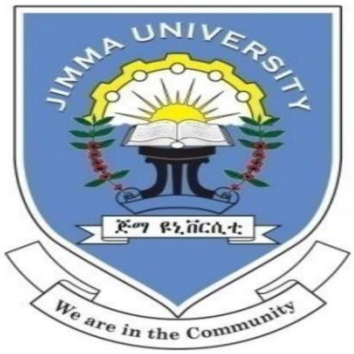


JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

HIGHWAY ENGINEERING STREAM

CORRELATION ANALYSIS OF TRAFFIC ACCIDENT ON EXISTING ROAD CROSS-SECTION ELEMENTS: A CASE OF SMALL AKAKI BRIDGE TO MENAGESHA ROAD SEGMENT

A Research submitted to the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Highway Engineering Stream.

By:

Bekele Tesfaye

February, 2020

Jimma, Ethiopia

JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

HIGHWAY ENGINEERING STREAM

CORRELATION ANALYSIS OF TRAFFIC ACCIDENT ON EXISTING ROAD CROSS-SECTION ELEMENTS: A CASE OF SMALL AKAKI BRIDGE TO MENAGESHA ROAD SEGMENT

A Research submitted to the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Highway Engineering Stream.

By:

Bekele Tesfaye

Main Advisor: Prof. Emer T. Quezon, P.Eng

Co-Advisor: Eng'r. Basha Fayissa

February, 2020

Jimma, Ethiopia

SCHOOL OF POST GRADUATE STUDIES

JIMMA UNIVERSITY

As members of the examining board of the final MSc open defense, we certify that we have read and evaluated the thesis prepared by Bekele Tesfaye entitled: **Correlation Analysis of Traffic Accident on Existing Road Cross-section Elements: A Case of Small Akaki Bridge to Menagesha Road Segment**"and recommended that it be accepted as fulfilling the thesis requirement for the degree of Master of Science in Highway Engineering.

Bushirelkerim Oumer (MSc.)	_____	_____
Name of chairman	signature	Date
Prof. Emer T. Quezon, P. Eng.	_____	07/03/2020
Name of Main Advisor	Signature	Date
Besha Feyisa (MSc)	_____	_____
Name of Co-advisor	signature	Date
Abel Tesfaye (Msc)	_____	_____
Name of Internal Examiner	signature	Date
Prof. Dr. Ing. Alemayehu Gebisa	_____	_____
Name of External Examiner	signature	Date

DECLARATION

I, the undersigned, declare that this thesis entitled "**Correlation Analysis of Traffic Accident on Existing Road Cross-section Elements: A Case of Small Akaki Bridge to Menagesha Road Segment**" is my original work and has not been presented by any other person for an award of a degree in this or any other University. Furthermore, all sources of material used for the thesis have been duly acknowledged.

Candidate:

Bekele Tesfaye _____ _____

Signature Date:

As Master Research Advisors, we hereby certify that we have read and evaluated this M.Sc. Research prepared under our guidance by **Bekele Tesfaye** entitled: **Correlation Analysis of Traffic Accident On Existing Road Cross-section Elements: A Case of Small Akaki Bridge to Menagesha Road Segment.**

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

Prof. Emer T. Quezon, P. Eng. _____ 20/11/2019

Main Advisor Signature Date

Eng. Basha Fayissa, MSc _____ ___/____/____

Co-Advisor Signature Date

ACKNOWLEDGMENT

First, I would like to give thanks to Almightily God who has given me the courage and strength to proceed with my thesis. Secondly, I would like to express my deep and sincere gratitude to my advisers Prof. Emer T. Quezon, Mr. Basha Fayissa for their comments, advice and guidance through and their invaluable support during this research work.

Thirdly, I would also like to express my gratitude to Mr. Oluma Gudina (MSc) Highway Chair Person for all his guidance and to my family who are always there by providing me morale support and encouragement in order to finish this research study.

Finally, I would like to thank Ethiopian Road Construction Corporation Alemgena district, ERA, Burayu Town Traffic police officers and to my friends who have shared their ideas and all senior researchers and authors for their valuable resources.

ABSTRACT

Traffic accident is increased from time to time in alarming rate and it is a serious problem throughout the globe, particularly, in developing countries like Ethiopia. Designs Cross-section elements are ineligible on existing roads potential lead to accidents, such as the narrowness of shoulder, lane, carriageways, roadways that do not meet the requirements contribute to the cause of the accident. Uncontrolled traffic accident happens from time to time in Burayu Town with an alarming rate. According to the Burayu town police report, the high number of road traffic accident recorded in Burayu town along Small Akaki Bridge to Menagesha, that was considered in this research. The main objective of this study was to analyze the correlation of road traffic road accidents related to road cross-section elements. The target populations considered in this research was the population existing within the range of the study area, composed of a total length of asphalt road, traffic accident report from police station (slight injury serious injury, fatal, and property damage. In addition to this, interview and questionnaire survey distributed to respondents who used the road. The pivotal necessary for the study used primary data taken from the geometry or road data metrics (during site survey using road safety audit, interview, and questionnaire, while the secondary data collected from the post road traffic accident data of Traffic Police Office and ERA standard. Data analyses were performed from the record and road safety checklist. All results are presented in the form of line graphs, pie charts, figures for a road traffic accident, and sketch for the suggestion improvement on the road design problem photo. The results indicated that 354 Road Traffic Accidents have occurred along the road segment within the study period from 2015 to 2019. There were 185 casualties as a result of the Road Traffic Accident, and 169 property damage due to road crashes, with an estimated total cost of about 8,583,285 ETB. The major cause of road traffic accidents was the problem of the road cross sectional elements, the driver's and pedestrian problems. Additionally, the study determines the relationship between road traffic accident with traffic Volume, age of driver's and cross-section elements using regression analysis. The result revealed that, there was significant relationship between traffic volume, selected road cross- sectional elements (shoulder, lane width, carriageway, roadways width) and traffic accident, which means road cross sectional elements, traffic volume are highly correlated or highly contribute for the occurrence of road traffic accident, while age of driver's have a low correlation with road traffic accident occurred. As a result, awareness and training regards to traffic laws must be given for both pedestrian and drivers regularly, strict traffic police enforcement and speed control should be correctly applying. Additionally, improve road cross-section elements, road side light, traffic sign, and pedestrian sidewalk and provide zebra and others in order to decrease road traffic accidents.

