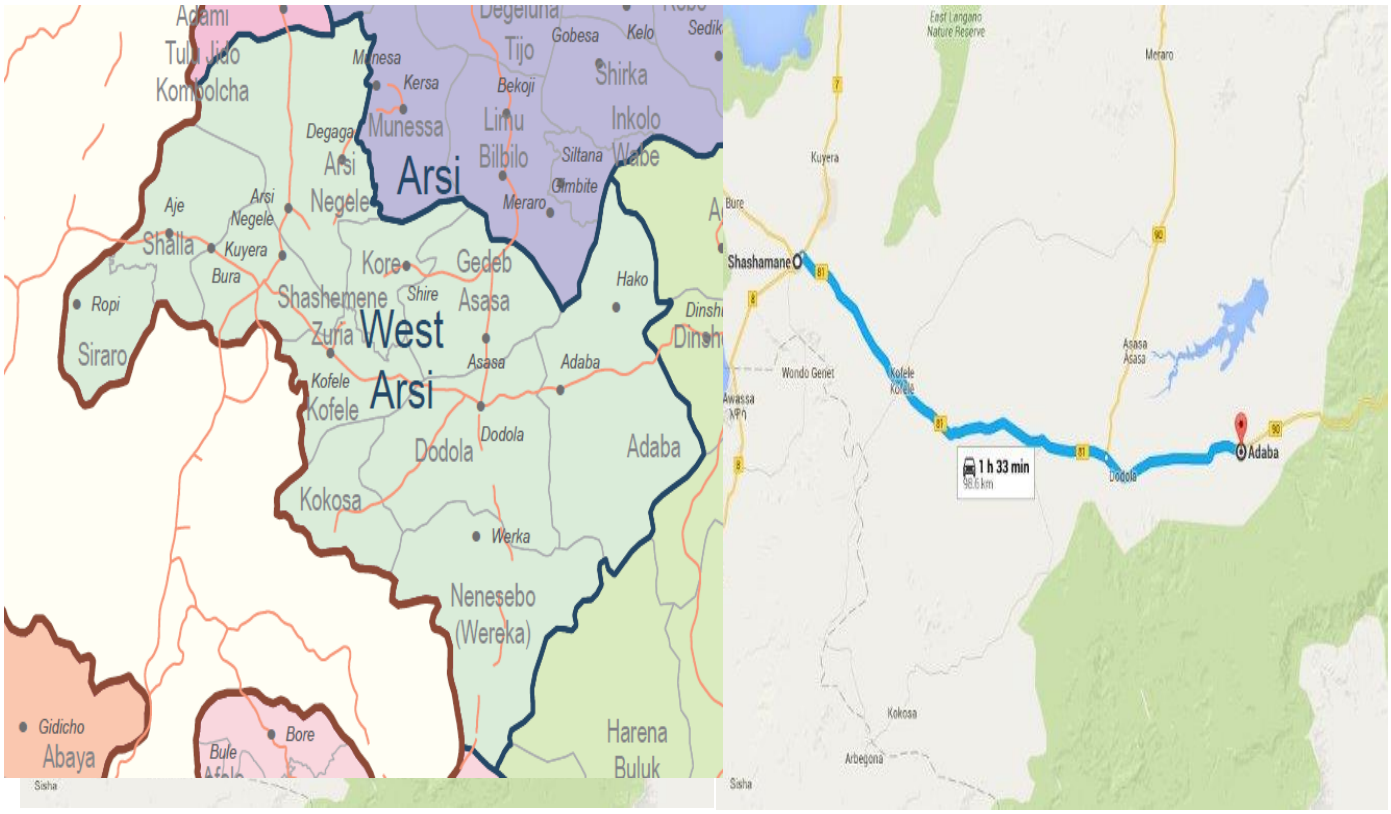

Figure 3.1 Map of West Arsi and location of study area

3.2 Sample size & sampling technique

The populations taken for this study were the traffic accident data of each of the Weredas along the road network and method of sampling used is purposive sampling technique. The areas to be sampled in this study are all weredas/districts located on the major/national road networks as they are suspected to high traffic volume

Figure 3.2 Observations on Existing Road

The study concentrated on the issue of the causes and its control mechanisms of road traffic accident along Shashemene to Adaba road. These high concentrations of activities along the main roads resulted in a large number of road traffic accidents. Finally the analysis was made and a proper control mechanism was applied based on traffic accident data.

3.3 Research Design

The study design type was both observational and secondary data of analysis. In connection to this, the study incorporated road safety audit and site visit of the black spot locations and also it incorporate the extraction of secondary data from respective traffic police stations of each wereda/districts.

3.4 Data Collection Methods

The study is undertaken on the Asphalt road along Shashemene- Adaba road. The route corridor touches different kebele and Weredas which are found in West Arsi Zone of Oromia regional states. The kebeles and Weredas which are touched by this route are: Shashemene , Kofele and Adaba town , Sole, Feji-hursa, Ashoka, Wabe , Edo , Dodola and Herero kebele.

The primary data used in the study was the road safety audit. When conducting the road safety audit, the safety problem was categorized under two main heading; road design problem and road side problem risk checklist. It was undertaken by site visiting were potential traffic accident locations using the prepared checklist and also by stating the comment for each potential accident locations.

The checklist has included the following road safety audit criteria's:-

1. Traffic sign along the curve was checked.
2. The adequacy of lane width of shoulder was checked.
3. The performance of traffic signal was checked.
4. Adequacy and visibility of pavement marking was checked.
5. Provision of pedestrian walking on town sections was checked.
6. Bridge width along black spot location was checked, check whether pedestrian walking is provided or not because sudden decrease of width may cause approaching vehicles to collide with the side barrier.
7. Road Side improvements were checked.
8. Provision of guard rails were checked both along carriage way and shoulders, because it helps vehicles from leaving the road way.
9. Provision of Median Barriers was checked.
10. The horizontal curve of the road is checked, whether the curve is sharp or not.
11. Road widening (wider road decreases occurrence of accident) so that the width will be checked and also the correct type of kerb to be used is checked.
12. The provision of Roadside Delineator was checked, because it helps vehicles not to leave the road.
13. Both the center and edge road marking was checked, because it reduces rate of occurrence of accidents.
14. The presence of Speed limit post was checked, because lower speed limits decrease the rate of occurrence of accidents.

The detailed road safety audit undertaken for each black spot locations were described on the Appendix c

The secondary data used were the traffic accident report collected from respective police stations found in each wereda's and 24hr traffic accident records. The data applied for study were the accident data from 2012-2017. Those data were collected from West Arsi Zone police commission and traffic police office.

The information Recorded on 24hr traffic accident happened were:

1) Date, Year at which the accident happened
2) Time at which the accident happened
    - Morning

- Afternoon
- Night

3) Location at which the accident happened

- Specific location of the area
- Kebele
- Town
- Wereda

4) Type of accident involved in the accident

- Fatally injured
- Slightly injured
- Severely injured

5) Number of victims involved in the accidents

6) Type of vehicle involved in the accident

7) Information about the driver

- Name
- Age
- Sex
- Education Level

8) Accident quantified in birr (ETB)

9) Information about the investigator

- Name
- Signature

10) Cause of accident

- Drivers‟ error
- Pedestrian error
- Design problem

3.5 Study variables

3.5.1 Dependent Variable:

Road traffic accident

3.5.2 Independent Variable:

- Identified black spot location
- Priority value
- Accident frequency

3.6 Data Analysis

Data collected was analyzed according to their types as quantitative and qualitative. The row data collected were organized and grouped to be easy for the analysis. The quantitative data are used to explain the general characteristics of road traffic accident along Shashemene to Adaba road. Also using these data the prioritization of sample population is done by using the following formula.

$$P = X + 3Y + 5Z$$

Where, P= priority value

X = total number of slight injury

Y = total number of serious injury

Z = total number of death.

