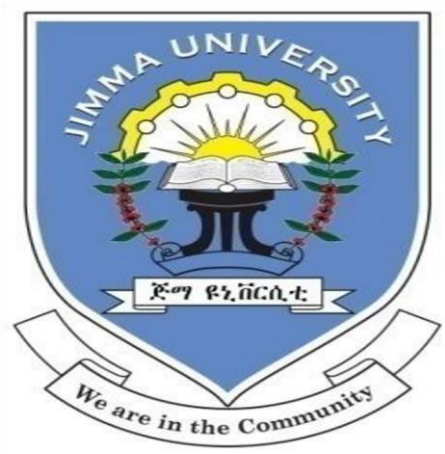

Jimma University

School of Graduate Studies

Jimma Institute of Technology

School of Civil and Environmental Engineering

Highway Engineering Stream

The Influence of Road Geometric Design Elements on Road Traffic Accident from Bedele City to Dedesa River.

A Thesis Submitted to School of Graduate Studies of Jimma University, Jimma Institute of Technology in Partial Fulfillment of Requirements for Degree of Masters of Science in Civil Engineering (Highway Engineering Stream)

By

Berhan Ganta

September, 2020

Jimma, Ethiopia

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Berhan Ganta

Main Advisor: - Elmer C. Agon (Associate professor).

Co-advisor: - Oluma Gudina (M.Sc.).

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DECLARATION

I, the undersigned declare that this thesis entitled by 'The Influence of Road Geometric Design Elements on Road Traffic Accident from Bedele Town to Dedesa River.' is my original work and has not been presented by any other person or an award of degree in this or other university and all sources of materials used for this thesis have been duly acknowledged.

Candidate: Mr. Berhan Ganta

Signature: _____ Date: _____

As members of the examining board of the final M.sc. online defense, we read and evaluated the thesis prepared by Mr. Berhan Ganta entitled by 'The Influence of Road Geometric Design Elements on Road Traffic Accident from Bedele Town to Dedesa River.' And recommended that it can be accepted as fulfilling the thesis requirement for the degree of Master of Science in civil Engineering under highway engineering stream.

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ABSTRACT

Road traffic accident are a global problem affecting all parts of society. The major causes of road traffic accident are road user, vehicle condition and road environment. In Ethiopia, road traffic accident has been worsened as the number of vehicles has increased and consequently due to increased traffic flow and conflicts between vehicles and pedestrians.

The highway from Bedele to Dedesa, has been experiencing many road traffic accidents. The main objective of this research work was to study the influence of road geometric design elements on road traffic accident. The Methods used on this research were, both qualitative and quantitative method of data analysis, black spot identification has been done. Next, interview for different stakeholders and comparison of the geometric data to the standard has been carried out. Finally, site inspection has been conducted.

There were eight black spot locations. Mine (25), Bedele ganda 01 (17), Lilkee qararo (26), Jisa (18), Saxa (32), Sidan (18), Adebi (20) and Demo (21) were the black spot locations which have the highest priority value. These black spot location geometric parameters were found below the minimum requirements. The required curve widening (0.6-1.2m) is not provided for these locations. The radius used at Mine, Lilkee qararo, Jisa, Saxa Adebi and Demo were below the minimum requirement. There were also a high gradient at Lilke qararo (9%) and Jisa (8.3%). In addition, the road length had lost all types of road markings, presence of vegetation obstruction, pavement deterioration, existence of sharp horizontal curves, occurrence of horizontal curve in steep vertical grade, absence of delineators with curve widening and sign posts.

The counter measures given were: - the installation of road side delineator, curve widening, the provision of sufficient site clearance and avoid obstruction, the installation of traffic signals and the re furnishing of pavement marking are measures that should be taken to minimize road traffic accident. As a long lasting solution, revision of road geometry must be done.

Key words; Curve Geometry, Black spot, Road Traffic Accident

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ACRONYMS

AASHTO	American Association of State Highways and Transport Officials
ERA	Ethiopian Roads Authority
ETB	Ethiopian Birr
GIS	Geographic Information Systems
JIT	Jimma Institute of Technology
Km	Kilo meter
M	Meter
RSDP	Road Sector Development Program
RTA	Road traffic accident
TRB	Transport Research Board
USD	United States Dollar
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background

Ethiopia has a vision of joining middle-income economy region by 2028. Hence, the country needs to increase its road network from 49,000Km 2010 to 201,750 Km by 2028. For this vision to come true, a need for a well-organized and strong local road construction industry is inevitable. However, the construction and design of these roads have still many defects. One of the main defects of road is its geometry which is the basic criteria to tell about the quality of road [1].

Nearly 1.3 million people die in road traffic accident each year, on average 3,287 deaths a day. Additional 20-50 million are injured or disabled. Road traffic accident rank as the 9th leading causes of death and account for 2.2 percent of all deaths globally. Road traffic accident are the leading causes of death among young people ages 15-29, and the second leading causes of death worldwide among young people ages 5-14. Over 90 percent of all road fatalities occur in low- and middle-income countries, which have less than half of the world's vehicles. Road traffic accident cost low- and middle-income countries USD 65 billion annually, exceeding the total amount received in developmental assistance. Unless action is taken, road traffic accident predicted to became the fifth leading causes of death by 2030 [2].

The ultimate objective of designing road is to construct a safe, maneuverable and good mobility roadway. There is a level of service that the road is expected to give and achieving the level of service one desire, applying a proper design standard during design and construction is a must. Accidents are the contra indication of development of countries. It is more serious in developing countries than in developed countries. Developed countries around the world have more advanced roads than developing countries. Therefore, they are less exposed to accidents. Specially, from accidents that happen from poor geometric design of roads [3].

The causes of road traffic accidents are multi-factorial. These factors can be divided broadly into human factors, vehicle factors and road and environmental factors. Accidents can be

caused by a combination of these factors. Human factor seems to be the dominant cause of accidents compared to the others. However, the control of road factor is much easier than human factor and the number of accidents can be seriously reduced if the road factor is evaluated better and highway design is made correctly. By making safe road design road traffic accident can be minimized significantly [4].

Ethiopia is one of the east African countries that is losing the working power. The geometry of the road can cause accidents. In addition to the accidents, the comfort that the road is expected to give is also below standard. One of this road, a road with poor geometry in Ethiopia is the Bedele to Dedesa river road which is part of the Addis to Gambela Trunk road.

A primary measure of the safety of an existing highway is its accident history. Once a highway location has been proposed, accident data should be collected and analyzed to determine the relative safety of the facility and to identify and describe the accident characteristics or patterns that have occurred. Safety enhancements to alleviate safety deficiencies can be more-readily identified from this analysis, and the extent of minimum safety enhancement can be determined [5].

1.2 Statement of the Problem

Road traffic accident is a growing problem in Africa resulting in close to thousands of deaths, tens of thousands of injuries and enormous amount of economic losses every day. The specific characteristics of victims in the region signifies that road crash is the fourth leading cause of deaths of people aged 5-44 years; over 75% of the casualties are of productive age between 16-65 years and the vulnerable road users constitute over 65% of the deaths. Road traffic accidents can cause physical, financial and mental effects for everyone involved. Drivers and passengers can suffer from minor cuts and bruises to broken limbs, whiplash, back and spinal injuries, paralysis and even death. Vehicles in road traffic accidents are damaged and may be in need of minor or costly repairs or may even be completed totaled and no longer drivable. Additional effects of road traffic accidents can include emotional and mental distress as people can suffer from post-traumatic stress from being involved in the accident or from losing a loved one due to a road traffic accident. [6]

In Ethiopia, road traffic accident has been worsening 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 traffic accident remains to be one of the critical problems of the road transport sector in Ethiopia.

The highway from Bedele to Dedesa, has been experiencing many road traffic accidents. Road traffic accident is big problem in this region, the number of road traffic accident has been increasing from time to time in alarming rate. The area is very much vulnerable to road transport related accidents. Road traffic accident has been happening on different section of the road.

Figure 1 Road Traffic Accident [28]

1.3 Research question

This research study has been sought to answer the following questions.

1. Where are the accident prone locations on the road from Bedele to Dedesa river road?
2. What are the causes for road traffic accident on the road from Bedele to Dedesa river road?
3. Which geometric components of the road and road side environments contribute to road traffic accident?

1.4 Objectives

1.4.1 General objective

The general objective of this research study was to study the influence of road geometric design elements on road traffic accident from Bedele town to Dedesa River.

1.4.2 Specific objectives

The specific objectives of the study are as follow:

- To identify high accident potential locations in the study area.
- To identify the major causes and contributing factor on the occurrence of road traffic accident.
- To evaluate geometric and road side components contributing to road traffic accident occurrence.

1.5 Significance of study

As described on the introduction, road traffic accident is increasing at alarming rate in developing country like Ethiopia. To decrease the effect of road traffic accident, it is important to know causes of road traffic accident. Among main causes of road traffic accident, road and environmental factor is one. This paper tried to study the effect of road geometry and road side environment on the occurrence of road traffic accident on Bedele to Dedesa River in detail. As many researches indicated making road its environment safe for drivers and vehicles significantly decrease road traffic accident. The study provided clues on how to decrease the rate of occurrence of accidents by identifying the causes of accidents at the hazardous locations. So that this thesis would help Ethiopian Roads Authority as a guide to apply the countermeasure at the road traffic accident prone areas or hazardous locations either to eliminate or decrease the occurrence of road traffic accidents.

1.6 Scope of the study

This particular research was focused on the analysis, the issues of Road Traffic Accident. The scope of the study was limited to Bedele to Dedesa River. The study area has a total length of 82km. This study mainly used the Road Traffic Accident data collected from the archives of the traffic office, Road Safety Audit and road design. Generally, the scope of the research was taken from Road Traffic Accident result and Road Safety Audit specifically. Finally, recommendation was drawn and formulate from result and discussion.

1.7 Organization of the research

The research 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. This chapter review different road traffic accident as a program, secondly touches the cause of road traffic accidents identified in different literatures in different countries, and finally states methods to prepare check list for site inspection of hazardous locations.

In chapter three, the materials and methods are fully described. In this chapter firstly the study area is clearly explained and study area map is drawn, secondly method to be used in order to collect the road traffic accident 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 focused on the results and discussion of the study. Analysis of each accident type has been done. Locations with high road traffic accident potential has been identified using black spot identification methods. Also, it discusses about road safety inspection done on hazardous locations of the road in order to know the effect of road geometry and road side environment on the occurrence of road traffic accident. At last measures that should have taken at black spots to decrease road traffic accident occurrence was discussed.

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

1.8 Limitation of the research

Obtaining data from traffic police was time taking and difficult, so that it became late to compare and analyze multi dimensionally.

Some of the traffic police officers found in the Weredas were not positive, cooperative and they were also not willing to give the road traffic accident data.

The budget provided by ERA was not sufficient to fully pay the per dime dues for the personal investigator and for the police inspectors, so that it hinders from undertaking the research fully without fear of financial constraints.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 General

In this part of the study, basic and important literatures are reviewed to provide background information and current state of RTA. A comprehensive collection of applicable works to support this research will also be compiled.

Over 1.2million peoples die each year on the world roads, and between 20 and 50 million suffer non-fatal accident. In most regions of the world this epidemic of road traffic injuries are still increasing. Here, this chapter, gives an idea about the previous studies of various researchers done in the analysis of road traffic accident, those are the parameters which have scientific relation to road traffic accident, directly or indirectly [1].

Highways are vitally important to a country's economic development. The construction of a high-quality road network directly increases a nation's economic output by reducing journey times and costs, making a region more attractive economically. The actual construction process will have the added effect of stimulating the construction market. The basic features of a highway are the carriageway itself, expressed in terms of the number of lanes used, the central reservation or median strip and the shoulders (including verges). Depending on the level of the highway relative to the surrounding terrain, side-slopes may also be a design issue [7].

The major causes of road traffic accident are road user, vehicle condition and road environment. So, studies proved that the main causes of road traffic accident occurrence when ranked first is road user while the road and vehicle condition Contribute small percentage.

Most safety studies come to the conclusion that vehicle operator or driver factors (or human error) are the main cause of road traffic accidents. Some of the human related causes of road traffic accident are as follows, drink driving use of drugs, over speeds, distracted driving, inexperience and unqualified drivers, Pedestrians (Pedestrian). Whereas vehicle design related causes of traffic accident are, Brake tension, over load, design vehicle weight vehicle lighting systems. The climatic and environmental conditions can also be a factor in transportation [8].