Keyword: Correlation analysis, Cross-section elements, Road, Traffic accident,

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

EQUATIONS

$Y=\beta 0 + \beta 1\ X + \varepsilon$ .....[14]

$Y = \alpha 0 + \alpha 1X1 + \alpha 2X2 \ldots + \alpha nxn + \varepsilon$.....[14]

$P = X + 3*Y + 5*Z$ ……..... [24]

ACRONYMS

AASHTO	American Association Study Of Highway And Transportation Organization
E. C	Ethiopian Calendar
ERA	Ethiopian Road Authority
ETB	Ethiopian Birr
EU	Europe Union
GDL	Graduated Driver Licensing
HCM	The Highway Capacity Manual
PDO	Property Damage Only
RTA	Road Traffic Accident
SPSS	Statistical Package for social science
TWLTL	Two-way Lane Turning Left
UK	United Kingdom
UN	United Nation
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

A traffic accident is a special case of suffering that constitutes a major cause of disability and untimely death [1]. Every year more than 1.25 million people die, and as many as 50 million people are injured or disabled on the world's road. Without action, road traffic crashes are predicted to result in the deaths of around 1.9 million people annually by 2020[2]. A traffic accident is the result of a multiplicity of factors, and it is often the interaction of more than one variable that leads to the occurrence of accidents, among which are driver, road, and traffic characteristics [3]. According to records have shown that over 87percent of all road accidents in Ethiopia are occurred by driver error [4].

Africa has one of the highest road traffic death rates in the world, with little difference in rates between those countries categorized as low-income. Whereas the range of fatalities per 100,000 populations in countries of African region is not very wide, 70 percent of all the deaths occurred in ten countries that account for 70 percent of the regional population: Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Madagascar, Mozambique, Nigeria, South Africa, and Tanzania [5] while this incident was more affecting countries in sub-Saharan Africa.

Three factors may have an influence on the occurrence of a road accident: human factor, vehicle, and road infrastructure. Some studies pointed out that the infrastructure factor is behind over 30 percent of road crashes. Therefore, geometric design parameters have a direct relationship with a road traffic accident. Key geometric design elements that influence traffic operations include the number and width of lanes, the presence, and widths of shoulders and highway medians [6]. In fact, previous research has shown that collisions tend to concentrate on certain road segments, indicating that besides the driver's error, road characteristics play a major role in collision occurrence [7].

In developing countries, the proportion of seriously injured and killed casualties is higher than in showing that the poorest countries have the highest road traffic-related mortality rates. Various studies done on road traffic accidents in Ethiopia have shown the escalation of the problem at the national level. Ethiopia has experienced high rates of road traffic accidents, as the road is the major means of transportation. The United Nation Economic

Commission for Africa reported that 15,086 road traffic crashes occurred in Ethiopia in 2008 resulting in a mortality rate of 95 deaths per 10,000 vehicles and causing losses of over 82 million Ethiopian Birr ($7.3 million USD) [8]. Furthermore, Ethiopia has a relatively high accident record despite having low road network density and vehicle ownership. Road traffic injury is high in Ethiopia; at least 70 people die for every 10,000 vehicle accidents annually [9]. According to the Road Transport Authority report, 1,800 people died and 7,000 injured in 2003 across the country. In the past eleven years (2007/08-2017/18) the number of road traffic accident were estimated around 291577. From those traffic accidents 36796, 54731, 58987 and 141063 roads traffic accident were fatality, serious injuries, light injuries and property damage respectively [53]. Even though the traffic accident rate is growing spontaneously from time to time in Ethiopia, the idea of road safety is applied lately throughout the country. So it showed that the lack of proper study on the accident suspected road section and also the absence of application of appropriate countermeasures provided to mitigate the effects. According to the report of the Association for Safe International Road travel list of dangerous Ethiopian roads, Ambo to Addis road is one which is suspected of the occurrence of accidents, and also it is a very congested road [11].

The study was dealt with the different problems related to road cross sectional elements and its effect independently on road traffic accident. it also determines the relationship between the selected cross sectional element and other related factor with road traffic accident and provided the possible counter measures to minimize loss of life and property damages through addressing the questions using a Post-accident approach to find correlations between road cross sectional elements and traffic accidents integrating with a statistical regression analysis method.

1.2 Statement of the Problem

In the world Over 90% of the world ‘s road traffic fatalities occur in low and middle income countries, even though these countries have only about half the world ‘s vehicle [12]. Without action, annual road traffic deaths are predicted to increase to around 1.9 million by 2030 and to become the seventh leading cause of death. Based on the study conducted by World Health Organization] WHO regional office for Africa the rate of road traffic injury in 2004 was 2.2% (9th leading cause) and it is predicted to be 3.6 %(5th leading cause) in 2030. Road traffic accidents are the critical health problems all over the world increasing its severity from

developed to underdeveloped countries, and it is more cause of death in sub Saharan Africa. In recent years, road traffic accident in Ethiopia is one of the worst accident records in the world [12].

In Ethiopia, the construction of the road is still consuming a huge amount of capital. However, the construction and design of these roads have still many defects. One of the main defects of the road is its geometry, which is the basic criterion to tell about the quality of the road. Geometric design elements play an important role in defining the operational traffic efficiency of any roadway [13]. Many types of research have been conducted more or less qualitatively. It is safe to say, from a traffic safety point view, that no one is able to say with great certainty, or prove by measure or number, where traffic accidents could occur or where accident blackspots could develop [14].

The problem of a road traffic accident is commonly observed in Burayu town, on the Small Akaki Bridge to Menagesha road segment. According to the Burayu town traffic office report on road traffic accident in the town, the trend of accident is not in a state of declining rather has continued to rise at an alarming rate over consecutive of five years from 2015 to 2019. The reported total crashes during these years were, 354 including property damages only.

The accidents in which the researcher come across Small Akaki Bridge to Menagesha road frequently happens motivated him to conduct this research both qualitatively and quantitatively, which was aimed at evaluating the road cross sectional elements on accident rate and identify road cross sectional elements impact in relation to their contribution for accidents and discomfort.

Therefore, aims of this research was to be encounter problem along this segment with respect to the road cross sectional elements on traffic accident by using correlation analysis between cross sectional elements and road traffic accident that will be create an understanding of the basic root causes of traffic accidents. Finally, determine effect of road cross sectional elements on road traffic accident with the help of regression analysis model then sets remedial measures to minimize road traffic accident in the study area.

1.3 Research question

This research questions used to seek for an answer in this study are:

1. What are the type of road traffic accidents happened on the existing road related to cross sectional elements?
2. What are the major causes of road traffic accident in related to road cross sectional elements?
3. What are the crashes and severity levels of road traffic accident on the existing road related cross sectional elements?
4. What is the relationship between road cross sectional elements and road traffic accident using regression analysis model?
5. What are the possible remedial measures needed to control the Road Traffic Accident related to road cross sectional elements?

1.4 Objective of Study

1.4.1 General Objectives

The general objectives of this study is to investigate Correlation between road traffic accidents and road cross sectional elements.

1.4.2 Specific objectives

- ✓ To identify the type of road traffic accidents in the study area.
- ✓ To identify the causes of road traffic accident related to road cross sectional elements.
- ✓ To rank the crashes and severity levels of road traffic accident of the road segment.
- ✓ To develop the relation between the road traffic accident and road cross sectional elements.
- ✓ To suggest a possible remedial measures to minimize road traffic accidents.

1.5 Significance of the Study

Nowadays, roads are not only required to connect two different places as per their main function; rather, they are evaluated by the geometry they have. However, they are expected to give comfort and safety. Moreover, they are judged based on their tendency to cause an accident.