Then the analysis was made using Belgium method for traffic accident data. Based on these data, the following criterion was applied. First, each site within the last five years or more accidents have occurred is selected. Then, a site is considered to be dangerous when its priority value (P) equals 15 or more.

Generally, since the accident numbers for Fatalities, Slight injuries, Severe Injuries are properly determined for Shashemene, Fejihursa, Kofele ,Dodola and Adaba priority value of Belgium method formula is used in order to rank black spot locations. But, due to unavailability of full data from traffic police stations Accident frequency were used for Ashoka, and Wabe kebele

The next step was the cause of accidents determination and the preparation of road safety audit checklist to provide control mechanisms based on the site inspection.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1 General Characteristic of Road Traffic Accidents in Shashamane- Adaba Road from 2012 - 2017

The occurrence of Road Traffic Accident (RTA) with in the study area significantly increased at alarming rates. According to west Arsi Zone Traffic Police commission report, from the year 2012 to 2017, Shashamane- Adaba exhibited the occurrence of spatially identified road traffic accident unevenly distributed through the rural and suburban area administration.

Table 4.1 Variations of Road Traffic Accident Frequency

District	Road Traffic Accident Per Year						Total	Share%
	2012	2012/2013	2013/2014	2014/2015	2015/2016	2017		
Shashamane	46	55	74	73	76	49	373	41.26
Feji hursa	15	14	3	10	12	7	61	6.75
Kofele	26	32	35	41	41	15	190	21.02
Ashoka	5	7	6	3	5	4	30	3.32
Wabe	5	10	8	11	8	15	57	6.3
Edo	2	1	3	5	5	7	23	2.54
Dodola	8	5	10	10	16	12	61	6.75
Herero	5	3	5	10	15	11	49	5.42
Adaba	12	11	10	8	5	14	60	6.64
Total	119	138	154	171	183	139	904	100

A comparison was made based on the road traffic accident occurrences between the nine districts of Shashamane,Fejihursa, Kofele, Ashoka, Wabe, Edo, Dodola , Herero and Adaba town. Based on the findings of this research study, Shashamane district has dominated the event of accident among the districts as shown in Table 4.1. There were 373 (41.26%) out of 904 accident occurred in Shashamane and its extension from 2012 to 2017. Kofele, Dodola town and Feji hursa, Adaba town ,wabe ,Herero , Ashoka and Edo district had shared 190 (21.02%), 61(6.75%), 60 (6.64%) , 57 (6.30%) , 49(5.42%) , 30(3.32%) and 23(2.54%) of accidents during the study period, respectively.

The road safety audit report revealed that the most vulnerable area traffic accidents happened in the mountainous and escarpment due to road design problems such as insufficient sight distance, sharp curve, missing narrow lane and shoulder, deficient and damage road pavement marking.

4.1.1 Variations of RTA by Severity Classes in Shashamane- Adaba Road from 2012 -2017

Severity classes of Road traffic accidents are classified as following: Fatal accident, serious injury, Sight injury, and Property Damage (PD).

Table 4.2 Accident Severity percentage Distributions of obtained Accidents Data Reported value 2012-2017

Severity Class	**Total Road Traffic Accident**						Total	Share %
	2012	2012/13	2013/14	2014/15	2015/16	2017		
Fatal Accident	26	29	36	36	57	42	226	25
Serious Injury	7	11	8	13	25	11	75	8.30
Slight Injury	20	20	7	22	25	21	115	12.72
Property Damage only	72	70	98	106	81	61	488	53.98
Total	125	130	149	177	188	135	904	100

Based on the road traffic accident police report in 2012-2017, the percentage distribution of severity class comprised of about 25% of the fatal accident, 8.3% serious injury, 12.72% slight injury, and 53.98% property damage, respectively (Table 4.2).

4.1.1.1 Analysis of fatal accidents

One of the negative impacts of road traffic accident is the occurrence of fatal accidents during and after the existence of crashes. It is the most dangerous part of road traffic accident as it results in the loss of life of the road user's such as the driver, passengers, pedestrians or an individual around the incidence.

As it is done in section 4.1.1 of this chapter the analysis of fatal accident were considered for five consecutive years. Based on the collected data there was an increase of the fatality rate in 2015/16 and

decrease in 2017. For instance there was an increase by 57.69% in 2014/15 and decrease by 17.07% in 2015/16.

Table 4.3 Percentage coverage of Fatality due to road traffic accident of each wereda /town along Shashemene to Adaba road from 2012-2017

No	Kebele (Town)	Years							
		2012	2012/13	2013/14	2014/15	2015/16	2017	Total	%
1	Shashemene town	4	7	9	10	16	8	54	23.89
2	Fejihursa	3	3	4	3	6	5	24	10.60
3	Kofele	4	5	7	5	10	7	38	16.00
4	Ashoka	4	3	1	2	3	3	16	7.00
5	Wabe	5	2	3	4	5	3	22	9.70
6	Edo	3	0	2	2	3	2	12	5.00
7	Dodola town	3	4	6	4	8	5	30	13.00
8	Herero	2	2	1	2	1	3	11	4.86
9	Adaba town	2	3	3	4	5	6	23	10.00
	Total	26	29	36	36	57	42	226	100
	Average	2.89	3.22	4	4	6.33	4.67		

From total fatality 226 Shashemene to Adaba road the highest fatal accident happened was 54 in Shashemene town which is about 23.89 % and the lowest fatal accident happened was 11 in Herero kebele . The average values also shows an increase from 2.89 to 6.33 in 2015/16 .From table 4.3 fatality coverage due to road traffic accident Shashemene 54 fatal (23.89%) , Kofele 38 (16%) ,Dodola town 30(13%) , Feji hursa 24 (10.6%) , Adaba town 23 (10%) , Wabe 22 (9.70%) ,Herero 11(4.86%) , Ashoka 16 (7%) and Edo 12 (5%).

4.1.1.2 Analysis of injury accidents

Similar to the fatal accidents caused by road traffic accident there is the probability for the occurrence of injury on the road users. Both fatal and injury accidents has common behavior in that they are happening on humans. In this analysis section for this study both series and slight injury were compiled together.

As it is done in the above sub-section for the analysis of fatal accident the same procedures were followed for this analysis of injury accidents.