While the African Region possesses only 2% of the world's vehicles it contributes 16% to the global deaths. Compared with other regions, the losses caused in Africa are in proportionate to the level of motorization and road network density. Unless appropriate comprehensive and effective actions are taken timely, the specific regional factors exacerbating road crash indicate that the disaster will rapidly increase and have unbearable impacts. Moreover, the solution at a later date will be more expensive [9].

Since road traffic accident is increasing in alarming rate throughout the world, the concept of road safety is becoming a major topic. Especially in developing countries, the issue of road traffic safety is more important and it needs a big focus. To address this issue properly, first we have to know major causes of Road traffic accident (RTAs).

In Ethiopia, road traffic accident 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 traffic accidents remain to be one of the critical problems of the road transport sector in Ethiopia. Every year many lives are lost and much property is destroyed due to road traffic accidents in the country. The financial estimation of property damage (excluding human deaths and injuries), is more than 15 million Ethiopian birr annually on average.

Figure 2 Ethiopian road traffic accidents cases [31]

Road construction and maintenance is an important desire for the development especially in developing countries. Reviewing the Ethiopia's road sector development (RSDP) in the past

16 years has revealed that the total road network expansion of the country has reached 85,966km. As part of the transformation plan of the country, Ethiopian government states that it will construct 82,500km of roads across the nations with cost of 122 billion birr during the specified period of time [10].

The geometric design of road is concerned with the alignment of the roadway. The elements of design comprise, where appropriate, grade, the radius of the central circular radius, the super elevation, the length of spiral transition curve, pavement widening and adequate sight distance and many more.

Geometric design of a highway should consider users, especially driver's performance limits. There are limits to a driver's vision, perception, reaction, concentration, and comfort that could directly lead to road traffic accident. When driving, most drivers receive information visually from their views of the roadway alignment, markings and signs. They do receive other information through vehicle feedback from the suspension system and steering control and roadway noise. The information received by a driver needs time to be processed before a response action takes place. They reported that when an event is expected, the driver's reaction time has an average value of 0.6 sec. For an unexpected event, the average reaction time is 0.8 sec. The average brake-reaction time of a driver (including decision time), is 2.5 sec. This is dependent on the driver's alertness. Brake-reaction time is important in determining sight distance in highway geometric design [11].

The alignment of a highway or street produces a great impact on the environment, the fabric of the community, and the highway user. The alignment is comprised of a variety of elements joined together to create a facility that serves the traffic in a safe and efficient manner, consistent with the facility's intended function. Each alignment element should complement others to produce a consistent, safe, and efficient design.

Accident prediction models indicate that inadequate super elevation increases curve accidents. There is no evidence; however, that safety is adversely affected along a curve where the actual super elevation is greater than that recommended by AASHTO policy. Therefore, research results indicate that safety can be enhanced when the super elevation is improved or restored along curves where the actual super elevation is less than the optimal

super elevation. The following section presents the safety effectiveness of improving or restoring super elevation along curves. The discussion is then concluded with a section that presents other issues relevant to this [12].

2.2 Main causes of road traffic accident

The causes of road traffic accidents are multi factorial. These factors can be divided broadly into human factors, vehicle factors and road and environmental factors. Accidents can be caused by a combination of these factors. Human factors in road traffic accidents are all factors related to drivers and other road users. Human factor seems to be the dominant cause of accidents compared to the others. However, the control of road factor is much easier than human factor and the number of accidents can be seriously reduced if the road factor is evaluated better and highway design is made correctly [13].

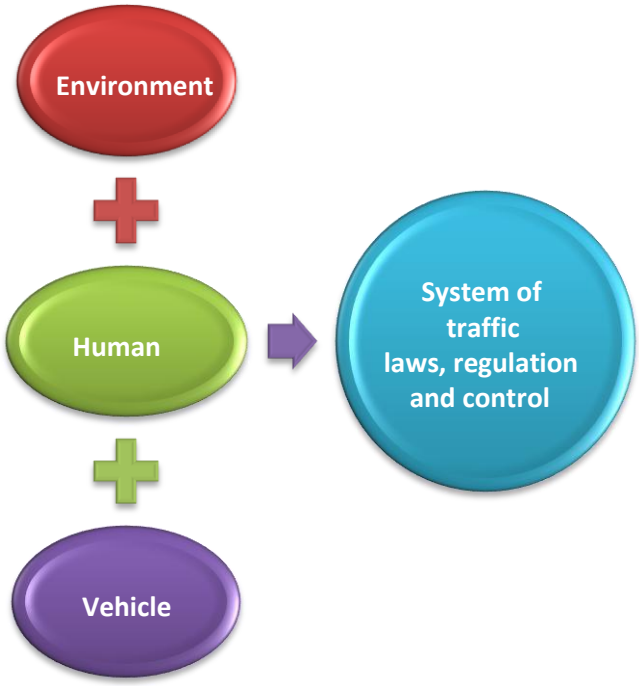

Figure 3 RTA as a public health concern [10]

Considering the Ethiopian case, according to the road safety report reported by united nation and according to the police reports, more than 90 percent of the traffic accidents are caused by human errors. Of these accidents, drivers are indicated as responsible causes in about 8 to 9

percent. Table 1 shows the causes of road traffic accidents as identified during police investigation.

Table 1 Road Safety Report on Cause of Road Traffic Accident in Ethiopia [10].

Causes of road traffic accident	Degree of severity					
	Fatal	Serious injury	Slight injury	Property damage	Total	% age
Influence of alcohol	51	7	17	193	268	2
Failure to respect right hand rule	110	129	131	856	1226	8
Failure to give a way for vehicles	20	65	112	1507	1704	11
Failure to give a way for pedestrian	598	661	728	2058	4045	27
Following too closely	39	77	69	161	346	2
Improper overtaking	44	52	78	547	721	5
Improper turning	37	71	98	1317	1523	10
Over speeding	426	436	295	852	2009	13
Failure to respect traffic signs	16	27	11	123	177	1
Driving with fatigue	30	20	20	23	93	1
Driving without attention	10	18	15	9	52	0
Improper parking	52	62	81	772	967	6
Excess loading	76	135	88	43	342	2
Failure in vehicles	79	73	110	171	433	3
Defective road environment	12	13	19	62	106	1
Pedestrian error	34	164	29	17	244	2
Others	81	81	162	240	564	4
Unidentified	87	65	60	54	266	2
Total	1802	2156	2123	9005	15086	100

2.2.1 Human factors of road traffic accident

Human factors causing accidents are factors that contribute to an accident and are directly attributable to the operator, worker, or personnel involved in an accident.

The human factors include but also go beyond willful violations of safety rules or blatantly engaging in risky behavior. They include factors such as inattention, fatigue, and impairment from drugs or alcohol.

It is important to consider and assess the human factors when investigating an accident. But this by no means condones or advocates placing blame on the workers. Many of the human factors causing accidents are not willful behaviors.

Human factors are responsible for large number of accidents that occur in a workplace. The following human factors are common causes of accidents:

- ⇨ Memory lapses (including forgetting a step in the work process or a safety measure)
- ⇨ Impaired judgment or reduced reasoning power
- ⇨ Inattention or distraction
- ⇨ Delayed or false sensation of the sensory organs
- ⇨ Lack of competence and experience
- ⇨ Skill level inadequate for the task performed
- ⇨ Personality or attitude, such as negligence, arrogance, or overconfidence
- ⇨ Poor risk perception due to poor knowledge and experience

Road traffic accidents caused by human factors may be prevented or reduced by implementing the following preventative measures:

- ➢ Training and awareness
- ➢ Supervision, monitoring, and controlling
- ➢ Feedback and reports
- ➢ Frequent inspections and audits
- ➢ Skill development
- ➢ Education

While considering the researches undertaken, the common behavior of humans which results in road traffic accident points are: -

A) Over Speeding

Most of the fatal accidents occur due to over speeding. It is a natural psyche of humans to excel. If given a chance man is sure to achieve infinity in speed. But when we are sharing the road with other users, we will always remain behind some or another vehicle. Increase in speed multiplies the risk of accident and severity of injury during accident. Faster vehicles are more prone to accident than the slower one and the severity of accident will also be more in case of faster and also the severity of accident will also be more in case of faster vehicles. At high speed the vehicle needs greater distance to stop i.e. braking distance. A slower vehicle comes to halt immediately while faster one takes long way to stop and also skids a long distance due to law of notion. A vehicle moving on high speed will have greater impact during the crash and hence will cause more injuries [14].

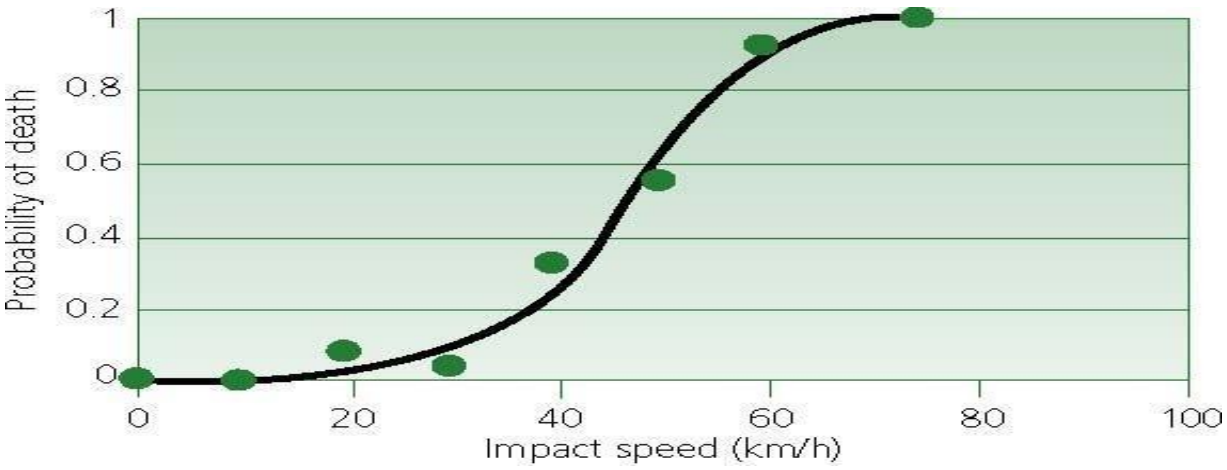

Figure 4 Impact speed and probability of death relation [14]

B) **Drunken**

Driving Consumption of alcohol to celebrate any occasion is common. But when mixed with driving it turns celebration into a misfortune. Alcohol reduces concentration. It decreases reaction time of a human body. Limbs take more to react to the instructions of brain. It hampers vision due to dizziness. Alcohol dampens fear and incites humans to take risks. All these

factors while driving cause accidents and many times it proves fatal. For every increase of 0.05blood alcohol concentration, the risk of accident doubles [15].

C) **Distraction to driver**

Though distraction while driving could be minor, but it can cause major accidents. Distractions could be outside or inside the vehicle. The major distraction now a day is talking on mobile phone while driving. Act of talking on phone occupies major portion of brain and the smaller Part handles the driving skills. This division of brain hampers reaction time and ability of judgment. This becomes one of the reasons of crashes.

D) **Avoiding safety gears like seat belts and helmets:**

Use of seat belt in four-wheeler is now mandatory and not wearing seat belt invites penalty, same in the case of helmets for two-wheeler drivers. Wearing seat belts and helmet has been brought under law after proven studies that these two things reduce the severity of injury during accidents. Wearing seat belts and helmets doubles the chances of survival in a serious accident. Safety Gears keep you intact and safe in case of accidents.

Table 2 Contributory Factors in Road Traffic Accident Occurrence in UK [15]

Contributory factors reported in accident				
	Fatal (%)	**Serious (%)**	**Slight (%)**	**All accidents (%)**
Driver/rider error	65.3	61.8	68.6	67.5
Injudicious action	31.4	25	26.1	26
Behavior or inexperience	28	25.8	24.4	24.7
Road environment	10.9	13.3	15.6	15.1
pedestrian only	18.2	20.4	11.5	13
Impairment or distraction	19.6	14.2	11.1	11.7
Vision affected	7.5	9.2	10.5	10.3
Special code	6.1	5.2	4.5	4.6
Vehicle defect	2.8	2.2	1.9	1.9

2.2.2 Road and environmental factors of road traffic accident

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 countermeasure.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) ,The location and spacing of signs are appropriately done: that is, they are placed at the required locations, That traffic signs are clearly visible and are prominently displayed to the intended road users, For instances where the legibility of the information on traffic 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 reflectorizing, 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.