This road has not been giving comfort for drivers as well as passengers. Moreover, many accidents were frequently happening at many similar locations along the road. As a result,

many people were losing their lives, and also a huge amount of economic damage was happening, which the researcher has been observing for a year and more having the chance of using the road frequently.

These researches have a valuable contribution to ERA to take necessary measures in enhancing the safety condition and improving the geometry of accident-prone locations. The improvement of the geometry and the enhancement of the safety conditions will decrease the number of accidents and increase the comfort of the area will be a valuable contribution to the country's economy. Furthermore, it can be a valuable reference for any researcher that is interested in doing similar research.

Finally, study have a novelty on the identifying RTA related to road cross section elements using the regression and correlation analysis, to determine which cross sectional element highly correlate with RTA as well as significance influence on road traffic accident.

1.6 Scope of the study

The research conducted mainly in Oromia Region, Burayu Town along Small Akaki Bridge to Menagesha road with total length of 21.1kilometers, which is part of Addis to Ambo Asphalt trunk road. The study was mainly focused on evaluating the effect of road cross sectional elements on traffic accidents excluding the other geometric parameters. The study used five years' recorded road traffic accident data from September 2015 to August 2019. Field measurements with respect to cross-sectional elements, Interviews, questionnaires were done on the selected respondents and road traffic accident data reported by traffic police was gathered and others.

1.7 Challenges and limitations of Study

The fieldwork came under some constraints. One such problem concerns the fact that the time for the data collection process was limited. A longer duration of time was needed in order to have a deeper insight into the theme under study. For instance, focus group discussion with some Regional, District and Ministry of Health officials could have been used in conjunction with the methods already adopted as it would have resulted in much research data. The study was done under some important groups such as interviews and questionnaires distribution to the driver, pedestrians, and traffic police. Some of the interviewees seemed to hold back in their answers with a fear of negative impacts from their answers, for example, admitting to driving under the influence of alcohol, over

speeding not give priority to pedestrians, and the misunderstanding and willingness of the pedestrians. During the questionnaires, some questioners was not carful the answer and due to Misunderstanding of the question. It sometimes seemed that the interviewee was giving answers they thought to be correct, with a fear of giving the incorrect answer. Therefore, all interviewees were informed that no bias would be seen in their answers, there was no such thing as an incorrect answer and that the objective of the interview was to obtain truthful and genuine answers and information. Both are interviewing and analyzing the data is a time-consuming process. Some irregularities exist in the data. Especially the road traffic accidents data of three districts contain a number of missing and incomplete data elements. The main sources of inconsistency in the road traffic accidents data were due to limitations and erratic reporting made by the traffic polices and road traffic accidents investigating officers at the data gathering and recording level mainly due to lack of knowledge and the main problem on the road traffic accident data was not include location of accident due to missing of accident location during data record.

1.8. Organization of study

Chapter one deals about the overall background of the study, statement of the problem, research question, scope, and limitation of the study.

Chapter Two describes literature which is relevant to the study. Chapter Three deals with research methods and procedures of data collection and analysis, Chapter four describe about result and discussion of the thesis and Chapter Five deals with Conclusion and Recomandation. The appendix attach at the end of the document presents the raw data used for analysis.

CHAPTER TWO
LITERATURE REVIEW

2. 1. Introduction

This chapter presents a comprehensive review of various literature related to the topic under consideration in order to find critical facts and findings which have already been identified by previous researchers and numerous studies in and around the causes of road traffic accidents with particular reference to the effects of geometric road features on a traffic accident. It covers the most significant parts of the subject area and is intended to serve as an introductory input to the subsequent analysis stages of the research by seeking to improve the knowledge and experience about the road traffic accident and its contributing factors which will guide the direction of this study and aid in exploring the unknowns.

It aims to critically assess and identify geometric elements relevant to the traffic accident of roads including the geometric requirement of roads such as lane width, length of roadway alignment and traffic volume through the evaluation of existing mathematical and statistical models for the existence of casualties in road accident using correlations and statistical regression techniques.

A large number of studies had conducted so far elsewhere in the world to characterize and quantify the relationships between traffic accident and road cross-section elements characteristics. It would be impossible to mention all of them in the space available. However, a summary of the major conclusions regarding the effect of geometric features, drivers, vehicles, and another road.

2.2. Overview of the road traffic accidents

Road accidents are a global problem affecting all parts of society. However, road safety has received insufficient attention at national and regional levels. As a result, a traffic accident has been increasing dramatically from time to time. Some of the common reasons for this change include

- ✓ Lack of information on the magnitude of the problem and its preventability;
- ✓ Lack of political responsibility and multidisciplinary collaboration that are needed to tackle its effect.
- ✓ Lack of road safety infrastructure and quality of serviceability.

This shows that traffic crash is the result of a multiplicity of factors and it is often the interaction of more than one variable that leads to the occurrence of a crash. An accident occurs as a result of the interaction of different factors, among which are road and traffic characteristics. Most of the traffic accident is happening due to human error. A large number of injuries and deaths that are occurring on roads do not describe the ability of drivers as alcohol and drugs affect the driver's ability to control the vehicle, which affects the concentration of drivers. Studies made on the area and published on books, journals, reports, and other literature share a common understanding and shows that accident registered in a different part of the regions are created due to factors indicated above.

According to [15], the accident is an event occurring suddenly, unexpectedly, and inadvertently under unforeseen circumstances. It further expressed that road traffic accidents can be defined as "An accident that occurred on a way or street open to public traffic; resulted in one or more persons being killed or injured, and at least one moving vehicle was involved [15].

The accident is defined as an error in the driver-vehicle-roadway system, and it must be recognized that different types of accidents are caused due to different reason at any given location, namely, rear-end, side-swipes, head-on, night-time, bad-weather, etc. Bad weather accidents can result due to road pavement, which becomes dangerously slippery when wet, or it may be due to inadequate signs for inclement weather [16].

Generally, road accidents are analyzed by means of precisely defining the event involving damage to the property and/or injury to the road users, which are recorded first-hand by the police and/or emergency services [17]. Accidents are rarely caused by a single factor. Usually, the interaction of the diverse set of factors such as roadway design parameters, road user behavior, environmental conditions, etc., cause accidents; however, one factor can be more responsible than the rest, and can easily be identified.

2.2.1 cause of road accidents

Guidelines for Planning and Operation of traffic in urban areas, Directorate of Traffic and Transportation Systems Directorate General of Civil City Army, stated that the factors causing accidents usually classified identically with the elements of the transport system, is road users (drivers and Pedestrians), Vehicles, Roads and the Environment, or a combination of two or more elements. Identifying the risk factors that contribute to road traffic crashes is important in identifying interventions that can reduce the risks associated with those factors [18].