Table 4.4 Percentage coverage of Injury (both slight and series) due to road traffic accident of each wereda along Shashemene to Adaba road from 2012-2017

No	Kebele (Town)	Years							
		2012	2012/13	2013/14	2014/15	2015/16	2017	Total	%
1	Shashemene town	5	6	3	5	9	6	34	17.89
2	Fejihursa	2	3	2	3	5	3	18	9.47
3	Kofele	4	7	3	6	10	7	37	19.47
4	Ashoka	3	3	1	3	3	2	15	7.89
5	Wabe	3	1	2	3	5	2	16	8.42
6	Edo	2	3	1	2	3	2	13	6.84
7	Dodola town	4	6	2	5	8	6	31	16.33
8	Herero	2	2	0	3	1	0	8	4.22
9	Adaba town	2	0	1	5	6	4	18	9.47
	Total	27	31	15	35	50	32	190	100
	Average	3	3.44	1.67	3.89	5.56	3.56		

A comparison was made based on injury accidents occurrences between the nine districts of Shashamane,Fejihursa, Kofele, Ashoka, Wabe, Edo, Dodola town, Herero and Adaba town. Based on the findings of this research study, Kofele district has dominated the event of accident among the districts as shown in Table 4.4. There were 37 (19.47%) out of 190 injury accident occurred in Kofele and its extension from 2012 to 2017. Shashemene, Dodola town, Feji hursa and Adaba town, wabe , Ashoka, Edo

and Herero district had shared 34 (17.89%), 31(16.33%), 18 (9.47%) , 16 (8.42%) , 15(7.89%) , 13(6.84%) and 8(4.22%) of accidents during the study period, respectively.

4.1.2 Property Damaged and RTA in Shashamane to Adaba Road from 2012-2017

On Shashamane to Adaba Road segments traffic accidents highly increase from time to time .The impacts of road traffic accidents had a direct related to economic effect when road traffic accidents was over a property damage together with the indirect influence to the pedestrians, animal, and the motorists passing through the route. The estimated total cost of road traffic accidents in Shashamane to Adaba Road segments from the year 2012 to 2017, have been reached to 26,697,236 birr as shown in Table 4.5.

The highest estimated cost has been recorded at 6216700.00birr (23.30%) in 2012 while the lowest was 2,762,563.00 birr (10.35%) in 2017. It means the nine districts have lost 26,697,236 birr in the last five years due to road traffic accidents.

Table 4.5. Estimated cost of Road Traffic Accident in Shashamane to Adaba Road Sections

Accident year	Number of Accident Resulting Property Damage	RTA Estimated Cost (ETB)	Percentage (%)
2012	99	6216700	23.3
2012/13	75	3546163	13.28
2013/14	85	4815145	18.04
2014/15	72	3378455	12.65
2015/16	95	5978210	22.39
2017	62	2762563	10.35
Total	488	26697236	100.00

Source: West Arsi Zone Traffic Office (2017)

4.1.2.1 Analysis of Property Damage

In the section 4.1.2 the rate of road traffic accident on the loss of human life and injury (both serious and slight) was presented. This is not the only side effect of road traffic accident; it is also the cause for the loss

of property which includes destruction of vehicles, goods or freights and damage on the road also. The amount of loss of property in the study area for each keble/town is shown in the following table 4.6.

Based on the data collected for the study period from 2012-2017 G.C there was a total damage of property estimated to 26697236 birr. Comparing the estimated loss of property the highest amount was recorded in Fejihursa about 4,258,585 birr. The least damage was in Ashoka about 2,504,929 birr.

Table 4.6 Percentage coverage of each wereda for property damage in each year

Kebele/town	Years						Total	%
	2012	2012/13	2013/14	2014/15	2015/16	2017		
Shashemene town	747106	437340	552335	220452	642363	415123	3014719	11.29
Fejihursa	756384	495326	737351	565839	1181606	522079	4258585	15.95
Kofele	747974	427571	229335	205452	773363	227123	2610818	9.78
Ashoka	656772	293321	238398	570452	526863	219123	2504929	9.38
Wabe	737127	399321	623386	405452	542363	218623	2926272	10.96
Edo	617909	443321	812335	201452	522563	465123	3062703	11.47
Dodola town	650088	393321	517335	221452	662363	222623	2667182	10
Herero	586542	313321	482335	540452	578363	226623	2727636	10.22
Adaba town	716798	343321	622335	447452	548363	246123	2924392	10.95
Total	6216700	3546163	4815145	3378455	5978210	2762563	26697236	100

Based on the findings of this research study, Feji hursa district has dominated the event of property damage among the districts as shown in Table 4.6. Property damaged in Shashemene to Adaba road from 2012 to 2017 Edo 11.47% ,Shashemene 11.29% , Wabe 10.96% ,Adaba 10.95% , Herero 10.22% ,Dodola 10% , Kofele 9.78% and Ashoka 9.38% respectively high property damage order.

Figure 4:1 Sample property damage in Edo kebele and Feji hursa kebele

4.1.3 Spatial and Temporal Variation of Road Traffic Accidents

A fundamental per-condition for safe traffic is that the road user has sufficient information about road conditions, traffic characteristics and traffic regulations. The road layout and design should be improved. If

is not safe, traffic accidents will tend to increase. And most road accidents occur in urban areas than in rural.

Road traffic accidents (RTA) increase from day to day. The occurrence of road traffic accidents (RTA) may vary within 24 hours of the day. As discussed in the previous section, different factors like geometric elements the availability of light, road pavement marking and road, signs, terrain characteristics of the road and the number of pedestrians and animals, would represent a greater impact in the variance of RTA distribution within the day. The period between 12:00 PM to 6:00 PM revealed the largest proportion of 44% of all the RTA incidents in five districts between the years 2012 to 2017. The frequency of occurrence of RTAs in the same period exhibited a dramatic increase in figures. In contrast, the time between 12:00 AM to 6:00 AM has contributed only 29% of road traffic accidents based on the records obtained from the nine districts. Road traffic accidents in Shashamane, Feji hursa,Kofele ,Ashoka,Wabe ,Edo, Dodola town Herero and Adaba town have frequently happened in the night time than in the daylight time (i.e. 12:00 PM to 6:00 PM and 12:00 AM to 6:00 AM).

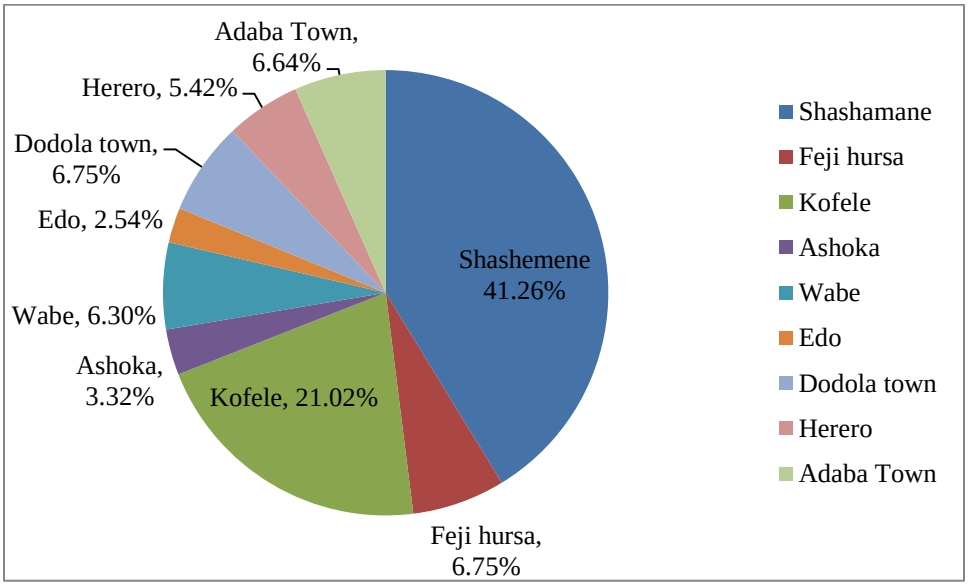

Figure 4.2. Number of RTA within nine District Area
Source : District Traffic Offices (2017)

Figure 4.2 showed that Shashamane area composed of about 41.26%, Kofele 21.02% ,Dodola town and Feji hursa 6.75 %, Adaba town 6.64 % , Wabe 6.30 %, Herero 5.42% ,Ashoka 3.32% and Edo 2.54% road traffic accident. Road traffic accident at urban area slightly higher than the crash happened in rural area.