G. General traffic management items

The degree of safety afforded to pedestrians, particularly school children, and record instances where there is a need for special provisions to be made will be primarily checked. In connection to this, the adequacy and credibility of existing speed limits and comment if they are not appropriate to the traffic situation and the nature of abutting development or are otherwise unrealistic in the view of most motorists will be taken into consideration. The effectiveness of speed limit signing: consider the need for more prominent signing of the start of "restricted" speed zones and for "reminder signs" within the speed zone, particularly near intersections where large numbers of vehicles enter the road in question from side roads. Substandard curves and low speed curved sections of the road; consider the need for "positive" advice to motorists about the safe travel speed and consider the need for "advisory curve speed" signing. The need

at substandard curves, for other delineation improvements such as the provision of "guidepost" delineation, and the use of retro reflective road studs. The degree of safety afforded to all road users in town centers, particularly where highways pass through shopping centers or near schools, record the need for "traffic calming" techniques to improve safety in these sensitive locations. The availability of overtaking opportunities along the route as a whole and comment on the need of specific "overtaking lanes" at regular intervals along two-lane undivided roads, particularly where traffic flows are high in hilly terrain.

2.2.3 Vehicle factors of road traffic accident

Vehicle factor can be divided into vehicle design and vehicle maintenance. Some safety features of vehicles like seatbelts and airbags are likely to reduce the risk of death and serious injuries. A well-designed and maintained vehicle is less likely to be involved in accidents. If the brakes and tires are good and the suspension well-adjusted, the vehicle is more controllable in an emergency and thus, better equipped to avoid accidents.

2.3 Definitions of road traffic accident black spots

Although, no universally accepted definition of a black spot or black zone is given, these locations will in general be described as high-risk accident locations. One of the definitions for highway accident black spots is 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 [16].

Thus, identification of black spot is a key for the whole component of the process in attaining the safety of road users. The correct location for the occurrence of accident black spot must be properly identified. And this stage is an important stage 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 also, different manuals prepared which guides for the identification of RTA black spots. But the problem or limitation is the manuals are

prepared based on the standards of the countries and defines their own criteria for the locations of the accident spots.

One of the methods used for the identification of RTA 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 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 accidents happened within 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 in accurate because the section length is fixed where accidents within each section may be related to each other.

All Methods discussed in the above sections use 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 RTA 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 RTA 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.

As it is known most of the developing countries record crash data's by using manual method. Thus, the opportunity of using modern applicable data base system for the analysis will be limited. In different countries there are different criteria for the analysis and identification of RTA black spots. For instance in Australia at least 3 causality crushes in 3 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 RTA hazardous locations.

In Ethiopia there are also researches conducted related to the identification of RTA black spots. One of these researches is conducted on Addis Ababa-Shashemene road for the identification of RTA black spots with their causes and proposing law 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 off pedestrian traffic, driver's fatigue's, lack of awareness of traffic rules and finally proposed low cost engineering solutions to improve the safety of the road [17].

Comparison between Black Spot Identification Methods

First and for all there is no integrated crash, accident and road traffic accident data in Ethiopia, and in connection to this when the road under consideration is assessed, the road traffic accident 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.

On this portion we try to give a better understanding for investigation of black spot location and improvement ways. Now the most commonly used steps of black spot improvement process are the following.

Figure 5 Black spot identification systematic process and procedure [15]

To determine the most dangerous accident sites, the Flemish government analyses the road traffic accident data that are obtained from the Analysis form for Traffic Accidents, this form should be filled out by a police officer for each road traffic accident that occurs with injured or deadly wounded casualties on a public road.

Based on these data, the following criterion is used. First, each site where in the last three years three 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

2.4 Road Safety Audit

In an effort to reduce the number of crash-related fatalities and incapacitating injuries, the issue of road Safety is to Develop, promote, implement, and evaluate data-driven, multidisciplinary strategies to maximize safety for users of the roadway system. One of the many strategies noted in the current Safety Plan is to conduct Road Safety Audits (RSA). A road safety audit is a formal examination of proposed or existing roads and road related areas from the perspective

of all road users with the intention of identifying road safety deficiencies and areas of risk that could lead to road crashes. It is conducted by an independent, qualified team of professionals.

For the purpose of road safety auditing, projects fall into three distinct categories. A project is either in the preconstruction phase of its life cycle, in the construction phase of its life cycle or in the post-construction phase of its life cycle. These phases are further divided into the key life cycle stages of the project: strategic design, concept design, detailed design, road works, pre-opening, finalization and existing road. Road safety audits are typically conducted at these key life cycle stages of a project. The types of road safety audits therefore reflect these key stages.

2.4.1 The objectives of the road safety auditing process are:

- To minimize the severity and crash risk of road traffic crashes that may be influenced by the road facility or adjacent environment.
- To minimize the need for remedial measures after the opening of a new road project.
- To reduce the full life-cycle cost of a road project by reducing its crash cost.
- To create and maintain an awareness of safe design practice during all stages of a road project.

2.4.2 The benefits of road safety audits

Road safety auditing is a recognized crash prevention road safety tool that has the following benefits: [18]

1. A reduction in the likelihood of crashes on the road network.
2. A reduction in the severity of crashes on the road network.
3. An increased awareness of safe design practices among traffic engineers and road designers.
4. A reduction in the need to modify projects after they are built.
5. A reduction in the life-cycle cost of a road.
6. A more uniform road environment that is more easily understood by road users.
7. A better understanding and documentation of road safety engineering.
8. Eventual safety improvements to standards and procedures.
9. More explicit consideration of the safety needs of vulnerable road users.

2.5 Systematic process of road traffic accident countermeasures

Road traffic deaths and serious injuries are to a great extent preventable, since the risk of incurring injury in a crash is largely predictable and many countermeasures, proven to be effective, exist. Road traffic injury needs to be considered alongside heart disease, cancer and stroke as a preventable public health problem that responds well to targeted interventions.

The provision of safe, sustainable and affordable means of travel is a key objective in the planning and design of road traffic systems. To achieve it requires firm political will, and an integrated approach involving close collaboration of many sectors, in which the health sector plays a full and active role. In such a systems-based approach, it is possible at the same time to tackle other major problems associated with road traffic, such as congestion, noise emission, air pollution and lack of physical exercise.

Progress is being made in many parts of the world where multi sectorial strategic plans are leading to incremental reductions in the number of road deaths and injuries. Such strategies address the three prime elements of the traffic system vehicles, road users and the road infrastructure. Vehicle and road engineering measures need to take into account the safety needs and physical limitations of road users. Vehicle technology needs to consider roadside equipment. Measures involving the road infrastructure must be compatible with the characteristics of vehicles. Vehicle measures should be complemented by appropriate behavior on the part of road users, such as wearing seat-belts. In all these strategies, managing speed is a fundamental factor.

Providing shorter, safer routes

In an efficient road network, exposure to crash risk can be minimized by ensuring that trips are short and routes direct, and that the quickest routes are also the safest routes. Route management techniques can achieve these objectives by decreasing travel times on desired routes, increasing travel times on undesired routes, and re-directing traffic. Having to take a detour in a car means that extra fuel will be used, but for pedestrians it means extra physical exertion. There is thus a strong incentive to find the easiest and most direct route. Studies have, in fact, shown that pedestrians and cyclists place a higher value on journey time than do drivers or those using public transport – a finding that should be reflected in planning decisions.

Trip reduction measures

It has been estimated from studies in high-income countries that, under certain conditions, for each 1% reduction in motor vehicle distance travelled, there is a corresponding 1.4–1.8% reduction in the incidence of crashes.

Encouraging use of safer modes of travel

Whether measured by the time spent travelling or by the number of trips, travel by bus and train is many times safer than any other mode of road travel. Policies that stimulate the use of public transport, and its combination with walking and cycling, are thus to be encouraged. While the walking and cycling parts of journeys bear relatively high risks, pedestrians and cyclists create less risk for other road users than do motor vehicles. However, by implementing known safety measures, it should be possible to achieve a growth in healthier forms of travel, such as walking and cycling, and at the same time reduce the incidence of deaths and injuries among pedestrians and cyclists. These are goals that are increasingly being adopted in national transport policies in high-income countries.

Giving priority in the road network to higher occupancy vehicles

Giving vehicles with many occupants priority in traffic over those with few occupants is a means of reducing the overall distance travelled by private motorized transport and hence of cutting down on exposure to risk. This strategy is adopted by many cities worldwide. For example, the high-capacity bus system in the city of Brazil, provides segregated bus lanes, priority at traffic lights for buses, as well as safe and fast access for users.

Restrictions on speed and engine performance of motorized two-wheelers

Many high-income countries have introduced regulations relating to speed and engine performance for motorcycles, with the aim of reducing rates of crashes and injury.

Shaping the road network for road injury prevention

Road safety considerations are central to the planning, design and operation of the road network. By adjusting the design of the road and road networks to accommodate human characteristics and to be more "forgiving" if an error is made, road safety engineering strategies can make a major contribution to road injury prevention and mitigation.

Classifying roads and setting speed limits by their function

Many roads have a range of functions, and are used by different types of vehicles and by pedestrians – with large differences in speed, mass of vehicle and degree of protection. In residential areas and on urban roads this often leads to conflicts between the mobility of motor vehicle users on the one hand and the safety of pedestrians and cyclists on the other. Most pedestrian crashes occur within one mile (1.6 km) of the victim's home or place of business.

Incorporating safety features into road design

A key objective of safety engineering is to make drivers naturally choose to comply with the speed limit. Through the use of self-explanatory road layouts, engineering can lead to safer road user behavior, as well as correcting defects in road design that otherwise may lead to crashes. The following description of different types of roads illustrates the relationship between road function, road speed and road design.

Traffic-calming measures

At speeds below 30 km/h pedestrians can coexist with motor vehicles in relative safety. Speed management and traffic-calming include techniques such as discouraging traffic from entering certain areas and installing physical speed-reducing measures, such as roundabouts, road narrowing, chicanes and road humps. These measures are often backed up by speed limits of 30 km/h, but they can be designed to achieve various levels of appropriate speed.

Safety audits

When new transport projects are proposed, area wide safety impact assessments are needed to ensure the proposals do not have an adverse safety impact on the surrounding network. Road safety audits are then required to check that the proposed design and implementation are

consistent with safety principles, and to examine whether further design changes are needed to prevent crashes.

An essential element of the audit process is that it should be carried out separately by both an independent design team, and a team with experience and expertise in road safety engineering and crash investigation. Guidelines for safety audits have been developed in many parts of the world, including Malaysia.

Formal safety audit procedures have been shown to be effective and cost-effective ways of improving road safety and reducing the long-term costs associated with a new road scheme. Mandatory safety audit procedures have existed in a number of countries including Australia, Denmark, New Zealand and the United Kingdom for several years. In New Zealand, it has been estimated that the procedures carry a cost–benefit ratio of 1:20. A Danish study assessed the value in cost–benefit terms of 13 schemes and found first year rates of return of well over 100%.

Crash-protective roadsides

Collisions between vehicles leaving the road and roadside objects including trees, poles and road signs, often of very high mass, are a major road safety problem worldwide. Research that built on work by the Organization for Economic Cooperation and Development in 1975 suggests that existing strategies to tackle the problem of roadside objects would be strengthened by:

- designing roads without dangerous roadside objects
- Introducing a clear zone at the side of the road
- designing roadside objects so that they are more “forgiving”
- protecting roadside objects with barriers to absorb part of the impact energy
- protecting vehicle occupants from the consequences of collisions with roadside objects, through better vehicle design

Collapsible lighting columns and other devices that break away on impact were first introduced in the United States in the 1970s and are now used widely throughout the world. These objects are either mounted on shear bolts, or else are constructed of a deformable, yielding material.

Slip base poles break away at the base when struck by a vehicle and include special provisions to ensure electrical safety. Early research conducted in the United States indicated that break-away columns could result in reductions in injuries of around 30%.

Safety barriers are frequently used to separate traffic or to prevent it from leaving the road. They are designed to deflect or contain the striking vehicle while ensuring that the forces involved do not result in serious injury to occupants of the vehicle. If properly installed and in the appropriate places, safety barriers can be effective in reducing the incidence of crashes, their severity and their consequences. Crash research has highlighted the need for more effective linkages between vehicle protection standards and standards for safety barriers, which take into account the range of vehicles – from small cars to heavy trucks that are likely to make use of them.