The four basic aspects of transport those are primary factors in the causes of a road traffic accident are:

- ✓ **Vehicle-related factors**: this may be due to inherent design limitations or defects to lack of maintenance, failure of components like brakes, tires, and lighting. Visibility, speed, and vehicle lighting are also important.
- ✓ **Road-related factors**: this includes pavement design and conditions, horizontal curves, insufficient lane and shoulder width, vertical curves.
- ✓ **Road user-related factors**: psychological factors of the users, alertness and intelligence, patience of the driver, drivers experience and age
- ✓ **Environmental related factors**: rain, bad weather, heavy fog and mist are plays an important role. Development and various factors causing road accidents are described in the following sections.

According to a report that an effective road safety management requires good insight into the factors that are believed to be related to road traffic [19]. In the area of accident severity, continuous efforts have conducted in order to investigate the relationship between the level of severity (dependent variable) and a set of explanatory variables (Independent Variables).

2.2.2. Vehicle crash types

A traffic crash is defined as any vehicle crash occurring on a public highway that is originating on, terminating on, or involving a vehicle partially on the highway. These crashes include collisions between vehicles, Collusion between Vehicles and static objects, vehicles and pedestrians, or animals. Car crashes can happen at any time due to speeding, traffic gridlock, negligence or recklessness and unsafe driving [20].

A. Common vehicle crash collisions

- ✓ **Rear-end Collisions** -Rear-end collisions are very common. These types of traffic crashes are often caused by sudden deceleration (slowing down or braking). In some cases, another driver is following too closely or accelerates to a higher speed than the car in front of it.
- ✓ **Side-impact Collisions** -Side-impact collisions can cause serious injuries. Often called "T-bone" or "broadside" collisions, side-impact crashes occur when the side of a vehicle is impacted. It can be impacted by the front or rear of another vehicle or in some cases, a fixed object. Vehicle damage is often severe and drivers or passengers on the impacted side of the vehicle usually sustain far worse injuries than they would in another type of crash.
- ✓ **Sideswipe collisions** - Sideswipe collisions occur when two cars that are parallel touch. In many cases, the damage is only severe, as the cars have just "swiped" each other. Injuries and

damages are typically minimal unless one of the drivers loses control of their vehicle as a result of the collision.

- ✓ **Vehicle Rollover** - Vehicle rollover crashes are extremely dangerous and frightening. A rollover occurs when a vehicle literally flips over onto its side or roof. Any vehicle can be involved in a rollover crash. Often caused by sharp turns at high speed, rollover crashes can lead to serious injuries, including spinal cord injuries and brain suffering.
- ✓ **Head-on Collisions** - These types of collisions are often fatal. Head-on collisions are exactly what they sound like - they occur when the front ends of two vehicles impact each other.
- ✓ **Single Car Crashes** - Crashes involving only one vehicle are also common. They occur when a vehicle strikes objects such as poles, trees, fire hydrants, and walls. In some cases, they may involve pedestrians and other innocent bystanders. Single car collisions can result in driver and passenger injuries, pedestrian injuries, and often extensive property damage.
- ✓ **Multi-vehicle collisions** - Multi-vehicle collisions are sometimes referred to as "pile-ups" and often occur on busy roads such as highways and freeways. They can involve many vehicles and be the most dangerous. Vehicles can be impacted multiple times, and it may be difficult to escape. It is also difficult to determine fault in these cases.

2.3. Effects of cross-section elements on traffic accidents

The effect of road cross-sectional elements on road traffic accidents, roadway cross-section encompasses features on the travel portion of road used by vehicular traffics and the roadside [21]. Accordingly, the design of the cross-sectional element influences the safety of the roadway. The portion of the road cross-section normally used for vehicles and pedestrian travel may serve multiple purposes, including future expansion and recovery room for errant vehicles. In addition, types and descriptions for the most common elements of roadway cross-section were given in the following ways; width of the lane, number of a lane, shoulder width, a pedestrian sidewalk in urban, median width, median type, and bicycle lane. Effect of lane and shoulder width on accident reduction on rural, Two-lane road [29].

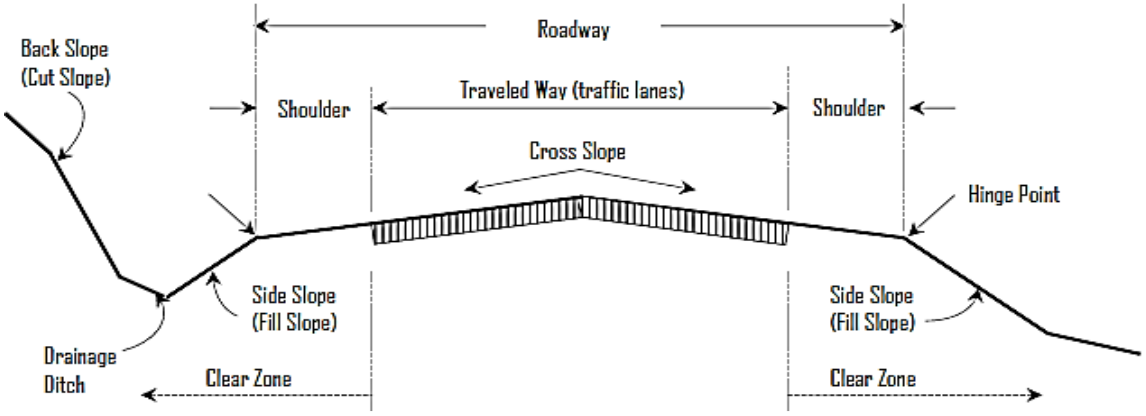


Figure 2. 1 Roadway cross section elements

2.3.1 Lane Width

Wider lanes are traditionally associated with higher operating speeds and increased safety. The Highway Capacity Manual (HCM) documents that a wider lane for multilane highways result in higher free-flow speeds [31]. On the other hand, very little has been found on the safety implications of wider lanes. It is reasonable to assume that wider lanes may provide additional space to the driver to correct potential mistakes and thus avoid crashes. However, a driver could be expected to adapt to the available space, and the positive safety effects from the wider lanes may be offset by the higher speeds [31]. Generally, most studies agree that lower accident rates are attributed to wider lanes. But it seems that there is an optimal lane width around 3.5m. Studies have also noted that approaches should base on more parameters of the cross-section, at least also on traffic volume [22].

2.3.2 Number of Lanes

The number of lanes is another variable which has been discussed in detail by various Researchers. Almost all studies do conclude that the higher the number of lanes, the higher the crash rate [23]. In their research, [24] found that increasing the number of lanes was associated with increasing traffic crashes. In another study, [25] found that more lanes in urban roadway sections are associated with higher crash rates. Garber [26] considered flow per lane and found that there was an increase in the crash rate as the flow per lane increased. Evidence of the effect of the number of lanes can be seen when a study is done on the conversion of a two-way roadway to four or six lanes. With such studies, most have shown an increase in the crash rate [23].

2.3.3 Shoulder Width and Type

Shoulders are the other important factors in road safety. The use of road restraints, signs, and signboards, especially in mountainous areas and high-density accident areas, is vital. Also, the

effect of road environment is significant in accidents in a way that mountainous roads are 13 times more unsafe than other roads. Moreover, in his study, it was shown that adverse weather conditions and the number of crossroads per kilometer do not have major effects on the safety of rural roads [27].