This accident was due to some factors such as the sections of the roads are almost narrow road right of way, narrow lane width, eroded shoulder, pavement markings not visible, over speeding, missing road sign like zebra, ignoring pedestrians and animals, improper locations by opening roadway medians and overloading.

4.2 Analysis and ranking of blackspot locations

The priority value is determined based on Belgium method formula which is

P = X + 3*Y + 5*Z, where

X = total number of light injuries/Slightly injured persons/

Y = total number of serious injuries /severely injured persons/

Z = total number of deadly injuries/Fatal/

And this formula is applied for four kebele/ town in order to rank the black spot location.

4.2.1 Shashemene Town

Total of about five black spot locations are identified within this town. Table 4.7 shows that the calculated values of priority value based on fatalities and injuries for each black spot locations. The highest priority value is recorded in Sole River (86), Infront of Ledester School (72), Bridge at Goget River (64) and Awasho Roundabout (64).

Table 4.7 Identified black spot Locations at Shashemene town from 2012-2017

Black spot locations	Fatalities	Injuries		Priority value(P)
		Slight	Serious	
Bridge at goget river	11	3	2	64
Awasho Roundabout	9	2	3	56
Infront of Dr.urgesa	8	5	3	54
Infront of ledester school	11	5	4	72
Sole river	15	5	2	86

4.2.2 Fejihursa Kebele

Total of about three black spot locations are identified within this town. Table 4.8 shows that the calculated values of priority value based on fatalities and injuries for each black spot locations. The highest priority value is recorded in Selam Water P.L.C (74), Sole forest (25) and Sole mosque in front (19).

Table 4.8 Identified black spot Locations at Fejihursa kebele from 2012-2017

Black spot locations	Fatalities	Injuries		Priority value(P)
		Slight	Serious	
Sole mosque in front	1	5	3	19
Selam Water P.L.C	8	3	7	74
Sole forest	5	0	0	25

4.2.3 Kofele town

Total of about five black spot locations are identified within this town. Table 4.9 shows that the calculated values of priority value based on fatalities and injuries for each black spot locations. The highest priority value is recorded in front of Kofele Bus station (81), In front of Kofele mosque and Around Alemehayu Atomsa Park (51), In front of Kofele Secondary School (48) and around post office (34).

Table 4.9 Identified black spot Locations at Kofele town from 2012-2017

Black spot locations	Fatalities	Injuries		Priority value(P)
		Slight	Serious	
In front of Kofele mosque	7	4	4	51
In front of Kofele Secondary School	6	3	5	48
In front of Kofele Bus station	12	6	5	81
Around Alemehayu Atomsa park	8	2	3	51
Around post office	5	3	2	34

4.2.4 Adaba Town

Total of about six black spot locations are identified within this town. Table 4.10 shows that the calculated values of priority value based on fatalities and injuries for each black spot locations. The highest priority value is recorded In front of Leliso Catholic Church (34), Around Shebele hotel (25), Leliso Bridge (23) and In front of Dr.Amin clinic (21).

Table 4.10 Identified black spot Locations at Kofele town from 2012-2017

Black spot locations	Fatalities	Injuries		**Priority value(P)**
		Slight	Serious	
Leliso bridge	3	5	1	23
In front of Leliso Catholic Church	4	5	3	34
Around Girma Clinic	5	0	2	11
In front of Dr.Amin clinic	4	1	0	21
In front of Abay Hotel	2	2	1	15
Around Shebele hotel	5	0	0	25

4.2.5 Dodola Town

Total of about six black spot locations are identified within this town. Table 4.11 shows that the calculated values of priority value based on fatalities and injuries for each black spot locations. The highest priority value is recorded Dodola Hospital (55), Asasa junction (49), Infront of Bus Station (33) and Infront of Bale Motel (28).

Table 4.11 Identified black spot Locations at town Dodola from 2012-2017

Black spot locations	Fatalities	Injuries		Priority value(P)
		Slight	Serious	
Asasa junction	7	8	2	49
Total gas station	3	2	3	26
Infront of Bale Motel	5	3	0	28
Infront of Bus Station	4	4	3	33
Infront of CBE	2	0	2	16
Dodola Hospital	9	1	3	55

4.2.6 Accident Frequency in the Sampled Population

Accident frequency is applied based on Australian Black spot programs, which takes into account the occurrence of accidents for the duration of five years period and it states that if more than three accidents happened in the last five years period then the site is considered as black spot location,. So that accident frequency value is determined for two kebele and the black spot locations are ranked based on this.

4.2.6.1 Ashoka kebele

Only one blackspot location is identified in this kebele and the result indicates 5 accidents happened in front of Ashoka clinic

Table 4.12 Identified Locations for BlackSpot Identification at Ashoka kebele from 2012-2017

Black spot location	**Accident Frequency**	**Rank**
Ashoka clinic	**6**	**1**

4.2.6.2 Wabe Kebele

Total of two black spot locations are identified within this Kebele. Table 4.13 shows the list of black spot locations together with accident frequency and the rank orders. The result indicates 10 accidents happened at Wabe River Bridge and have the first rank.

Table 4.13 Identified black spot Locations at Wabe Kebele from 2012-2017

Black spot location	**Accident Frequency**	**Rank**
Ashoka clinic	**5**	**2**
Wabe River Bridge	**10**	**1**

4.2.7 Locations of Hazardous Sections

Finally after the priority value and the accident frequency are determined, each site within the last five years three or more accidents have occurred is selected. Then, a site is considered to be dangerous when its priority value (P) is equals 15 or more. Based on this, 25 Hazardous locations are prioritized from the total of selected sites.

Total of thirty black spot locations are identified along Shashemene to Adaba road from the total black spots five are from Shashemene town, three are from Fejihursa, five locations are from kofele

kebele,Adaba five locations are from ,six location are from Dodola town, one location from Ashoka kebele and two locations from Wabe kebele . Table 4.14 shows the list of black spot locations together with their rank orders within each kebele/town.