2.6 Summary

There are different researches done that evaluate road traffic accident causes at hazardous locations by making accident prone location identifications after making necessary traffic data analysis. The general accident statistics related to trucks can be used in the investigation of the high-accident locations to identify factors which may be contributing to the accident problem. The combined effects of sharp horizontal radius, higher super elevation and poor visibility tends to increase the accident frequency and provide very high accident rate on the model.

Besides making the identification of accident-prone location and analyze of road traffic accident causes, researches has forwarded the following countermeasures. If the case of sharper horizontal curves cannot be avoided, countermeasures such as warning signs can be used. Widening and improving clear zones is an alternative countermeasure, which also helps to reduce run-off-road crashes. This may include flattening side slopes, removal of roadside obstacles and increasing available stopping distance adjacent to the road. As identified in this study, geometric changes such as horizontal alignments decrease truck crash frequency. Geometric alternations may be considered when other less costly countermeasures are not effective.

CHAPTER THREE

MATERIALS AND RESEARCH METHODOLOGY

3.1 Study Area

The study carried out in the Bedele to Dedesa River found in the south western part of Ethiopia, which is specifically under Buno Bedele zone, oromia region state.

Bedele town is separate town in south-western Ethiopia. Located in the Buno Bedelle Zone of the Oromia Region, this town has a longitude and latitude of 8°27′N 36°21′E and an elevation between 2,012–2,162 meters (6,601–7,093 ft) above sea level. In winter there is much less rainfall than in summer. The average temperature in Bedele is 18.4 °C. About 1850 mm of precipitation falls annually. In addition, Didesa is one of a river tributaries of the Abay River. Bedele Zone is bordered on the East by the Didesa River which separates it from the Jimma Zone. Under this study Didesa River is a river on Jimma-Bedele road segment. The total length of the road under consideration is 82km.

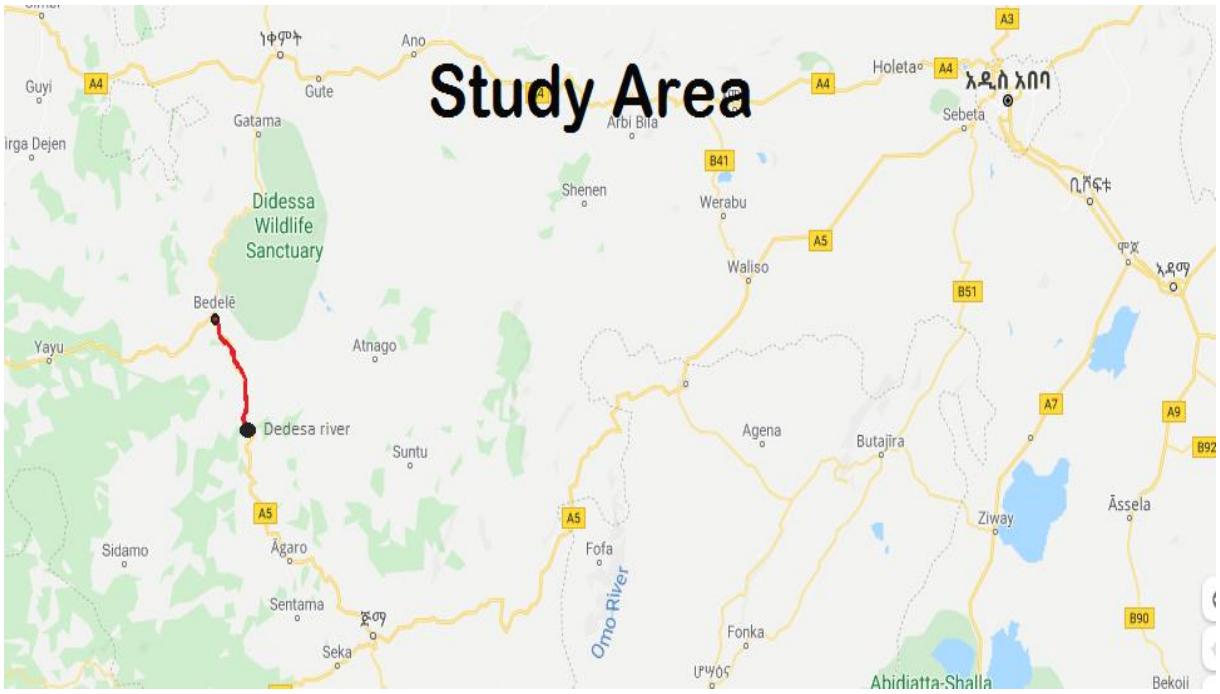

Figure 6 Google Map of Bedele to Dedesa River

The road passes through major towns of Bedele, Denbi, Yenbero and Gechi. Therefore, the output of this research is important for this region and Ethiopia in general.

3.2 Study variables

3.2.1 Independent variables

- General characteristics of road traffic accident
- Black spot location
- Causes of road traffic accident
    - Road and environmental factors
    - Curve geometry (Horizontal radius (R), Gradient and Middle ordinate (M))

3.2.2 Dependent variables

- Road traffic accident.

3.3 Population and Sources of Data

The populations taken for this study were the road traffic accident data, as built drawing of the road and the road safety inspection report. Random sampling was used for interview in the study area. Next, high road traffic accident potential areas have been selected using historic road traffic accident data by priority value. Therefore, the center of interest or the principal sites were the black spot locations for further detailed investigation, then the road safety audit and comparison to ERA standard requirement were made, finally countermeasure was applied.

3.4 Study Design

The study design used in this study was case study and field-based research design. The data type used was both primary data (road safety audit using ERA manual, photograph of black spot location and observation) and secondary data of analysis (Road traffic accident data, interview, ERA manual and Design document).

The procedure of this study described as follows: Review related literatures on relevant areas of accident and other related discussions. Includes the basic manuals, hand books, hand notes, magazines, journals, dictionaries, standards, specification and codes of practice.

The first step was conducted as collecting the road traffic accident data. This involved the gathering together all types of accident data from the respective Wereda police office.

The second step was conducted at ERA head office, Addis Ababa to obtain data from the as

built plan.

The third step was observation and interview by taking photos of materials used in road safety audit for the black spot. The site visits involved observations where the researcher wanted to find out the major causes of road traffic accident.

Analysis was made from the site observations, interview, from desk reviews and from the road safety audit, discussion was made after proper comparison of the results. Then, conclusion and recommendation were made from the results.

3.5 Data Collection Procedure

The road under study is Bedele to Dedesa River asphalt road project. Its functional classification is categorized under trunk road. This road project corridor touches different small town of Buno Bedele zone under Oromia Regional State.

Road traffic accident data reports has been collected from respective traffic offices. As built drawing is taken from ERA office. After completing black spot identification, interview and site inspection has been done in order to know prevailing condition at the sites. This are the steps followed to collect data used on this research. In order to conduct road safety inspection, check list was prepared based on ERA road safety audit manual the checklist included the following items.

1. Vertical and Horizontal Alignment
2. Cross-Section
3. Intersections
4. General Layout Features
5. Roadside Safety and Landscaping
6. General Traffic Management Items

The secondary data used were the traffic accident data collected from respective police stations found in each Woreda 24hr road traffic accident records. The data applied for study were the accident data from 2015-2017. Information Recorded on 24hr traffic accident report were:

1) Time at which the accident happened
2) Date, Year at which the accident happened
3) Location at which the accident happened

4) Type of accident involved in the accident

5) Number of victims involved in the accidents

6) Type of vehicle involved in the accident

7) Information about the driver

8) Accident quantified in birr (ETB)

9) Information about the investigator

10) Cause of accident

3.6 Method of Analysis

Accordingly, both qualitative and quantitative method of data analysis were used. Three years of road traffic accident data was collected. First the road traffic accident data was stratified, then road traffic accident were characterized, ranked and related. The following form was prepared in order to record the road traffic accident data.

- Time at which the accident happened
- Type of accident involved
- Drivers age
- Type of vehicle involved in the accident
- Cause of accident

Additionally, interview was made, Flemish government formula was used in order to identify the black spot location, based on the data, and the following criterion was applied. First, every site within the last three years three or more accidents have occurred was selected. Then, a site was considered to be dangerous when its priority value (P), calculated using the formula equals fifteen or more.

The next step was comparison with ERA manual requirement and preparation of road safety audit inspection checklist to provide countermeasures at black spot locations. Checklist for site inspection prepared using ERA road safety audit manual.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 General Characteristics of RTA on Bedele to Dedesa River (2015-2017 G.C)

Total of 347 road traffic accidents happened on the road from Bedele to Dedesa River, this accident includes fatal, injury and property damage accidents. Figure 7 shows the point of time together with number of accidents and the percentage of accidents for both weredas. Then next in Figure 8. 44.95% of road traffic accidents happened in Gechi Wereda, 55.04% in Denbi Wereda.

The road traffic accident data numerically shows that there were 12, 16 and 25 fatal accident in 2015, 2016 and 2017 respectively. In the same year it was recorded to have 29, 39 and 36 for injury in those respective years. In addition to this the piece of evidence about the past specific years gave 65, 54 and 71 for property damage only accordingly.

Those lists of noticeable evidences and data make it open that all types of accidents, fatal, injury and property damage, has been increasing from time to time. Unless and otherwise immediate countermeasures take place, the records at hand points directly that the case will possibly become greater in the future to come.

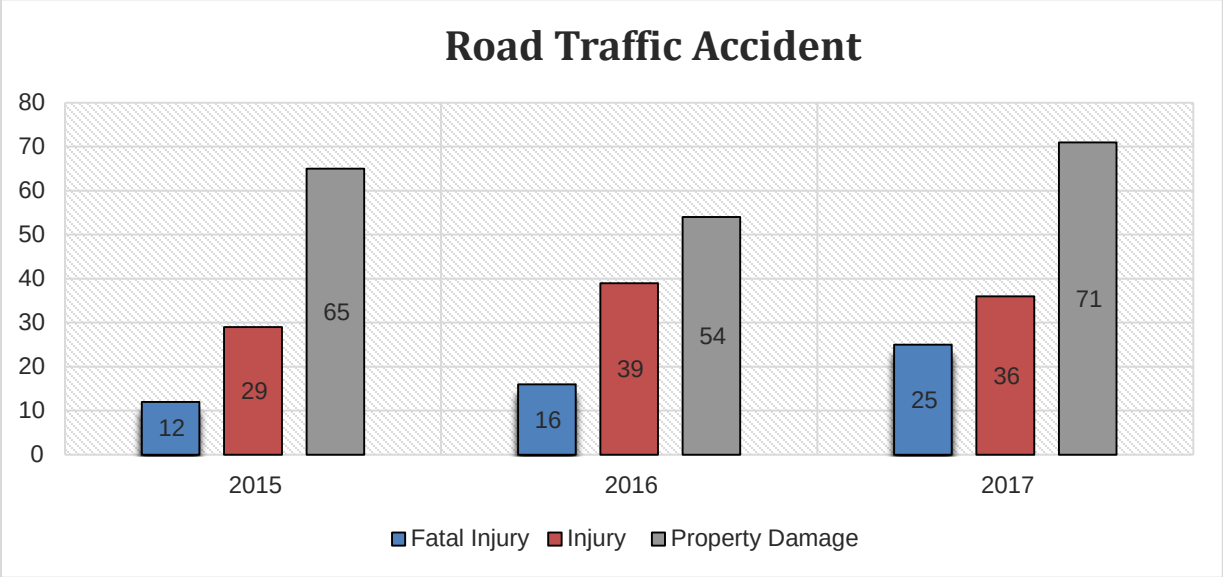

Figure 7 Road Traffic Accident Occurred (2015-2017G.C)