There are several purposes in providing shoulder along the highway; these include accommodating stopped vehicles so that they do not encroach on the travel lane, to make maintenance work, to facilitate the access by emergency vehicles, and to protect the structural integrity of the pavement. About the impact of shoulder-width or shoulder, in general, there are various opinions in the literature several positive as well as negative aspects are discussed. Increasing the shoulder width is associated with a decline in accidents by 21% reduction of total accidents was determined on the road with shoulders of 0.9m-2.7m compared to the road without shoulders [28].

Based on experience, drivers are wary of un-stabilized shoulders, especially on high-volume highways, such as suburban expressways. Such experience has led to the replacement of un-stabilized shoulders with some form of stabilized or surfaced shoulders [29].

2.3.4 Median Width and Type

The most important objective for the presence of medians is traffic separation. Additional benefits from medians include the provision of recovery areas for errant maneuvers, accommodation of left-turn movements, and the provision for an emergency stop. Median design issues typically address the presence of median, along with its type and width [23]. One study which evaluated median types found that, the safety of the median type decreased in the following order: flush unpaved, raised curb, crossover resistance, TWLTL [30].

Srinivasan [31] found that on high-speed roads with two or more lanes in each direction, medians improve safety in a number of ways, for example, by reducing the number of 150 head-on collisions. The Danish design standards [32] which were showed the relationship between the median width, the accident frequency of through section and a severity index for medians with and without the crash barrier, medians, particularly with barriers, reduce the severity of accidents, but medians wider than 3m show little additional benefit. In contrast, United States studies show continuing reductions in the number of injuries crashes for widths up to 12m and over [33].

2.3.5 Median Barrier

A highway with a median width of 15 m [50 ft.] or more has a very low incidence of head-on collisions caused by vehicles crossing the median. A median width of 23 to 30 m [75 to 100 ft.] on freeways is very desirable as a means of reducing cross-median collisions. On a divided highway with partial access control (i.e., an expressway) or where no access control exists, the width of the median should also take into account the operation of at-grade intersections. With narrower medians, median barriers will eliminate head-on collisions, but at the cost of some increase in same-direction crashes because recovery space is decreased. Properly designed median barriers minimize vehicle damage and lessen the crash severity. However, if a narrow median with a median barrier is proposed on a high-speed highway, the design should include adequate shoulder widths in the median for emergency stops and emergency vehicle use [29].

2.3.6. Clear zone

Once a vehicle has left the roadway, an accident may occur. The end result of an encroachment depends upon the physical characteristics of the roadside environment. Flat, traversable, stable slopes will minimize overturning accidents, which are usually severe. Elimination of roadside furniture or its relocation to less vulnerable areas are options in the development of safer roadsides. If a fixed object or another roadside hazard cannot be eliminated, relocated, modified, or shielded, for whatever reason, consideration should be given to delineating the feature, so it is readily visible to a motorist. For lower standard roads, the clear zone can be reduced as practical. It should extend beyond the toe of the slope. Lateral clearances between roadside objects and obstructions and the edge of the carriageway should normally be not less than 1.5 meters [34].

2.4 current accident severity definition in Ethiopia

In Ethiopia, even though a documented definition of different accident severity levels was not obtained for this study, the information obtained from the interview of some patrol and police officers shows that: injuries.

- ✓ A **fatal accident** is the one in which one or more individuals die as a result of traffic accidents within the same reporting 30 days of the occurrence of the accident.
- ✓ A **serious injury** is one in which a victim sustains severe cuts, bleeding, breaks, and other damages that require medical treatment as "in-patient" in the hospital.

- ✓ A **slight injury** is the one as a result of which the victim sustains only small cuts, scratches, and other small damages that may be treated as an out-patient without requiring admission to a hospital.
- ✓ **Property damage only** accident is the one as a result of which no person is injured Only one or more vehicles involved in the accident are damaged.

2.5 Correlation and regression analysis

Regression analysis is a statistical technique that is very useful in the field of engineering and science in modeling and investigating relationships between two or more variables [51]. The method of regression analysis is used to develop the line or curve, which provides the best fit through a set of data points. This basic approach is applicable in situations ranging from single linear regression to more sophisticated nonlinear multiple regressions. The best fit model could be in the form of a linear, parabolic, or logarithmic trend. A linear relationship is usually practiced in solving different engineering problems because of its simplicity.

Linear regression analysis is a statistical method for modeling the relationship between two or more variables using simple and multiple linear equations [51]. In this research work, an attempt is made to apply single linear regression models to characterize the influence of geometric road parameters on the rate of traffic accidents using a statistical approach. Simple linear regression refers to a regression on two variables, while multiple linear regressions refer to a regression on more than two variables. A statistical software program (SPSS) has been used in regression analysis to find the effect of road attributes on the accident rate.

The general equations of a probabilistic single and multiple linear regression models are presented in the following forms [51].

$Y=\beta 0 + \beta 1\ X + \varepsilon$ .....[3]

$Y = \alpha 0 + \alpha 1X1 + \alpha 2X2\ldots + \alpha nxn + \varepsilon$.....[4]

Where the slope ($\beta 1$) and intercept ($\beta 0$) of the single linear regression model are called regression coefficients. Similarly, coefficients $\alpha 0$, $\alpha 1$, $\alpha 2\ldots\alpha n$ are termed as multiple regression coefficients which is not applied in this study. The standard error term (ε) is used to estimate the dispersion of prediction errors when it is needed to predict dependent values from the independent variables in a regression analysis.

The basic assumption to estimate the regression coefficients of the single regression model is based on the least square method. The correlation coefficient R2 only gives a guide to

the "goodness-of-fit" or how closely variables X and Y are related. It does not indicate whether an association between the variables is statistically significant. A number of techniques can be used to judge the Assessment of the Effects of Road Geometric Design Elements on Traffic Safety May, adequacy of a regression model, some of which are a standard error (ε), R-squared value (R^2), R-adjusted and the p-value. The value of R^2 is always between 0 and 1 because R is between -1 and +1, where by a negative value of R indicates relationship inversely, and positive value implies a direct relationship. Confidence of the result indicates in terms of significant value (P). The correlation was considered significant if (P) is zero or 5 percent different from zero [52].

2.6. How to reduce the severity of injuries and prevents road accidents?

Accidents have occurred for several reasons, and it is difficult to decide the main causes of RTAs [35]. It is, therefore, important to work on all aspects relating to RTAs to ensure a reduction in the future.