Table 4.14 Identified Black spot locations along Shashemene to Adaba road from 2012-2017

Black spot locations	Rank	Kebele/ Town
Sole river	1	Shashemene
Infront of ledester school	2	
Bridge at goget river	3	
Awasho Roundabout	4	
Infront of Dr.urgesa	5	
Selam Water P.L.C	1	Fejihursa
Sole forest	2	
Sole mosque in front	3	
In front of Kofele Bus station	1	Kofele
In front of Kofele mosque	2	
In front of Kofele Secondary School	3	
Around post office	4	
Ashoka clinic	1	Ashoka
Wabe River Bridge	1	Wabe
Ashoka clinic	2	
Dodola Hospital	1	Dodola
Asasa junction	2	
Infront of Bus Station	3	
Infront of Bale Motel	4	
Total gas station	5	
Infront of CBE	6	

In front of Leliso Catholic Church	1	Adaba
Around Shebele hotel	2	
Leliso bridge	3	
In front of Dr.Amin clinic	4	
In front of Abay Hotel	5	

4.2.8 Causes of Road Traffic Accident at Hazardous Locations

The cause of accident is determined based on the traffic accident data collected from the traffic police stations

4.2.8.1 Shashemene Town

Total of thirteen causes of accidents are identified in this town. Table 4.15 shows cause of accidents with the number and percentages of each of the causes from the total 28.57% of the accidents were due to over speeding, 14.29% due to Failure to Respect the Right-Hand Rule, 9.52% is due to Failure to give away for Pedestrians,11.90% is due to Failure in vehicle,7.14% is due to Driving with fatigue,4.76% is due to Following too closely,8.33% is due to Driving without attention,2.38% is due to (Pedestrian Error, Excess Loading and unidentified, Others),2.39% is due to Improper Turning and. 1.19% due to failure to give away for vehicles.

Table 4.15 Cause of accident in Shashemene

Cause of accident	**Number**	**%**
Over speeding	24	28.57
Driving without attention	7	8.33
Failure in vehicle	10	11.90
Failure to give away for Pedestrians	8	9.52
Driving with fatigue	6	7.14
Failure to give away for vehicles	1	1.19
Pedestrian Error	2	2.38
Improper Turning	2	2.39
Following too closely	4	4.76
Excess Loading	2	2.38

Failure to Respect The Right-Hand Rule	12	14.29
Unidentified	2	2.38
Others	4	4.77
Total	84	100

4.2.8.2 Fejihursa kebele

Total of five causes of accidents are identified in this kebele. Table 4.16 shows cause of accidents with the number and percentages of each of the causes from the total. 38.10% of the accidents happened due to Failure to Respect the Right-Hand Rule, 30.95% due to over speeding, 14.29 % is due to Failure to give away for Pedestrians, 9.52 % is due to Driving without attention and 7.14 % of the accidents were others.

Table 4.16 Cause of accident in Fejihursa Kebele

Cause of accident	Number	%
Failure To Respect The Right-Hand Rule	16	38.10
Failure to give away for Pedestrians	6	14.29
Driving without attention	4	9.52
Over speeding	13	30.95
Others	3	7.14
Total		100

4.2.8.3 Kofele Town

Total of thirteen causes of accidents are identified in this town. Table 4.17 shows cause of accidents with the number and percentages of each of the causes from the total 23.81 % of the accidents were due to over failure to give away for Pedestrians, 12.38 % due to Pedestrian Error, 11.43 % is due to excess loading,11.90% is due to Failure in vehicle,11.42 % is due to unidentified,10.48 % is due to failure to give away for vehicles,9.52 % is due to over speeding, 7.62% is due to Driving with fatigue,6.67 % is due to driving without attention , 4.76 % due to failure in vehicle, 3.81 is due to Following too closely,1.90 is due to (Others, Improper Turning and Failure to Respect The Right-Hand Rule)

Table 4.17 Cause of accident in Kofele Town

Cause of accident	Number	%
Over speeding	10	9.52
Driving without attention	7	6.67
Failure in vehicle	5	4.76
Failure to give away for Pedestrians	25	23.81
Driving with fatigue	8	7.62
Failure to give away for vehicles	11	10.48
Pedestrian Error	13	12.38
Improper Turning	2	1.90
Following too closely	4	3.81
Excess Loading	2	11.43
Driving Without respecting Right hand Rule	12	1.90
Unidentified	2	11.42
Others	4	1.90
Total	84	100

4.2.8.4 Ashoka Kebele

Total of four causes of accidents are identified in this kebele. Table 4.18 shows cause of accidents with the number and percentages of each of the causes from the total. 48.39 % of accidents happened due over speeding, 25.81% due to Driving without attention, 19.35% due to improper overtaking, 6.45 % due to unidentified cases by police officers.

Table 4.18 Cause of accident in Ashoka kebele

Cause of accident	Number	%
Driving without attention	8	25.81
Improper overtaking	6	19.35
Over speeding	15	48.39

un identified	2	6.45
Total	31	100

4.2.8.5 Dodola Town

Total of nine causes of accidents are identified in this town. Table 4.19 shows cause of accidents with the number and percentages of each of the causes from the total 19.67 % of the accidents were due to Failure to give away for Pedestrians, 18.03% due to Driving without attention, 16.39% is due to Pedestrian Error,13.11% is due to Over speeding,9.83 % is due to Driving with fatigue,8.20 % is due to Failure to Respect The Right-Hand Rule,6.56 % is due to Failure in vehicle, 4.92% is due to Influence of alcohol or drug,6.67 % is due to driving without attention , 4.92 % due to failure in vehicle and 3.29 is due to Others.

Table 4.19 Cause of accident in Dodola Town

Cause of accident	Number	%
Over speeding	8	13.11
Driving without attention	11	18.03
Failure in vehicle	4	6.56
Failure to give away for Pedestrians	12	19.67
Driving with fatigue	6	9.83
Influence of alcohol or drug	3	4.92
Driving Without respecting Right hand Rule	5	8.20
Pedestrian Error	10	16.39
Others	2	3.29
Total	61	100

4.2.8.6 Adaba Town

Total of five causes of accidents are identified in this town. Table 4.20 shows cause of accidents with the number and percentages of each of the causes from the total. 35.71% of accidents happened due to over speeding, 28.57% due to influence of alcohol or drug, 23.81% due to Failure to give away for vehicles, 7.10% due to unidentified cases and 4.76% is due to others.

Table 4.20 Cause of accident in Adaba Town

Cause of accident	Number	%
Failure to give away for vehicles	10	23.81
Over speeding	15	35.71
Influence of alcohol or drug	12	28.57
Un identified	3	7.10
Others	2	4.76
Total	42	100

4.2.9 Effects of existing road geometric design element of the path traffic accident

Existing road geometric design elements which lead to potential accidents, such as curve is too sharp, layered condition, road pavement that does not meet the minimum requirement s (i.e. Too slippery surface) is contributory to the cause of the road traffic accidents in the study area.

4.2.10 Characteristic of Geometric Design Element on Road Traffic Accident

The emphasis of the geometric design is to address the requirement of the driver and the vehicle such as safety, comfort, efficiency, etc. The features normally considered are the cross section elements, sight distance consideration, horizontal curvature, gradients, and intersection. The design of these features is to a great extend influenced by driver behavior and psychology, vehicle characteristics, traffic characteristics such as speed and volume. Proper geometric design will help in the reduction of accidents and their severity. Therefore, the objective of geometric design is to provide optimum efficiency in traffic operation and maximum safety at reasonable cost. The planning cannot be done stage wise in this case like that of a pavement, but has to be done well in advance.

4.2.11 Observed effects of existing geometric design parameters on road traffic accidents

A field survey in the study area was conducted for the purpose of determining the general characteristic of road traffic accidents; verify the effect of road geometric design elements and for further evaluation. All of the problems, deficiencies, and the hazards recorded on the checklist.