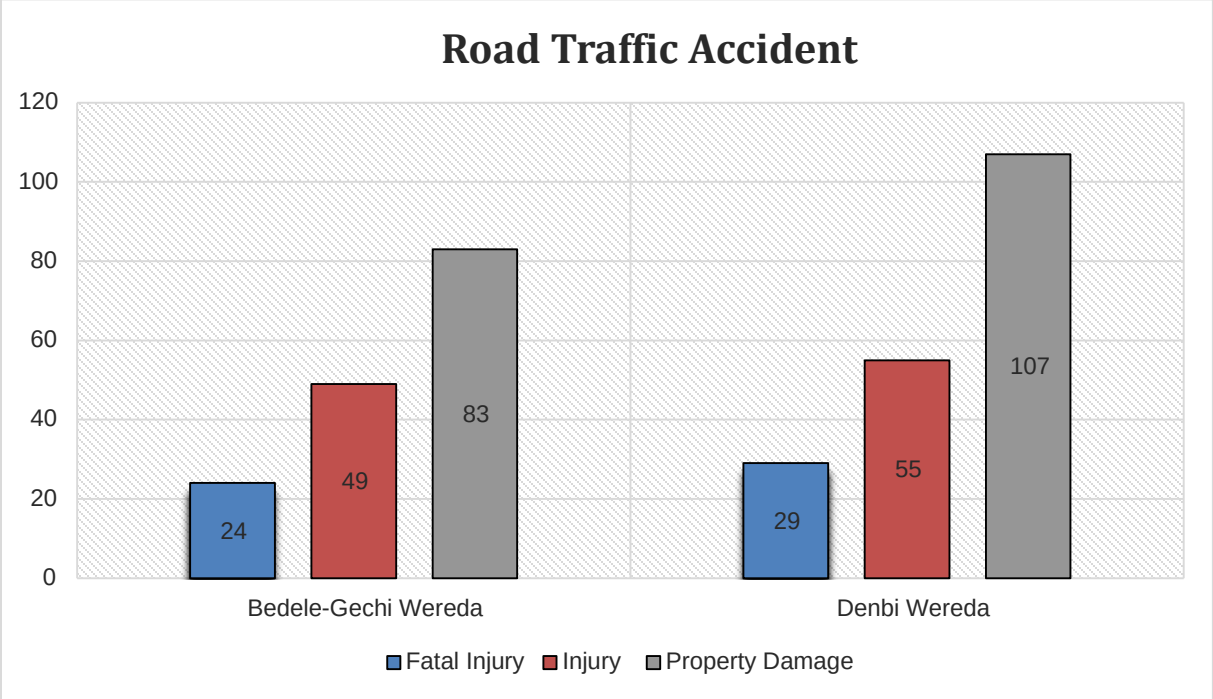

Figure 8 Road Traffic Accident Occurred in Bedele-Gechi & Denbi (2015-2017G.C)

4.1.1. The Major Causes on the Occurrence of RTA

a. Accident time

Table 3 shows the time with the road traffic accidents. According to the traffic police reported data majority of the accidents happened during day time, specifically in the morning, which is 36.31% from 7:00-12:00AM. The highest number of accidents happened during this duration.

Generally, it is very clear the actual meaning from the road traffic accident, the fact that during 7:00-12:00AM morning there is a high situation involving exposure to danger in to road traffic accident. It can make anyone become aware or give due regard concerning traveling in not the same as another duration puts in different extent to accident. Additionally, there is also a second-high risk of road traffic accident during 1:00-6:00PM

In addition, also the traffic report shows majority of the road traffic accidents occurred on Tuesday, which is the major market day of the week. The significant road traffic accident was

found to encounter on this specific day. This showed there was a high probability of road traffic accident on Tuesday.

Table3 Duration with RTA (2015-2017)

Duration	Death	Injury	PDO	Total	Percentage
1:00-6:00AM	8	13	33	54	15.56
7:00-12:00AM	21	41	64	126	36.31
1:00-6:00PM	11	29	52	92	26.5
7:00-12:00PM	13	21	41	75	21.6
Total				347	100

Table4 Days with RTA (2015-2017)

Duration	Death	Injury	PDO	Total	Percentage
Sunday	9	15	28	52	14.99
Monday	11	14	25	50	14.41
Tuesday	16	19	35	70	20.17
Wednesday	8	11	32	51	14.70
Thursday	8	14	15	37	10.66
Friday	6	12	18	36	10.37
Saturday	13	19	19	51	14.70
Total				347	100

b. Driver age group

Table 5 shows the age group of the drivers with the road traffic accident occurrence. Drivers Age range from 31-40 caused the largest number of road traffic accidents totally (30.55%) on the road from Bedele to Dedesa River. The second highest age group for road traffic accident was 21-30 (27.95%). Therefore, this shows the early stage of life was suspected to cause the highest road traffic accidents. Therefore, a serious attention should be given to this age group.

The road traffic accident rate of drivers ages 31-40 years was nearly double that of drivers ages 40-50, triple to that of age<20 and 51-60 then approximately 6 times that of drivers age>60. Of the total cases, the majority had been recorded the youth for road traffic accident while driving, in all people had succumbed in the last three years in the limits for failing to adhere to the road safety norms, most especially the young age groups.

Table 5 Age Group with RTA (2015-2017)

Duration	Death	Injury	PDO	Total	Percentage
Age<20	1	6	25	32	9.22
21-30	13	30	54	97	27.95
31-40	18	39	49	106	30.55
41-50	12	21	24	57	16.42
51-60	5	5	27	37	10.66
Age>60	4	3	11	18	5.19
Total				347	100

c. Vehicle type

Figure 9 shows that basic vehicle type with type of road traffic accident on the road from Bedele to Dedesa. This explains which vehicle had caused the majority of the road traffic accidents. Therefore, based on the general fact concerning this issue greatly assist the way for a scientific solution.

The aim of this specific study portion is to investigate of road traffic accident per vehicle type. The higher in speed showed increased the risk of road traffic. Smaller and faster vehicles had a higher tendency or inclination to road traffic accident than the slower one. 43.23% of all the road traffic accidents in the study period was caused by passenger cars. Therefore, it needs careful observation and systematic examination concerning these vehicle type.

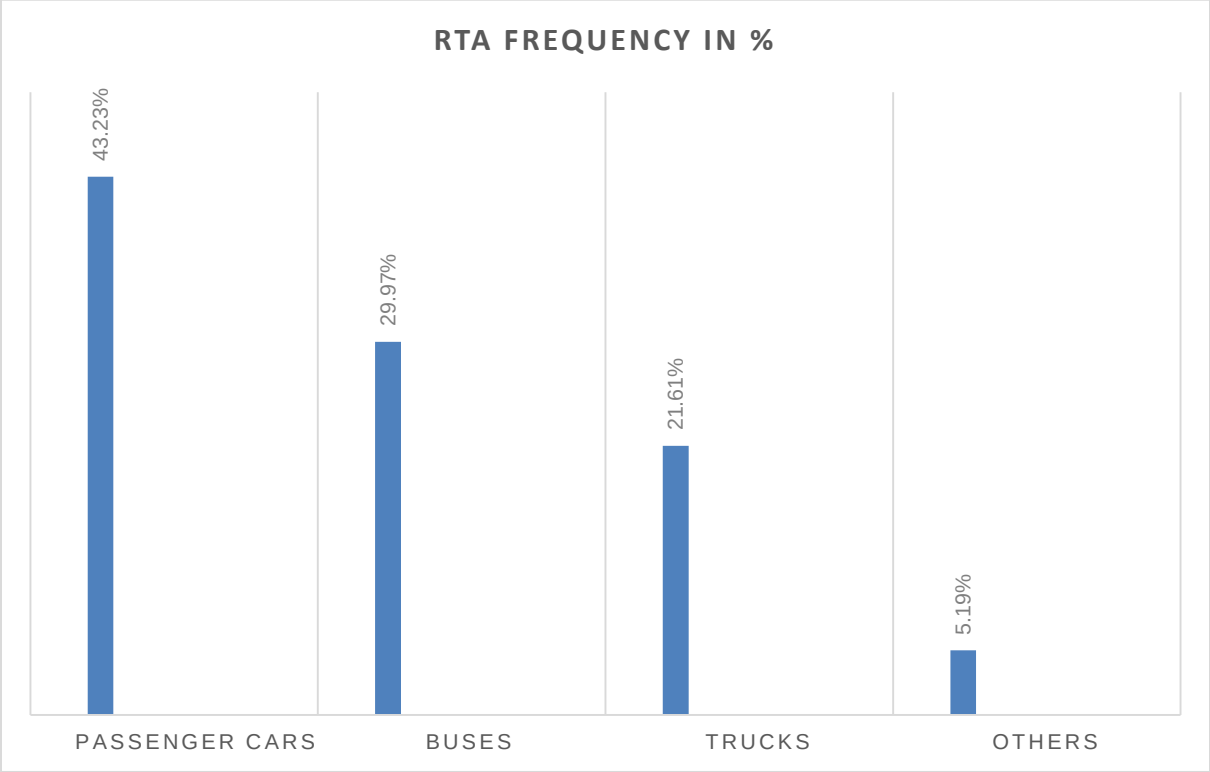

Figure 9 Vehicle Type with RTA (2015-2017)

d. Causes of RTA

Table 6 shows that cause of road traffic accident in relation to type of accident on the road from Bedele to Dedesa. Most of the fatal road traffic accidents occur due to over speeding (22.19%). The secondary road traffic cause was due to improper over turning (16.71%) and the third went to driving without attention (10.09%).

Road accident is the most unwanted thing to happen to a road user, though they happen quite often. The most unfortunate thing is that we don't learn from our mistakes on road. Most of the road users are quite well aware of the general rules and safety measures while using roads but it is only the laxity on part of road users, which cause road traffic accident [14].

Table 6 Cause of RTA (2015-2017)

Cause of Accident	Fatal Injury		Injury		PDO		Total	%
	No.	%	No.	%	No.	%		
Over speeding	19	35.85%	26	25.00%	32	16.84%	77	22.19%
Driving without attention	5	9.43%	11	10.58%	19	10.00%	35	10.09%
Failure Priority to Pedestrians	2	3.77%	7	6.73%	14	7.37%	23	6.63%
Following too closely	2	3.77%	9	8.65%	16	8.42%	27	7.78%
Failure in vehicle	3	5.66%	6	5.77%	9	4.74%	18	5.19%
Influence of alcohol or drug	4	7.55%	8	7.69%	17	8.95%	29	8.36%
Improper Turning in curves	8	15.09%	21	20.19%	29	15.26%	58	16.71%
Failure to respect Traffic sign	2	3.77%	4	3.85%	11	5.79%	17	4.90%
Improper overtaking	3	5.66%	7	6.73%	14	7.37%	24	6.92%
Excess Loading	3	5.66%	4	3.85%	22	11.58%	29	8.36%
Others	2	3.77%	1	0.96%	7	3.68%	10	2.88%
Total	53	100%	104	100.00%	190	100.00%	347	100%

e. Analysis of property damage only

Figure 10 showed the incurred amount for this study period. As estimated by traffic police officers, a total amount of money 171,117,000.00birr property has been damaged from 2015 to 2017 on Bedele to Dedesa road. This cost has been increasing from time to time. Therefore, this greatly affects the economy of both the region and the country as a whole.