2.6.1 The influence of efficient and effective emergency services

One of the key things to do concerns pre-hospital care and traffic injury services at the site of road accidents [36]. After the event, a fast response is needed to provide the essential health services for accident injuries, thereby reducing the mortality rate caused by RTAs. The paramedics should also provide an appropriate level of care for traffic injuries at the scene of a crash. The distance between the scene of the accident and the hospital can be the difference between life and death [37; 38]. For example, a six-mile distance from a traffic accident location to a hospital will cause a 1percent increase in death [39]. However, some traffic injuries (such as excessive bleeding) need urgent care at the scene of the crash. A whole variety of actions can affect response times, such as the time of the accident and whether or not it occurs in the evening or in the morning. Traffic congestion and weather conditions also play a role as regards the response time**.**

2.6.2 Enforcement:

Police enforcement plays a vital role in addressing the problem of road accidents. The police need greater powers to increase breath analyzer tests and to increase penalties against drunk driving. Moreover, enforcing speed limits is critical for reducing the severity of RTAs. According to the WHO report in 2009, police enforcement reduced the number

of serious injuries and fatalities in the UK by 33percent, and in the EU, law enforcement could reduce this problem by 50 percent [40].

The first safety belt campaign was introduced in the USA in 1985. This resulted in an increase from 49 percent to 77percent of people using seat belts within a three-week period. Moreover, alcohol checkpoint campaigns have reduced the number of accidents related to drinking driving; in Charlottesville, Virginia, the number of accidents caused by drink-driving declined to 13percent [41].

It is essential for police enforcement organizations to analyze public attitudes towards Traffic safety in order to determine if any change has occurred. This requires the public to understand the aim of the campaign and to cooperate with the police in order to achieve road safety. During 2001 and 2004, a study into a large gas company in France was carried out to establish the main risks that drivers take. The objective was to investigate the behavioral changes of drivers in order to identify the risks. The researchers found that police enforcement and traffic campaigns are very effective in preventing drivers from speeding and using mobile phones while driving. The number of drivers both speeding and using mobile phones when driving decreased from 2001 to 2004 because of traffic enforcements and strict traffic laws [42]. In addition, speed cameras have proved to be very effective in reducing the number of drivers speeding. In 2003 in Spain, eight-speed cameras were installed in Barcelona at 22 sites. As a result, the average number of accidents declined from 638 to 486, and the average number of traffic injuries also went down from 946 to 696 [43].

2.6.3 Providing valuable education on road safety issues

Education can have a huge impact on raising awareness of road safety matters [44]. Governments should, therefore, provide traffic safety education programs in all schools so that road safety for children and teenagers can be achieved through these programs. In addition, drivers need to understand what acceptable driving behavior is, and, in this way, education will help reduce traffic hazards, especially for people who break the law. In the Netherlands from 1998 to 2006, for example, the use of seat belts increased from 40percent to 43percent for all rear-seat passengers in rural areas. This was because a campaign was organized, which used a cartoon for children aged between 4 and 12 to encourage them to wear seat belts (Government Accountability Office, 2008). In 1996 in the USA, the government began Graduated Driver Licensing (GDL) courses,

and the number of accidents for the 15 to 17 age group declined after applying these policies, especially at night and at weekends. According to the study, accidents decreased because the number of teenagers driving dropped [45]. GDL courses for 15 to 17 year-olds reduce RTAs by 10percent for nighttime driving. The GDL also reduced accidents caused by drunk-driving by 13percent. Additionally, passenger restrictions preventing passengers from traveling with teenage drivers also resulted in a 9percent drop in RTAs. [46]. Education programs should, therefore, focus on traffic safety issues, such as speeding, drink driving, using mobile phones, and other types of distractions. One of the most successful traffic campaigns was used in the UK: the „THINK! The campaign" was run by the Department of Transport in 1963 and focused on drink driving, speeding, motorcycle safety, the importance of seat belts for adults and young drivers. A useful website has since been set up to provide education and awareness for teachers, parents, and pupils. This website presents road safety information for road users to reduce the number of fatalities and encourage road safety in the UK [47]. In the USA, RTAs are the leading cause of death for young people. In 2005, a total of 5,300 teenagers aged between 13 and 19 lost their lives as a result of RTAs. A range of studies has indicated that the reason for this was that young drivers do not have experience in driving at riskier times of day, such as when it is dark. Moreover, since teenagers tend to carry more teenage passengers while driving, this also contributed to the high death rate [47].

2.6.4 Engineering the key for safer standards

Road engineering is extremely important in the field of traffic safety [88]. By comparing accident locations (black spots), the engineers can determine the main faults on the road, which lead to RTAs [49];[50]. The role of traffic Engineers are to examine the road conditions and to collect the statistics of the accident data, such as the locations of the accidents, the speed zones, and traffic congestion. Roads should also meet road standards to ensure that they are safe at all times. Some of the characteristics include:

- ✓ Traffic signpost,
- ✓ The proper width of shoulder and Lanes,
- ✓ Design speed,
- ✓ **R**oadside mark and centerline
- ✓ Proper pedestrian crossing.

- ✓ Installing proper drainage systems
- ✓ Repairing any defects of pavements as early periods
- ✓ Constructing guardrail at proper place
- ✓ Finally making road safety audit to prevent roads traffic accident to loss of life and damages property

CHAPTER THREE

RESEARCH METHODOLOGY AND MATERIALS

3.1. Description of the study area

Burayu is located at longitude 38°31′19.17" East and Latitude 9°05′08.93"North (Google Earth, 2019). It is bounded by Addis Ababa City to the East, Sululta District to the North, Walmera District in the West and Sabata Hawas District to the South and North West [54]. Administratively, Burayu town is under the special Zone of Oromia surrounding Finfine City Administration.

According to 2007 census, the 2013 projected population size of the town was 81,740. Whereas as, it was counted in year 2011 by Burayu town Municipality, the population size of the town was around 114,426. Out of the total population of the town, migrants constituted close to 61 percent [54]. The study was conducted on existing trunk road of Ambo new road connecting Small Akaki Bridge to Menagesha, which have a well-recorded history of remarkable traffic safety problems at an adverse geometric location. It is economically important, since it connects western and central parts of the country with the capital city of Addis Ababa.

The Road connects Small Akaki Bridge to Menagesha Towns passing through different kebeles and villages having ample raw material resources for construction material, different huge Industries and place where high business take place in it, due to short distance have from Addis Ababa.