The list categorized under two main headings. One was road design problem, danger, while the one was the roadside problem risk. When conducting the road safety audit, the safety problem were categorized under these two main heading and recorded accordingly to the respective portion of the checklist.

Table 4.21: Road design problem checklist during site visit

A. Road design problem	
No.	Observed (Hazard)
1	Limited Sight Distance
2	Narrow Right Of Way
3	Shoulder too narrow
4	Improper Pedestrian Crossing
5	Missing Road marking
6	Carriageway too narrow
7	Shoulder missing
8	Bridge span too narrow
9	Asphalt defects
10	Dismantling road sign , No inventory speed control
11	Too small radius of horizontal curve (sharp curve)
12	Improper drain

Table 4.22: Roadside problem checklist during site visit

B. Roadside Hazard	
No.	Observed road side problem
1	Improper culvert design on the roadside
2	Temporary narrow bridge
3	Missing sign boards
4	Improper bus stop location
5	Missing guardrails

Based on the field survey, it observed that the road within road segment from Shashamane to Adaba jurisdiction were improperly designed such as no provision of road shoulder in case of an emergency situation to be used by vehicles, insufficient sight distances, narrow lane width, limited road right of way , and too sharp curves.

In addition to this, the road signs are not installed in the appropriate locations, and most signboards have been thoroughly worn out. Another thing, the horizontal and vertical alignments were not suitable for the design speed of vehicles. Some sections of the pavement surface traced with old patched, and potholes of varying dimensions were believed to be the main contributory of the dramatic increase in traffic accidents.

4.3 Comparison of road segment from Shashamene to Adaba With the standard

The existing geometric dimension of the cross sectional elements of the audit road has been measured and compared with ERA 2013 ; geometric highway Design Manual (Two-lane Rural road DC5 paved) Highway as presented in Table 4.23.

Table 4.23 Observed values compared with ERA Standard

NO.	Roadway Element	ERA Standard Value	Observed Value
1	Number of lanes	2 lanes	2 lanes
2	Shoulder width	0.5-1.5 m depending on terrain	0.5-1 m
3	Carriageway width	7m	5-6 m
4	Bridge Width	At least full approach travelledway width or 0.6m clearance on each side	2/3 of travelled way width
5	Minimum bridge clearance	50m	40-45m
6	Pedestrian Crossing	Controlled	Uncontrolled
7	Road Alignments	Adequate and a smooth alignments	Poor alignments

4.3.1 Safety Audit Checklist of Existing Road

Tables 4.24 shows the safety audit checklist, with entirely the field observations recorded during the site survey of the asphalt road from Shashamene to Adaba road.

Table 4.24 Observed Road Design Problem

Road Location	Observed Road design problem Hazard	Results
	Improper Median Opening	Reduce roadway capacity
	30 m right of way but town master plan is 50m	

Shashamene Town	Dangerous pedestrian crossing	Increase traffic accidents
	Missing of road sign	
	Improper installation of traffic signal	
Shashamene Town	Missing shoulder	Dangerous for road user
	Narrow bridge	
	Narrow of walk side	
	Dismantling road marking	
	Improper constructed of traffic rotary	
	Narrow traffic rotary	
Kofele	Missing Road sign and marking	Increase traffic accidents
	Missing shoulder	
Kofele	Narrow bridge	Reduce roadway capacity
	Insufficient sight distance	
	Narrow right of way	
	Improper constructed of traffic rotary	Dangerous for driver
	Narrow traffic rotary	
Dodola Woreda	Narrow right of way	Reduce roadway capacity
	Insufficient sight distance	
	Dismantling road marking	Dangerous for road user
	Narrow bridge	
	Missing of road sign	
	Dangerous guardrail start and end	
	Dangerous pedestrian crossing	Increase traffic accidents
	Missing shoulder	
Dodola Town		
	Missing Road sign and marking	Increase traffic accidents
	Missing shoulder	
	Dangerous pedestrian crossing	

	Dangerous guardrail start and end	
	Narrow bridge	Reduce roadway capacity
	Insufficient sight distance	
	Narrow right of way	
Adaba Town	Missing Road sign and marking	Increase traffic accidents
	Missing shoulder	
	Dangerous guardrail start and end	
	Narrow right of way	Reduce roadway capacity
	Insufficient sight distance	

The above table illustrates the problem related to road design elements on RTA. This shows the road design elements do not affect the motorist's operational capacity on road travel, but merely on the condition of the road. It is varied with location and terrain features. Based on the data gathered in Shashamene town, the effect of road design element which reduce roadway capacity is due to narrow of right of way which is 30m but Shashamene town master plan is 50m on main road; also narrow bridge, narrow walk side and missing shoulder which the affect the road design elements. In shashamene town when new driver for town entered into town he/she does not under standard traffic signal because due to improper installation of traffic signal and road sign increase potential accidents While Dodola wored , Dodola town and Adaba town the effect of road design element which increase traffic accident is due to Missing Road sign and marking, Dangerous guardrail start and end , Missing shoulder and Insufficient sight distance.

Based on the data gathered in Kofele town the effect of road design element which dangerous for driver due to improper constructed of traffic rotary and narrow traffic rotary. Another factor that affect road design element at kofele town is reduce roadway capacity due to insufficient sight distance, Narrow right of way and narrow bridge.

4.4 Control Mechanisms of road traffic accident in Hazardous Locations and Features of the locations

Having identified the probable causes of the accident, possible control mechanisms have been suggested to improve the road accident situation along the road. The counter measures usually used are low cost

engineering measures which include traffic signs and road marking, channelization, improvement lighting, and the like.

Accidents commonly have a multitude of cause, for the stem from a number of diverse factors. In order to minimize or to reduce their frequency, the concerned bodies have adopted and implemented different control mechanisms. In our context, West Arsi traffic police and ERA Shashemene district have been discharging their responsibility.

4.4.1 Roundabout below Awasho bus station at 252+030

Site inspection: At the time of inspection, public transport vehicles used the junction for picking and dropping of passengers. Specially, drivers of Bajaj did not respect traffic rules at the spots. There were no traffic signs around the junction also vehicles operated above the speed limits.

Figure 4.3 Feature of roundabout below Awasho bus station

Proposed Control mechanisms: As mentioned earlier, an accident prone spot was four legs priority junction. The following measures should be applied to improve the situation at the priority junction.

a) Trees and advertisement bill boards should be removed from the junction.
b) The roundabout should be furnished reflective chevron on island with a dimension (62 cm x210 cm)

c) Prohibition of parking sign should be placed before 50 meters of each leg and provided off road parking facilities.
d) A speed limit sign should be placed where the town begins and ends.
e) Zebra crossing for pedestrian should be provided in every 50 meters.
f) 1-2 sets of rumble stripes should be furnished before every zebra crossing

4.4.2 Sole River at station253+060

The control mechanisms that should be applied are:

a) centerline and edge line should be painted,
b) There is steep gradient along the road stretch so that speed limit posts should be installed along the road,
c) speed breaker should be provided,
d) Installation of warning posts which informs the existence of bridges.

4.4.3 Selam Water factory at station 255+050

Because of the water factory there is high traffic volume especially, heavy trucks.