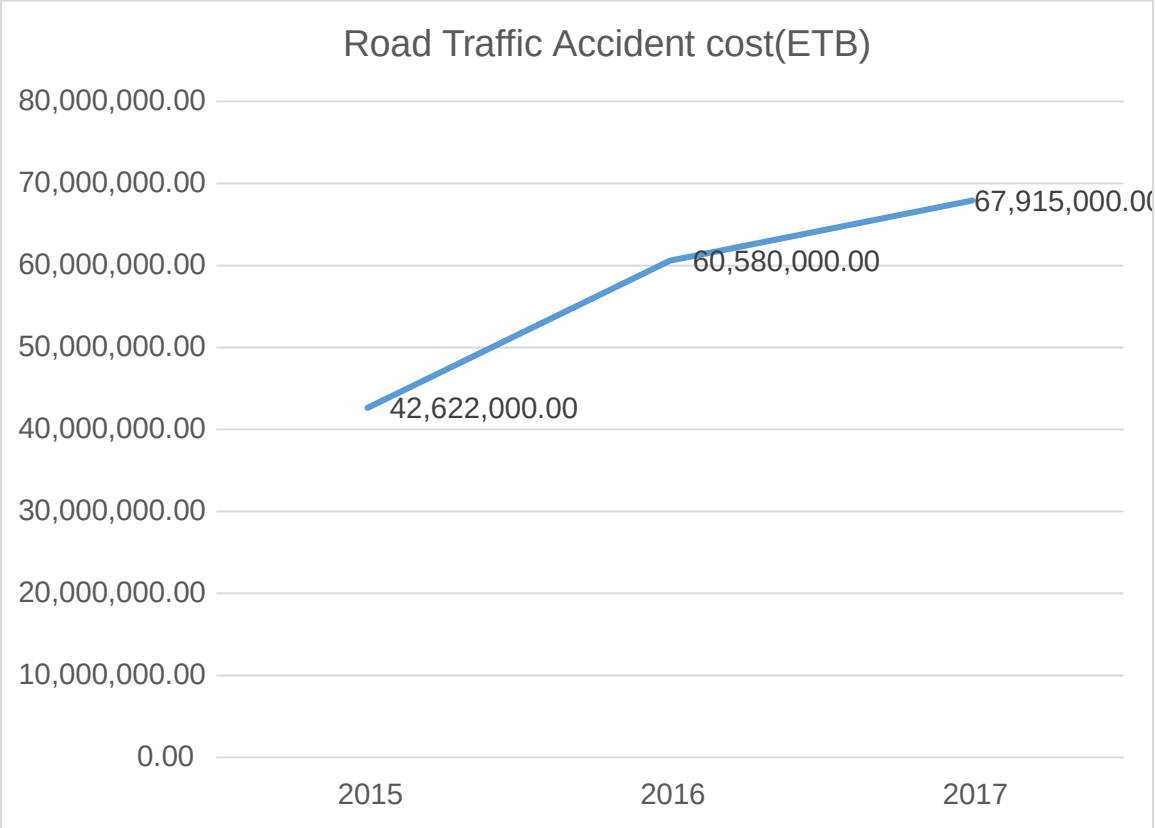

Figure 10 Road Traffic Accident Cost (2015-2017)

4.1.2. Summary of Road Traffic Accidents on Road from Bedele to Dedesa River

Most of the accidents happened during day time, which is from 7:00-12AM (morning). This shows those hours listed above needs special care and consideration. The facts and statistics used for reference and analysis cause to be visible the need of solving this problem.

Drivers Age range from 21-40 causes the highest and majority number of road traffic accidents totally (58.5%) on the road from Bedele to Dedesa. So that this shows the young age is suspected to highest cause of road traffic accidents on this road and special focus should be given to this young age. Causing the specific age group on normal state or conditions by orderliness of thought or behavior can significantly make the rate of all kind of accidents smaller.

It shows that most of the accidents happened were due to all type of passenger cars (43.23%) and next to that Buses (29.9%) got the second rank. Due to this special focus should be given towards these vehicles. Studying the phenomena of those types of vehicles in detail possibly minimizes the rate of road traffic accident.

Which explains that greater majority of the road traffic accidents occurred due to human factors mainly over speeding (22.19%), improper turning in curves (16.71%) and driving without attention (10.09%). In combination with vehicle factor. Greater extent of consideration must be given to avoid and minimize the rate of road traffic accident to these circumstances.

4.2 Analysis of interview and questionnaire

A total of 52 questionnaires were distributed equally for drivers and pedestrian. 49 questionnaires were returned back with complete answer for each question and the rest had gaps that were filled by interview, different drivers and pedestrian. On the other hand, to full fill the gap of population which is not returns the questionnaire form, the study conducted an interview for the pedestrian and driver to full fill this gap.

a. Questionnaire response for pedestrians

Generally, the questionnaire submitted from the pedestrians pointed and defined the main influential possible causes for road traffic accident. This can guide for real solution and recommendation that can reduce this huge problem at hand.

Most of the road users concluded they are not following traffic regulations. In addition, majority of the road traffic accident occurs in is because of drivers do not give priority to pedestrians and over speeding. Moreover, there is no evidence that shows major road traffic accident happened due to vehicle failure.

Furthermore, the pedestrians altogether concluded there is a variety structural problem on this road section. Finally, most of all defined traffic rules and regulations can significantly reduce road traffic accident.

Table 7 Questionnaire for pedestrian

Item	Questionnaire for pedestrian	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	Do you Agree the amount of road traffic accident in Bedele-Dedesa is greater compare to other section of roads?	5	12	26	4	2
2	Do you Agree you and other pedestrian follow the traffic regulations like crossing road using on zebra crossing to protect from road traffic accident in the area?	31	7	6	3	2
3	Do you Agree most of the road traffic accident occurs in Bedele-Dedesa is b/c of drivers do not give a priority to a pedestrian and speeding?	36	9	2	1	1
4	Do you Agree most of the road traffic accident occurs in Bedele-Dedesa is b/c of failure in vehicle?	2	2	23	9	13
5	Do you Agree most of the road have comfortable shoulder, curve and clearance?	0	3	6	15	25
6	Do you Agree most of the road have comfortable and adequate pedestrian road crossing structures and zebra crossing for normal person and disable person?	1	3	5	19	21
7	Is there adequate number of traffic police, traffic regulation, traffic sign and road environment available to reduce road traffic accident in the area?	0	5	39	4	1
8	Are you comfortable waking and crossing zebra without any problems?	5	5	14	11	14
9	Do you think available traffic rules and regulations can reduce road traffic accidents?	0	0	6	13	30

Questionnaire response for drivers

Next, it was tried to collect a Questionnaire from vehicle drivers, which specifically used this road section. Here, majority of the drivers accepted that they were not giving a priority for pedestrians and have over speeding problem.

Considering the road geometry and structure, the vehicle drivers answered there is a road geometry and structural problems. Besides, they give a recommendation if there is black spot study on the road section so that the government bring a permanent solution.

Table 8 Questionnaire for drivers

Item	Questionnaire for drivers	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	Do you Agree the amount of road traffic accident in Bedele-Dedesa is greater compare to other section of roads?	8	5	31	3	2
2	Do you Agree most of the road traffic accident occurs in Bedele-Dedesa is b/c of drivers do not give a priority to a pedestrian and speeding?	21	21	4	1	2
3	Do you Agree most of the road have comfortable shoulder, curve and clearance?	5	3	13	11	17
4	Do you Agree most of the road traffic accident occurs in the area is at the same location and it must be putting a black spot location is necessary?	22	14	8	5	0
5	Do you Agree most of the road traffic accident occurs in Bedele-Dedesa is b/c of failure in vehicle?	2	4	35	5	3
6	Do you think the available traffic rules and regulations can reduce road traffic accidents?	19	16	10	2	2

After this, it is attempted to identify and prioritize the road traffic accident prone area (black spots) in Bedele-Dedesa road location. In each section, potentially hazardous locations were identified in addition to the above questionnaires filled.

4.3 Black spot locations identification

Using three-year traffic police road traffic accident report on Bedele to Dedesa road, Flemish government formula has been used to prioritize accident locations in Bedele-Gechi and Denbi Wereda.

Therefore, priority value was determined based on Flemish government's formula. Based on these data, the following criterion is used. First, each site where in the last three years three or more road traffic accidents have occurred is selected. Then, a site is considered dangerous when its priority value (P), calculated using the following formula, equals 15 or more.

$$P = X + 3*Y + 5*Z, \text{ where,}$$

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/

For instance,

- At Yebala it was 1, 1 and 1 for X, Y and Z respectively, the priority value became,

$$P= 1+3*1+5*1=9$$

- At Mine it was 1, 3 and 3 for X, Y and Z respectively, the priority value became,

$$P= 1+3*3+3*5=25$$

- At Doriya Jiren it was 2, 0 and 1 for X, Y and Z respectively, therefore the priority value became,

$$P= 2+3*0+5*1=7$$

1. Hazardous Location in Bedele-Gechi Wereda Ranking

According to the calculation from table 9 the rank for priority value was listed for Wereda, based on the priority value four black spot locations were observed and identified, which are Mine (25), Badele ganda 01 (17), Lilkee qararo (26) and Jisa (18).

Analyzing the most potential different road traffic accident location is important to assess its priority, to know the place and put black spot marking for this location. From this point of view, the first thing is to identify black spots location and take safety action with different safety measurement ways.

Table 9 Priority value (P) for Bedele-Gechi Wereda

No	Local Name	Fatalities (Z)	Injuries		Priority value(P) P = X + 3*Y + 5*Z
			Serious (Y)	Light (X)	
1	Yebala	1	1	1	9
2	Mine	3	3	1	25
3	Doriya jiren	1	0	2	7
4	Badele ganda 01	1	4	0	17
5	Lilkee qararo	5	0	1	26
6	Kaba guda	0	0	4	4
7	Jisa	2	2	2	18
8	Gola qore	1	1	1	9
9	Gachi 01	0	1	3	6
10	Mazoria	0	0	6	6
11	Gixo	0	2	4	10

2. Hazardous Location in Denbi Wereda

According to the calculation from table 10 the rank for priority value was listed for Denbi, based on the priority value four black spot locations were identified, which are Saxa (32), Sidan (18), Adebi (20) and Demo (21).

Table 10 Priority value (P) in Denbi Wereda

No	Local Name	Fatalities (Z)	Injuries		Priority value(P) P = X + 3*Y + 5*Z
			Serious (Y)	Light (X)	
1	Seko	1	0	4	9
2	Bido jiren	0	2	1	7
3	Saxa	5	1	4	32
4	Yembero	1	1	2	10
5	Sidan	2	2	2	18
6	Saso	0	2	1	7
7	Dembi 01	2	1	1	14
8	Sobo	1	1	1	9
9	Torban	0	3	3	12
10	Adebi	2	3	1	20
11	Demo	4	0	1	21
12	Seko	1	0	4	9

3. Summary of black spot locations

Therefore, totally 8 black spot locations have been identified specifically on the road section in all the Wereda. Tables from 9 and 10 showed that calculated priority value of each black spot locations using fatality and injury traffic police reports of each location. Mine (25), Bedele ganda 01 (17), Lilkee qararo (26), Jisa (18), Saxa (32), Sidan (18), Adebi (20) and Demo (21) were the black spot locations which have the highest priority value. The above priority values calculated was summarized as below.

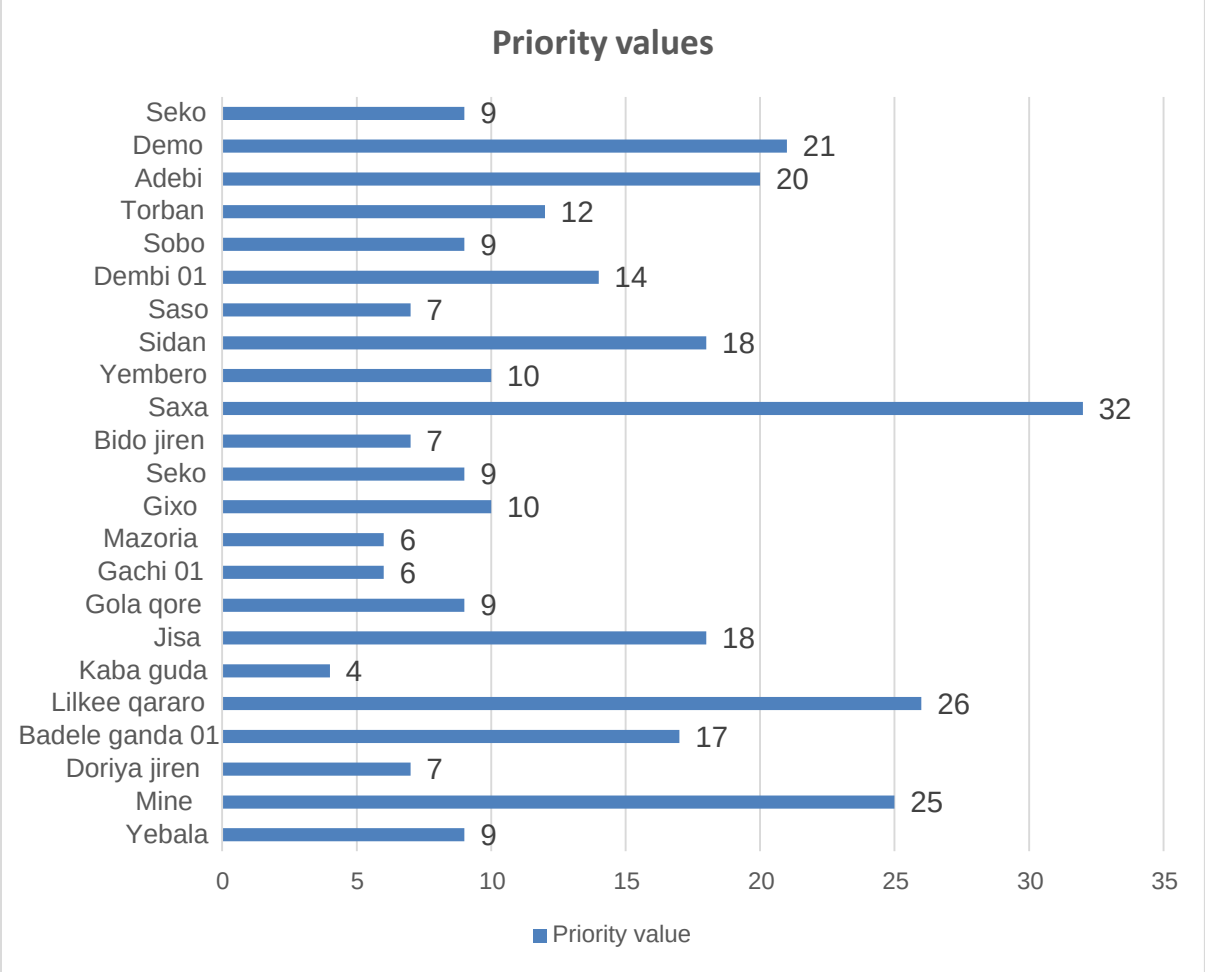

Figure 11 Road Traffic Accident with priority value

Further scope of work

Based on this road traffic accident black spots can be identified and studied with respect to gradient, radius of horizontal curve, super-elevation and curve widening by referring the as built and road safety audit. Referring to this data on the accident-prone locations, highly assist the study of road traffic accident geometric causes.