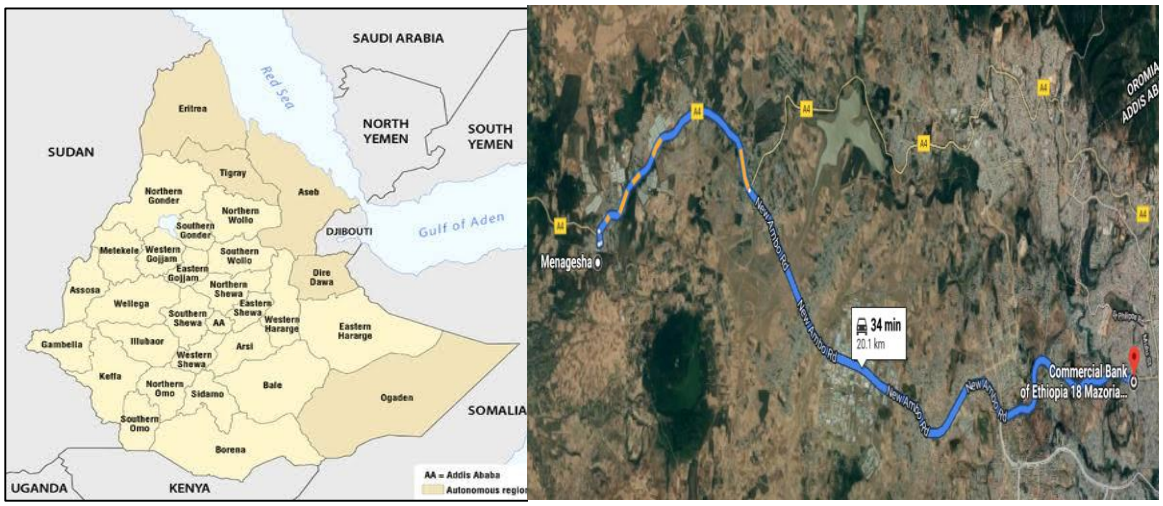


Figure 3. 1 Satellite image of Menagesha to Small Akaki Bridge(Google map 2019)

3.2. Population

The population is the total collection of elements about which one wishes to get information[47]. From this perspective, the population is the target group to be studied in a particular place while the sample is a part of the population. Therefore, representative samples are used for the study from the total population. From the nature of the work, drivers move from one place to another. Hence, it is not easy for the researcher to involve all the target population in the study because of problems related to time and finance. Thus, it is believed that the researcher need not take the whole population as a result of a good representative samples have the same characteristics as the population as a whole [39].

Therefore Sample of the population that considered in the study was only the population existing within the range of my study area, which covers the study area, from the origin to destination. Drivers, pedestrians, and traffic accident report from the police station, Police officer, and ERA district was taken into consideration.

3.3. Study variables

3.3.1. Dependent Variable

- ✓ Road traffic accident

3.3.2. Independent Variable

- ✓ Road cross-sectional elements
- ✓ Traffic volume(AADT)
- ✓ Age of drivers
- ✓ Vehicle type

3.4 Materials

The materials used for this research: - checklist format for safety audit, note book, ERA standard manual data used as an input data for analysis and compare it with existing built data, Road Traffic data, Digital camera and tape to measure the road elements width are used beside Microsoft word, excel and SPSS which used to analysis data.

3.5. Methods

3.5.1. Research design

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

traffic accidents that occurred on the road related to road geometric elements (cross-section elements).Relationships develop to bind cross-sectional road elements to road traffic accident data in order to determine a correlation between carriageway width, Lane width, shoulder, Median, traffic composition, and accident frequency (or, rate of traffic accidents). Single regression analysis models are used to analyze the dynamics of changes, variations, and interruptions in road traffic accidents and road cross-section elements characteristics of the subject trunk-road segment selected for the case-study from Small Akaki Bridge to Menagesha.

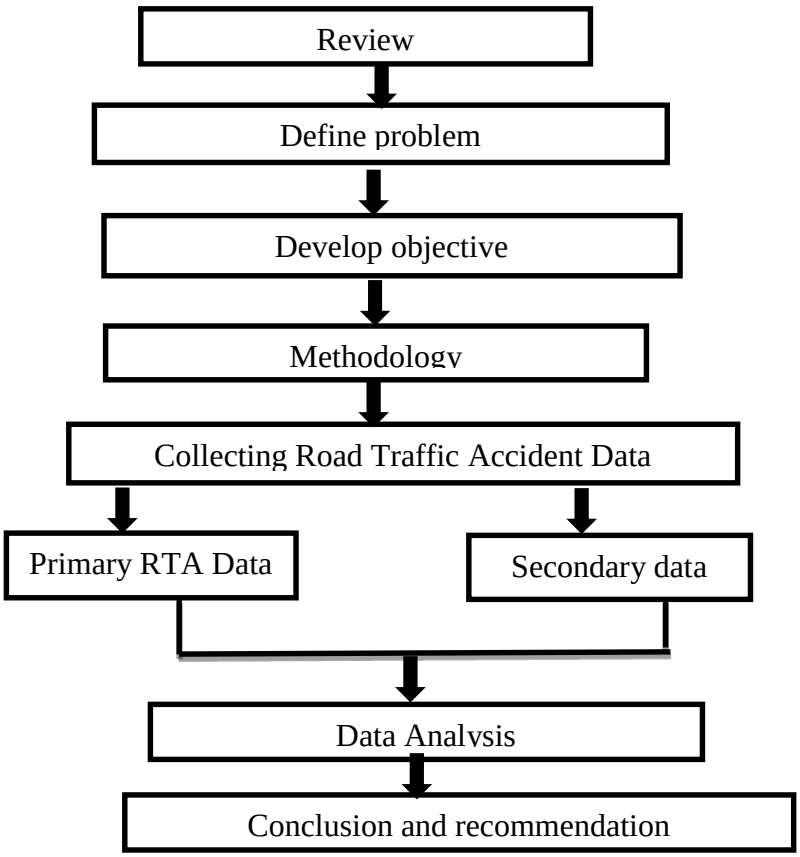


Figure 3. 2: Research design

3.5.2. Nature and source of data

The literature reviews provide a broad background of the existing knowledge of road traffic accident and insight into the Problems encountered by the researchers at a different stage of their works. The knowledge and experience gained during this period helped the writer of this paper in developing a reliable, efficient, and effective study approach to focus on stated goals. Before data collection was carried out, training was provided to data collectors to arm them with knowledge on how to gather reliable data.

Road accident data, which are classified into four degrees of severity (fatal, serious, slight, and property damage only accidents) was obtained from the Traffic Police Department, while the number of casualties, which are classified into three degrees of severities (fatality, serious injury, and slight injury) were also acquired from Traffic Police Department. Two main categories of data were used: road traffic accident data, road data (cross-sectional road data). Qualitative and quantitative data were collected from both primary and secondary data.

3.5.2.1 Primary data collection

The major primary data collection was site visit, road safety audit, through interviews and questioner is made with key informants of Burayu Town road transport office, three district Traffic police office, vehicle drivers and pedestrians.

3.5.2.2 Secondary data collection

The secondary source of data was taken from recorded data compiled by Burayu traffic office (Melka wereda, Gefersa Nono wereda, Gefersa Guje wereda) and Burayu Town Road Transport Offices. Those data were recorded by taking pictures the original. The data applied to study were the accident data from 2015 to 2019 and Existing road data measured from the field.

3.5.3 Sample size & sampling technique

3.5.3.1. Sample size

The sample inspections selected by using purposive sampling. The area which is very vulnerable by a traffic accident, characterized by dense vehicle, pedestrian movement, road cross-section elements problems was considered.

3.5.3.2 Sampling technique

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

Therefore, in this study, a total of 70 respondents was chosen randomly, 30 Pedestrians, 30 car driver, and 10 traffic office for an interview. In order to analyze the data simply, the study was preparing questioner for a total of 100 respondents of population groups, 10

traffic police, 45 pedestrians, 45 car driver. The table 3.1 showed the number of completed interviews and questioner reached 170.