Therefore the control mechanisms that should be applied are:

a) Speed limit post should be installed;
b) road side delineator should be installed along the road that guides vehicles to flow on the vertical curve
c) Zebra crossing for pedestrian should be provided and
d) Speed breaker should be installed to regulate the speed of vehicles.

Figure 4.4 Around Selam water factory road section

4.4.4 Fejihursa Kebele at Station 260+020

The control mechanisms that should be applied are:

a) Centerline and edge line should be painted,
b) There are trees surrounding the curve that obstructs the vision of the drivers, so that it should be cleared,
c) There is steep gradient along the road stretch so that speed limit posts should be installed along the road,
d) Road side delineator should be installed,
e) Speed breaker should be provided,
f) Installation of warning posts which informs the existence of bridges,
g) There is also pavement deterioration along the road so that the pavement should be rehabilitated.

Figure 4.5 Fejihursa road section

4.4.5 Kofele Town: station 275+080

Site inspection: There is a market place near the junction .Many pedestrians and animal drawn carts cross the road at this point. Public transport mini –buses use the shoulder and road side spaces for picking and dropping passengers. The other phenomenon was that daily laborers gathered together and stand looking for manual labor at the junction. The main problem is mix of traffic within the influence area.

Figure 4.7 Feature of kofele town roundabout

Proposed counter measure: The following control mechanisms are proposed to reduce focused on reducing accidents.

a) Pedestrian refuge should be provided by widening of the sites in order to have safer crossing.
b) Prohibition of parking sign should be placed.
c) Traffic channelization should be made to reduce conflict points. By doing this, traffic flows are segregated reducing the area of conflict. Moreover, visibility is improved.
d) Zebra crossing should be provided at each leg of the junction before 50 meters.
e) 1-2 sets rumble stripes should be furnished before zebra crossing.
f) Strict enforcement should be implemented in the town.
g) Campaigns for road uses should be performed during market days.
h) 1-2 sets of rumble stripes should be furnished at each leg before zebra crossing.

4.4.6 Wabe Bridge : Station 320+030

The road section is horizontal curve with bridge. The control mechanisms for this location are Speed limit posts should be installed; warning sign which indicate the presence of narrow bridge and Road side delineator should be installed along the road.

Figure 4.8 Wabe Bridge

4.4.7 Dodola Town : Station 326+050

The road section is found in dodola town with a combination of reverses curves and a narrow bridge.

Proposed counter measure: proposed counter measures are listed below.

a) Reflective marking and road signs should be provided to help drivers in finding their ways during poor conditions.
b) Warning sign should be placed a head of 50 meters.
c) Zebra crossings should be provided at the upper and down approaches of the curves.
d) Pedestrian side walk should be constructed with steel sides at the Kora bridge
e) 1-2 sets of rumble stripes should be furnished before zebra crossing

Figure 4.9 Kora Bridge sections

4.4.8 Adaba Town: Station 350+000

Site inspection: A visit was made on the road sections. During site visit, the following problems were observed. There was no properly constructed side walk. Pedestrian mostly use outside lanes as a side walk. Besides, pedestrian do not have knowledge about traffic regulations. Illegal walking along the road and crossing between parked vehicles were common practices. Heavy vehicle are usually parked on the side for a long time until the time of restriction to enter the town is over. With regard to road marking, the road was painted during the construction of the road .However; the markings were faded with no sign to road users. Many Mini-buses and other public transport vehicles carry passengers over the legal limit.

Proposed counter measure: The countermeasures were proposed based on the accident analyses, identified causes, and site inspections report. Appropriate engineering measures are provided to suggest solutions to the problem.

The study road incorporates Adaba town that requires reduction and improvement of pedestrian facilities. The following are proposed in order to alleviate the problem of the road section.

a) A speed limit sign (30km/hr) should be placed where town begins, before 100-150 meters.
b) 1-2 sets of rumble stripes should be furnished before entering the town to notify reckless drivers
c) Road side parking should be prohibited and provide off-road packing for heavy trucks
d) Zebra crossing for pedestrian should be marked in 50 -70 meters interval
e) 1-2 sets of rumble stripes should be furnished before zebra crossing
f) Strict traffic police enforcements should be required during day time because more 70 percent of the recorded accidents occurred during this period. Special attention should be given on Wednesday and Saturday in controlling traffic because these two days is market day many people become form village.
g) For problem of lane discipline, improper overtaking and the like. Re-painting of the road should be given much attention.

Figure 4.10 Adaba town road section

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the analysis, the occurrence of road traffic accident increase up to 2016 and decrease in 2017. The loss of human life due to crashes decreases as the number of districts with fatal accidents decreased. Whereas the amount of property damage due to traffic accidents is decreasing in a similar fashion with the number of the accidents. It is thus directly proportional to the occurrence of the crashes. Percentage distribution of severity class comprised of about 25% of the fatal accident, 8.3% serious injury, 12.72% slight injury, and 53.98% property damage. Thus exposure to high traffic volume results in high amount of road traffic accidents and its effects.

Road safety audit and traffic data analysis for the year 2012-2017 were under taken for the road corridor. Based on the available data, priority value and accident frequency were used in order to rank the blackspot locations. Priority values were used for Shashemene, Fejihursa, Kofele, Dodola and Adaba while Accident frequency is used Ashoka and Wabe kebele. Regarding the causes of the accidents, 48.39%, 35.71% and 28.57% of the accidents that happened in Ashoka kebele, Adaba and Shashemene town were due to over speeding drive respectively.23.81% and 19.67% of the accidents that happened in Kofele town and Dodola town were due to failure to give away for pedestrian. 38.10% of accident happened due to failure to respect the right hand rule. From this, it is concluded that it was also indicated that there was majority of the accidents that happened were due to over speeding drive and driving without attention.

Based on the data gathered in Shashamene town, the effect of road design element which reduce roadway capacity is due to narrow of right of way which is 30m but Shashamene town master plan is 50m on main road; also narrow bridge, narrow walk side and missing shoulder which the affect the road design elements. From this, it's concluded that the existing geometric layouts of the identified blackspots in the study area are far away from ERA 2013.

Based on the analysis of the black spot locations, the major control mechanisms that should be applied in order to decrease the occurrence of accidents along this road will be:-provision of speed breaker, the provision of pedestrian lane, the installation of road side delineator, the provision of roadside improvements, the installation of traffic sign and the repainting of pavement marking. In connection to this,

the Ethiopian roads authority should take the control mechanisms as input and undertake road safety audit on the road in order to mitigate the effects.

5.2 Recommendation

Based on the analysis of the blackspot locations, the major control mechanisms that should be applied in order to decrease the occurrence of accidents along this road sections . On the existing situation or identified causes, improvement was suggested. In general the following recommendation should be implemented.

- Provision of speed breaker
- Bridge widening
- the provision of pedestrian lane
- the installation of traffic side delineator
- Prohibition of on road side parking
- the installation of traffic sign and the repainting of pavement marking Strict traffic police enforcement and speed control
- Road user information and campaign
- Rumble stripes should be placed on changing traffic and road environment
- Traffic channelization
- Providing pedestrians side walk
- Limiting driving time for professional drivers and
- Access density and access permit regulation should be given a focus by the road Authority.