4.4 Geometric Causes of RTA on Bedele-Dedesa River

The next analysis was made based on the comparison made for the as built data with ERA Design manual (2011) and the RSA done that is data collected at the identified accident-prone locations and from actual site investigation.

4.4.1 Comparison b/n ERA Manual Requirement and Actual Result

After making the necessary site investigation to know the exact black spot location, the area was identified from the as built along the road and compared.

Accordingly, considering the road was classified under trunk road and design standard DS3.

Table 11 Comparison between ERA Requirement and Actual Results

	Description	Curve Radius	Super elevation	Gradient	Length of gradient	K value	Shoulder widths
Location	Unit	m	%	%	m	k	m
	ERA Standard	174.8	8	8	400	31	1.5-3.0++
	Mine	144.7	6	6	286	-	1.75
	Bedele ganda-01	-	-	6.5	295	82	1.75
	Lilkee qararo	157	6.7	9	88	51	1.75
	Jisa	176	5.5	8.3	120	-	1.75
	Saxa	84.2	6.9	4.8	307	55	1.75
	Sidan	190	7	4.4	314	102	1.75
	Adebi	122	5	6	295	91	1.75
	Demo	135	5.3	4.1	324	59	1.75

In Table 11, it was indicated that, the radius that was used at Mine, Lilkee qararo, Saxa Adebi and Demo were below the minimum requirement. The super elevation accustomed was under

the minimum requirement and safe. In addition, there were a high gradient at Lilke qararo and Jisa. Therefore, all the curves of the black spot locations were found to be hazardous and risky due to these required standard was not satisfied.

Table 12 Comparison between Required Curve Widening and Actual Curve Widening

	Description	Curve widening required	Actual Curve Widening
Location	Unit	m	m
	Mine	0.6	-
	Bedele ganda-01	-	-
	Lilkee qararo	0.6	-
	Jisa	0.6	-
	Saxa	1.2	-
	Sidan	0.9	-
	Adebi	0.6	-
	Demo	0.6	-

The above table, Table 12 showed the required curve widening was not actually provided, curve widening is not provide for these accident prone locations. This indicated, insufficient curve widening caused these road traffic accident.

Another element of road alignment is the sight distance across the inside of curves which is horizontal sightline offset (HSO) or middle ordinate (M). Where there are sight obstruction (such as walls, cut slopes, building and longitudinal barriers) on the inside of curves. Therefore, for Middle ordinate (M), with different R and Δ having the following equation, the adequacy of sightline offset was checked.

$$\text{Middle ordinate (M)} = R\,(1-\cos \Delta/2)$$

- Mine, Radius = 144.7 meters, $\Delta = 41^{o}$,

  Middle ordinate (M) = 144.7 (1-cos 41/2) = 9.2m

- Lilkee qararo, Radius = 157 meters, $\Delta = 74.8^{o}$,

  Middle ordinate (M) = 157 (1-cos 74.8/2) = 32.27m

- Jisa, Radius = 176 meters, $\Delta = 55.2^{o}$,

  Middle ordinate (M) = 176 (1-cos 55.2/2) = 20.03m

- Saxa, Radius = 84.2 meters, $\Delta = 57.59^{o}$,

  Middle ordinate (M) = 84.2 (1-cos 57.59/2) = 10.41m

- Sidan, Radius = 190 meters, $\Delta = 48.5^{o}$,
  Middle ordinate (M) = 190 (1-cos 48.5/2) = 16.76m

- Adebi, Radius = 122 meters, $\Delta = 87^{o}$,

  Middle ordinate (M) = 122 (1-cos 87/2) = 33.5m

- Demo, Radius = 135 meters, $\Delta = 69^{o}$,

  Middle ordinate (M) = 135 (1-cos 69/2) = 23.74m

We had calculated the sight distance on horizontal curve and next below examined with the standard ERA manual.

Table 13 Comparison between Required Middle ordinate and Actual Middle ordinate

	Description	Curve length	Design speed	Required Middle ordinate	Actual Middle ordinate
Location	Unit	m	Km/h	m	m
	Mine	95	50	9.2	6.4
	Lilkee qararo	142	50	32.27	21.5
	Jisa	125	60	20.03	8
	Saxa	80	40	10.41	9.2
	Sidan	140	70	16.76	6.9
	Adebi	148	50	33.5	16.4
	Demo	110	50	23.74	11.62

As described in Table 11, Table 12 and Table 13, the highest (greatest) priority value (32) occurred at Saxa, at this location the road section has very sharp curve radius (84.2m), steep grade (4.8%), inadequate of curve widening and very small horizontal sightline offset.

The second highest priority value occur at Lilkee qararo (26), at this place also have very sharp curve radius (157m), absence of curve widening and small horizontal sightline offset (21.5m).

The third highest priority value occur at Mine (25), this place has very sharp horizontal curve radius (144.7m), absence of curve widening and minimum horizontal sightline offset.

The fourth highest priority value occur at Demo (21), this place has very sharp horizontal curve radius (135m), absence of curve widening and minimum horizontal sightline offset.

The fifth highest priority value occur at Adebi (20), this place has very sharp horizontal curve radius (122m), absence of curve widening and minimum horizontal sightline offset.

The sixth highest priority value occur at Sidan (18), this place encountered absence of curve widening and minimum horizontal sightline offset.

The seventh highest priority value occur at Jisa (18), this place encountered absence of curve widening and minimum horizontal sightline offset.

Therefore, the above examination generally summarized the geometry of the road has been discovered to be dangerous and not safe for road user. All the black spot locations lack the ERA geometric requirement.

4.5 Summary of Road Safety Audit

The lack and absence of the following highway features was obviously visible on the road from Bedele to Dedesa. The black spot locations was high accident prone location with the following main causes to road traffic accident.

1. Lilkee qararo (P value-26)

The road safety audit indicated that road length has a sharp curve, steep vertical grade of 9%, pavement deterioration and the presence of curve obstruction made the transport risky and dangerous.

The counter measure that should be applied on this road section include: -

a. Road side delineator should be properly installed
b. Sign posts with speed limit 50km/hr. should be placed and obstruction should be removed for good sight distance

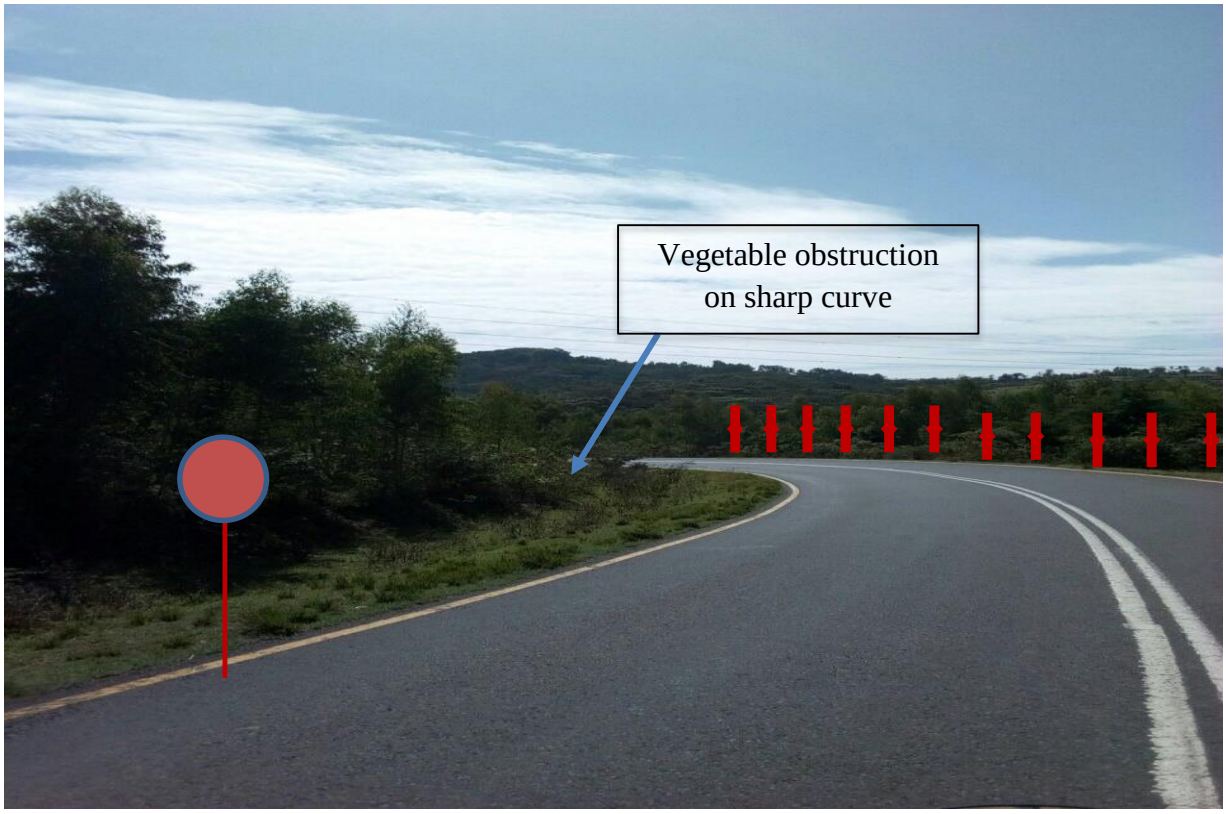

Figure 12 Lilkee qararo (P value-26)

2. Mine (P value-25)

On the site visit (RSA) we inspected the following problem in this road section, delineators, sign posts with speed limit posts are missing and presence of sharp curve is also visible.
The action that should be applied is:

a) Road side delineator should be properly installed

b) Sign posts including warning and speed limit 50km/hr.

c) If possible, provision of wider road curve widening.

Figure 13 Mine (P value-25)

3. Bedele ganda 01 (P value-17)

At the specific location, Bedele ganda 01, it was clearly visible that the road section is steep grade. In addition, it lack road marking and sign post.