To summarize, Shashemene priority junction has a number of conflict points. As result, accidents occurred due to these conflict points. To solve this, placement of roundabouts were proposed with appropriate road signs and markings. In case of kofele junction, channelization of road either using road marking or construction of island and placement of road sign will solve problems on the spot.

Road sections problem in Adaba town will be resolved by furnishing proposed low cost engineering measures like installing traffic signs, traffic campaign and enforcement. Regarding Dodola town, accidents are much concentrated on the approaches of the Dodola Bridge. Pedestrian side walk is proposed along sides of the bridge which should be made of steel structure. The recommendation mention above implemented by the Ethiopia roads authority Shashemene district and West Arsi Zone Traffic police should take the control mechanisms as in put and undertake road safety audit on the road in order to mitigate the effects.

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APPENDIX

Road traffic accident data report of Shashemene to Adaba road.

A. Traffic accident records from 2012-2017

No.	Kebele /Town	Number of			Percentage values (%)		
		Fatality	Injury	Total Road accident	Fatality	Injury	Total RA
1	Shashemene	54	34	373	23.89	17.89	41.26
2	Fejihursa	24	18	61	10.62	9.47	6.75
3	Kofele	38	37	190	16.81	19.47	21.02
4	Ashoka	16	15	30	7.08	7.89	3.32
5	Wabe	22	16	57	9.73	8.42	6.31
6	Edo	12	13	23	5.31	6.84	2.54
7	Dodola	30	31	61	13.27	16.32	6.75
8	Herero	11	8	49	4.87	4.20	5.42
9	Adaba	23	18	60	10.18	9.47	6.64
	Total	226	190	904	100	100	100

B. Checklist format used by West Arsi Zone traffic officers at road hazardous locations

NO	Level of driver license	Plate no.	Type of vehicles	Passengers			Sign
				Male	Female	total	
1							
2							
3							
4							
5							

C. Road Safety Audit Check list (Source ERA Manual)

Date			
Name of Black spot Location; Shashemene town ; Awasho Roundabout station 252+030			
Check list of site Inspection for the Identified Black Spot Locations			
No	Type of Measure	Comment	
		Is needed(√)	Not needed (x)
1	The provision of Road widening	√	
2	The provision Climbing Lane		X
3	The provision of Road side Delineator		
4	The provision of Road marking	√	
5	The presence of speed limit post	√	
6	Bridge widening		x
7	The provision of clear (flat slopes) road side improvements		x
8	The provision of Guard Rails		x
9	The provision of median Barriers		x
10	The provision of adequate horizontal curve radius		x
11	The provision of Signing in horizontal Curves		x
12	The provision of adequate lane width of shoulder	√	
13	The provision of efficient signals installed		
14	The provision of adequate and visible pavement marking	√	
15	The provision of Effective road marking at night and in wet weather	√	
16	The provision of pedestrian walking on town section	√	

Date			
Name of Black spot Location; Fejihursa Kebele at Station 260+020			
Check list of site Inspection for the Identified Black Spot Locations			
No	Type of Measure	Comment	
		Is needed(√)	Not needed (x)
1	The provision of Road widening	√	
2	The provision Climbing Lane	√	
3	The provision of Road side Delineator		x
4	The provision of Road marking	√	
5	The presence of speed limit post	√	
6	Bridge widening		x
7	The provision of clear (flat slopes) road side improvements	√	
8	The provision of Guard Rails		x
9	The provision of median Barriers		x
10	The provision of adequate horizontal curve radius	√	
11	The provision of Signing in horizontal Curves	√	
12	The provision of adequate lane width of shoulder	√	
13	The provision of efficient signals installed		x
14	The provision of adequate and visible pavement marking		x
15	The provision of Effective road marking at night and in wet weather		x
16	The provision of pedestrian walking on town section		x

Date			
Name of Black spot Location; Kofele Town: station 275+080			
Check list of site Inspection for the Identified Black Spot Locations			
No	Type of Measure	Comment	
		Is needed(√)	Not needed (x)
1	The provision of Road widening	√	
2	The provision Climbing Lane	√	
3	The provision of Road side Delineator		x
4	The provision of Road marking	√	
5	The presence of speed limit post	√	
6	Bridge widening		x
7	The provision of clear (flat slopes) road side improvements		x
8	The provision of Guard Rails		x
9	The provision of median Barriers	√	
10	The provision of adequate horizontal curve radius		x
11	The provision of Signing in horizontal Curves		x
12	The provision of adequate lane width of shoulder	√	
13	The provision of efficient signals installed	√	
14	The provision of adequate and visible pavement marking	√	
15	The provision of Effective road marking at night and in wet weather	√	
16	The provision of pedestrian walking on town section	√	

Date			
Name of Black spot Location; Ashoka Kebele: station 285+050			
Check list of site Inspection for the Identified Black Spot Locations			
No	Type of Measure	Comment	
		Is needed(√)	Not needed (x)
1	The provision of Road widening		x
2	The provision Climbing Lane		x
3	The provision of Road side Delineator		x
4	The provision of Road marking	√	
5	The presence of speed limit post	√	
6	Bridge widening	√	
7	The provision of clear (flat slopes) road side improvements	√	
8	The provision of Guard Rails	√	
9	The provision of median Barriers		x
10	The provision of adequate horizontal curve radius	√	
11	The provision of Signing in horizontal Curves	√	
12	The provision of adequate lane width of shoulder	√	
13	The provision of efficient signals installed		
14	The provision of adequate and visible pavement marking	√	
15	The provision of Effective road marking at night and in wet weather		x
16	The provision of pedestrian walking on town section		x

Date			
Name of Black spot Location; Dodola Town : Station 326+050			
Check list of site Inspection for the Identified Black Spot Locations			
No	Type of Measure	Comment	
		Is needed(√)	Not needed (x)
1	The provision of Road widening	√	
2	The provision Climbing Lane	√	
3	The provision of Road side Delineator		x
4	The provision of Road marking	√	
5	The presence of speed limit post	√	
6	Bridge widening		x
7	The provision of clear (flat slopes) road side improvements	√	
8	The provision of Guard Rails		x
9	The provision of median Barriers		x
10	The provision of adequate horizontal curve radius	√	
11	The provision of Signing in horizontal Curves	√	
12	The provision of adequate lane width of shoulder	√	
13	The provision of efficient signals installed	√	
14	The provision of adequate and visible pavement marking	√	
15	The provision of Effective road marking at night and in wet weather	√	
16	The provision of pedestrian walking on town section	√	

Date			
Name of Black spot Location; Adaba Town at station 350+050			
Check list of site Inspection for the Identified Black Spot Locations			
No	Type of Measure	Comment	
		Is needed(√)	Not needed (x)
1	The provision of Road widening	√	
2	The provision Climbing Lane		x
3	The provision of Road side Delineator		x
4	The provision of Road marking	√	
5	The presence of speed limit post	√	
6	Bridge widening		x
7	The provision of clear (flat slopes) road side improvements	√	
8	The provision of Guard Rails		x
9	The provision of median Barriers		x
10	The provision of adequate horizontal curve radius	√	
11	The provision of Signing in horizontal Curves		
12	The provision of adequate lane width of shoulder	√	
13	The provision of efficient signals installed		x
14	The provision of adequate and visible pavement marking	√	
15	The provision of Effective road marking at night and in wet weather		x
16	The provision of pedestrian walking on town section	√	