Therefore, it needs a remedial and correction measures to protect the road user:

a) Road side delineator should be properly installed

b) Sign posts including warning and speed limit 30km/hr. because it is urban area

c) Install traffic calming

Figure 14 Bedele ganda 01 (P value-17)

4. Jisa (P value-18)

There is steep grade on horizontal curve, lack of road marking and absence of sign posts. An action to be taken to counteract the road traffic accident should be applied is:

a) Obstruction should be removed
b) The road width should be widened specifically
c) Both centerline and edge pavement marking should be provided
d) Due to the road is with steep gradient, proper speed limit post 60Km/hr. should be installed

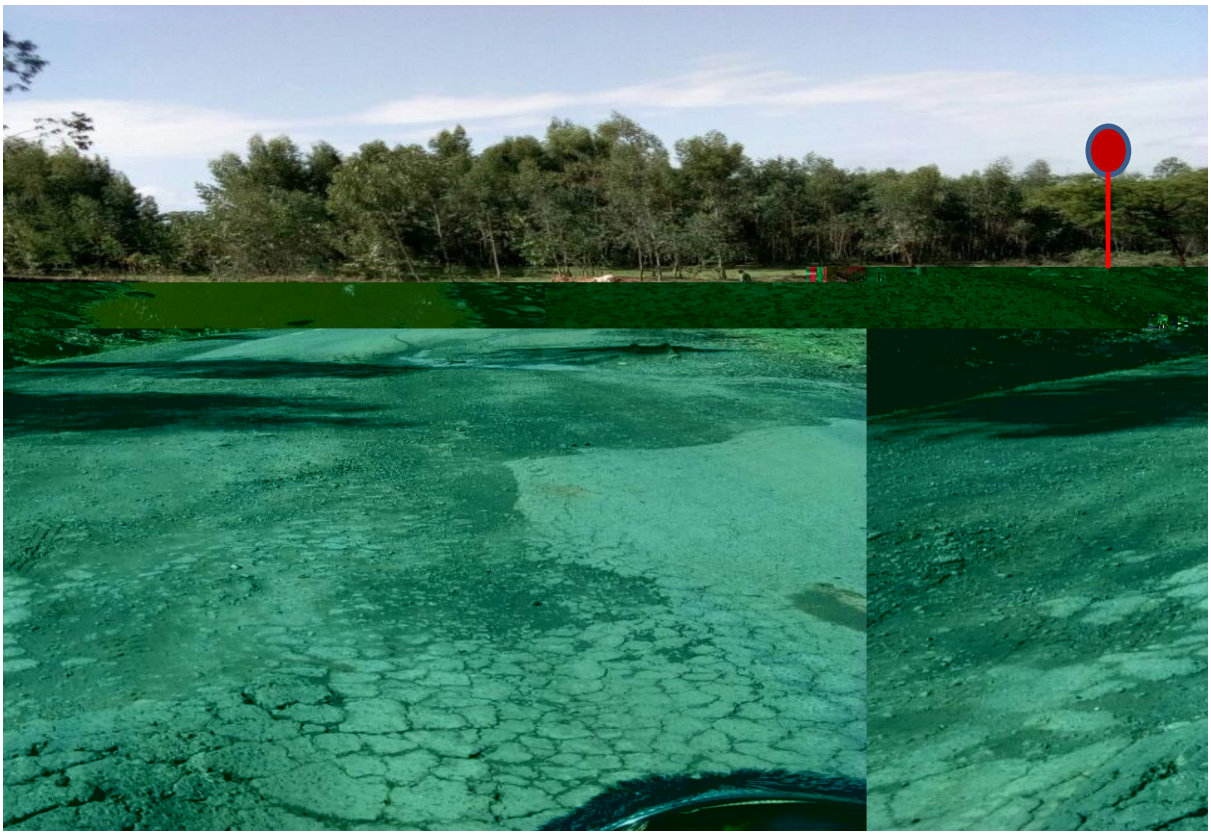

Figure 15 Jisa (P value-18)

5. Saxa (P value-32)

Actually, the presence of very sharp curve on this road. Existence of these sharp horizontal curves made every travel risky and dangerous. Furthermore, there occur curve obstruction. Therefore it needs measures to decrease the road user from any accident.

a) Sign posts with speed limit 40km/hr.
b) Vegetation obstruction should be removed
c) It is recommendable to place guard rail

Figure 16 Saxa (P value-32)

6. Sidan (P value-18)

The road segment lack traffic sign posts and curve widening where it is necessary. The counter measure:

a) Proper traffic sign should be installed and speed limit of 70Km/hr. on curve area
b) Avoiding curve obstruction and blockage.
c) Maintain the shoulder and road section
d) Provide road marking

Figure 17 Sidan (P value-18)

7. Adebi (P value-20)

Perhaps, the lack of curve widening, road markings had already faded and curve obstruction is also visible. In addition, the road section has sharp curve.

a) Removal of vegetation obstruction

b) Providing sign posts and speed limit of 50Km/hr.

c) Construct road side delineators

Figure 18 Adebi (P value-20)

8. Demo (P value-21)

The main reason of traffic accident at this black spot is obstruction, vertical curve at horizontal curve and existence of an intersection at the curve. To decrease occurrence of road traffic accident at this identified black spot location;

a) Provide standard curve widening, sign posts and speed limit of 50Km/hr.
b) Removing vegetation
c) Reflective guide posts and studs should be placed

Figure 19 Demo (P value-21)

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As per the objective of the study the influence of road geometric elements on road traffic accident, the general characteristics of road traffic accident were distinguished and related, black spot locations were identified. Additionally, after accident prone curve location identification, evaluation of road traffic accident causes were done at the identified locations. Based on the analysis and discussion done in chapter four, the succeeding conclusion was given as final activity.

On road safety work, the critical step is identifying accident potential areas. Eight black spot locations has been identified on Bedele to dedesa River. Mine (25), Bedele ganda 01 (17), Lilkee qararo (26), Jisa (18), Saxa (32), Sidan (18), Adebi (20) and Demo (21) were the black spot locations which have the highest priority value.

The required curve widening (0.6-1.2m) is not provided for these locations. The radius used at Mine, Lilkee qararo, Jisa, Saxa Adebi and Demo were below the minimum requirement. There were also a high gradient at Lilke qararo (9%) and Jisa (8.3%). In addition, the road length had lost all types of road markings, presence of vegetation obstruction, pavement deterioration, existence of sharp horizontal curves, occurrence of horizontal curve in steep vertical grade, absence of delineators with curve widening and sign posts. The road geometry and environment has great contribution on road traffic accident occurrence at the study area.

5.2 Recommendation

Based on the results of this research, the following recommendations have been given for different stakeholders;

Road traffic accident data handling way should be improved at Police stations so that information can be gathered from road traffic accident reports easily. And awareness of traffic polices should be increased on the issue of road geometry and environment so that everyone can understand the impact of road geometry and its road side environment on road traffic accident severity.

To minimize the occurrence of road traffic accident in a short term on the identified black spot locations, it is important to apply the following countermeasures. Installation of delineator and traffic sign, removal of curve obstruction and construction of proper medians, provision of pavement markings and provision of curve widening, posting additional speed limits at appropriate locations, construction of side walk should be placed at the entrance of every town and villages.

As a permanent solution, revision and redesign of road geometry has to be done to fully satisfy the minimum requirement. Periodic road safety audit should be undertaken for the actually operating roads.

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APPENDIX A

QUESTIONNAIRE FORM

QUESTIONNAIRE FORM FOR INDIVIDUAL PEDESTRIANS

SECTION ONE

Personal details

1. Age in years

(a) Below 18 ☐

(b) 18 – 30 ☐ (c) 30 – 40 ☐

(d) 40 – 50 ☐ (e) 50 above ☐

2. Sex: (1) Male. ☐ (2) Female ☐

3. Occupation: labor ☐

Civil servant ☐

Businessman/woman ☐

Others (specify) ☐

4. Driving experience in years

(a) Below 1 ☐

(b) 1 – 5 ☐ (c) 5 – 10 ☐

(d) 10 – 20 ☐ (e) 20 above ☐

SECTION TWO

Q.1. Do you agree the amount of road traffic accident in Bedele-Dedesa is greater compare to other section of roads?

(a) Yes ☐ (b) No ☐

Q.2. Do you agree you and other pedestrian follow the traffic regulations like crossing road using on zebra crossing to protect from road traffic accident in the area?

a) Strongly agree ☐ b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.3. Do you agree most of the road traffic accident occurs in Bedele-Dedesa is b/c of drivers do not give a priority to a pedestrian and speeding?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.4. Do you Agree most of the road traffic accident occurs in Bedele-Dedesa is b/c of failure in vehicle?

a) Strongly agree ☐ b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.5. Do you agree most of the road have comfortable shoulder, curve and clearance?

a) Strongly agree ☐ b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.6. Do you agree most of the road have comfortable and adequate pedestrian road crossing structures and zebra crossing for normal person and disable person?

a) Strongly agree ☐ b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.7. Is there adequate number of traffic police, traffic regulation, traffic sign and road environment available to reduce road traffic accident in the area?

(a) Yes ☐ (b) No ☐

Q.8. Are you comfortable waking and crossing zebra without any problems?

a) Strongly agree ☐ b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.9. Do you think available traffic rules and regulations can reduce road traffic accidents?

a) Strongly agree ☐ b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.10. Who do you think should be the most responsible for road traffic accident?

a) Driver ☐ b) pedestrian ☐ c) government ☐ d) traffic police

Q.11. what factors do you think facilitate the occurrence of road traffic accident?

In terms of Vehicles ☐

In terms of (environment) road net work ☐

In terms of Peoples behavior ☐

In terms of legislation and regulations ☐

QUESTIONNAIRE FORM FOR INDIVIDUAL DRIVERS

SECTION ONE

Personal details

1. Age in years

(c) Below 18 ☐

(d) 18 – 30 ☐ (c) 30 – 40 ☐

(d) 40 – 50 ☐ (e) 50 above ☐

5. Sex: (1) Male. ☐ (2) Female ☐

6. Occupation: labor ☐

Civil servant ☐

Businessman/woman ☐

Others (specify) ☐

7. Driving experience in years

(c) Below 1 ☐

(d) 1 – 5 ☐ (c) 5 – 10 ☐

(d) 10 – 20 ☐ (e) 20 above ☐

SECTION TWO

Q.1. Do you agree the amount of road traffic accident in Bedele-Dedesa is greater compare to other section of roads?

(a) Yes ☐ (b) No ☐

Q.2. Do you Agree most of the road traffic accident occurs in Bedele-Dedesa is b/c of drivers do not give a priority to a pedestrian and speeding?

a) Strongly agree ☐ b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.3. Do you Agree most of the road have comfortable shoulder, curve and clearance?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.4. Do you Agree most of the road traffic accident occurs in the area is at the same location and it must be putting a black spot location is necessary?

a) Strongly agree ☐ b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.5. Do you Agree most of the road traffic accident occurs in Bedele-Dedesa is b/c of failure in vehicle?

a) Strongly agree ☐ b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.6. Do you think the available traffic rules and regulations can reduce road traffic accidents?

a) Strongly agree ☐ b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

APPENDIX B

ERA MANUAL GUIDE TABLES

Table 2-5: Geometric Design Parameters for Design Standard DS3 (Paved)

Design Element	Unit	Flat	Rolling	Mountainous	Escarpment	Urban/Peri-Urban
Design Speed	km/h	100	85	70	60	50
Min. Stopping Sight Distance	m	205	155	110	85	55
Min. Passing Sight Distance	m	375	340	275	225	175
% Passing Opportunity	%	50	33	25	0	20
Min. Horizontal Curve Radius	m	395	270	175	125	85
Transition Curves Required		Yes	Yes	No	No	No
Max. Gradient (desirable)	%	3	4	6	6	6
Max. Gradient (absolute)	%	5	6	8	8	8
Minimum Gradient	%	0.5	0.5	0.5	0.5	0.5
Maximum Superelevation	%	8	8	8	8	4
Crest Vertical Curve	k	105	60	31	18	10
Sag Vertical Curve	k	51	36	25	18	12
Normal Crossfall	%	2.5	2.5	2.5	2.5	2.5
Shoulder Crossfall	%	4	4	4	4	4
Right of Way	m	50	50	50	50	50

Table 8-3: Widening on Curves and High Fills

Radius of Curve (m)	Curve Widening: Single Lane (m)	Curve Widening: Two Lanes (m)	Fill Widening	
			Height of fill (m)	Amount (m)
>250	0.0	0.0	0.0-3.0	0.0
120- 250	0.0	0.6	3.0- 6.0	0.3
60-120	0.0	0.9	6.0 - 9.0	0.6
40-60	0.6	1.2	Over 9.0	0.9
20-40	0.6	1.5	Over 9.0	0.9
<20	See section 8.8: Switchbacks			

APPENDIX C

SITE INSPECTION CHECK LIST

Road Safety Audit List			
Station(km):			
Location on Road:			
Rural Highway-			
Site Inspection Check List			
No.	Description	Remark	
		Present	Absent
1	Road widening		
2	The provision of Road Side Delineator		
3	All Kinds of Road Markings		
4	Speed Limit Posts		
5	Sharp Reverse Curve		
6	Sharp Horizontal Curve		
7	Median Barriers		
8	Curve obstruction		
9	Improved pavement shoulders		
10	Mis-phasing		
11	Bridge on Curve		
12	Guard Rails		
13	Adequate Lane Width		
14	Pedestrian Walking		
15	Proper Cross Section		