Table 3. 1 Sample size respondent

No.	The sample size for the questioner		The sample size for the interview	
1	Pedestrians	45	Pedestrians	30
2	Vehicle drivers	45	Vehicle drivers	30
3	Traffic Police	10	Traffic Police	10
Total respondent		170		

3.5.4. Data collection methods

The accident data provided by the Police Agency, only the data happening on the provincial road from 2015 to 2019 G.C, were collected from Burayu Town traffic police, the three districts (Melka Gefersa, Gefersa Nono and Gefersa Guje Kebeles). The main RTA input data sets collected from the daily RTA records file of Burayu Town Traffic Office include the following variables.

- ✓ Accident reason
- ✓ Accident type
- ✓ Accident year
- ✓ Accident Location
- ✓ Age of Drivers
- ✓ Sex of Drivers
- ✓ Types vehicles
- ✓ Education level
- ✓ Estimated accident cost in ETB

During interview and questioner, the researcher considers respondents who are affected by road traffic accident and the road side light, pedestrian cross, drainage system, roadside sign, etc. were also gathered by using road safety audit of ERA standard at the time of site visit. Road cross-sectional problem like narrow carriageway, Lane, shoulder, road marking, road traffic signpost on the side of the road.

Figure 3. 3: flied measurement during the site survey and interview

3.5.5 Data processing and analysis

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

$P = X + 3*Y + 5*Z$ ……...…. (3)

Where:

P = priority value

X = total number of light injuries

Y = total number of serious injuries

Z = total number of deadly injuries

After the analysis and identification of blackspot locations, the site observations were followed. from here, the causes of accidents at the location concerning geometric factors are identified by using the safety audit checklist of existing road.

3.5.6 Methods of Data Analysis

In the research, the study analysis of the data had been basically made in four sections. The first and second parts are discussing general characteristics and cause of RTAs in the study area using post-RTA data from traffic police and throw interviews and questioner by using descriptive analysis. The third part was evaluating the cross sectional elements by using the road safety audit checklist and compare with ERA standard during a site survey in the proposed area. The fourth part was all about the effect of cross elements on road traffic accidents by using correlation analysis.

The road factors being investigated in the geometric design includes cross-sectional Element (lane, shoulder width, road marking and light, design, and median barrier). These were substantiated through actual measurements and visual inspection, which was made on the road site.

- During the Site visit, observation survey, different types of data were gathered.
  - ✓ Road environment
  - ✓ Check Road Cross-section Elements like the width of the lane, the width of shoulder, road barrier, width of the median, road marking, road side light by using the Safety Audit Checklist of Existing Road.
- All of the observations achieved during the audit are recorded on the safety audit checklists and forms prepared in a special format.
- Below are examples of some features to be observed during the field survey;
  - ✓ Locations in which shoulder widths are inadequate
  - ✓ Markings that are not in existence or in a complex condition (old and new markings mix each other)
  - ✓ Improper location of the bus stops
  - ✓ Non-guard-rail sections
  - ✓ Improper information signs
  - ✓ Improper design median
  - ✓ Improper drainage structures.

All these features above and many others are recorded on the safety audit checklist on the existing road related to road cross-section Elements during the field survey. photographs were also made during the site visits, which are used to make final discussions and evaluations. During the site observation recommended structure of safety audit checklist on an existing road is illustrated below.

1. **Road characteristic**
   - ✓ Missing of zebra
   - ✓ Shoulder missing
   - ✓ Shoulders too narrow
   - ✓ Shoulder unpaved
   - ✓ Improper connection to the small access road
2. **Road side problem**
   - ✓ Missing median
   - ✓ Improper or dangerous pedestrian crossing
   - ✓ The dangerous fixed object on roadside
   - ✓ Road edge deterioration

- ✓ Dangerous free stones
- ✓ missing of drainage on the roadside
- ✓ Improper commercial activities on the roadside
- ✓ Missing sign
- ✓ Improper parking

Table 3. 2 Comparison of Observed values with the ERA Standard

	Roadway Element	**ERA Standard values**	**Observed Values**
1	AADT(Traffic Volume)	200-1000	10275
2	Carriageway width	6.5-7m	5.8-6.46m
3	Shoulder width	1.5m- 3m	0.1m- 1.1m
4	Lane width	3.65m	2.8m-3.23m
5	Pedestrian cross	controlled	Not exist
6	Roadside mark	controlled	Not exist
7	Drainage system	controlled	Not work properly
8	Roadside signpost	controlled	Not exist
9	Road side light	controlled	Not work properly

3.5.7 Data quality assurance

In this study, the data was collected in two ways of data collection from the sources. Thus the primary source of data collection (the first witness of a fact) and secondary source of data collection (record of an event, books, or circumstance). Therefore, the assurance of those data to be highly recognized, and those data are true. In order to obtain the quality of data, the researcher would be to be assured by giving attention to the following points.

- ✓ Before collecting data, all the source of population availability has to be checked, and respondents' daily work schedules have to be respected.
- ✓ All the questions have to be put in simple & clear ways;

- ✓ The willingness of the respondents to answer the questions and collaboration with the study will be tested out.
- ✓ All necessary schedules are going to be worked out the need to be administered the questionnaire, conducted observations or group interviews, and make measurements.
- ✓ All the system for quality control /assurance of data collection has to be worked out effectively.

3.5.8. Ethical considerations

The data was collected after ethical permission is given from ERA and Jimma University, Jimma Institute of Technology, before continuing the study, acceptance should be given from local authorities in order to follow the research. Make sure the confidentiality of data, Approval of research by an ethics review committee to make sure the study is not contradicting any of the above considerations; follow the procedure that is required with the concerned organization. This study was conducted in a manner that was consistent with ethical issues that need to be considered in conducting research. Hence, most individuals the researcher visited for an interview accepted and cooperated with the researcher willingly. Moreover, prior consent of the participants was requested before conducting the interview.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1. General Characteristics of RTA

Now a day, the occurrence of road traffic accident is increasing in alarming rate in Burayu town. Thus, it's important to look for the characteristics of accident registered to identify the black spot locations where accident frequently happened on the road segment. In this line, traffic police report was assessed from September 2015 to August 2019 as shown in table 4.1. A total of 354 crashes were reported in the stated duration from Small Akaki Bridge to Menagesha road segment. Among these crashes, human injuries are reported as 159 and the rests are reported as property damage. Similarly, out of human injuries, 72 were fatal, 54 and 59 were serious and slight injuries respectively as shown in figure 4.2 below.

Table 4. 1 Road Traffic Accident and cost of PDO

Year	Number of Accident	Percentage share(%)	The estimated cost of property damage(Birr)
2015	52	14.69	3,262,300
2016	56	15.82	1,028,239
2017	68	19.21	1,333,846
2018	84	23.73	1,506,100
2019	94	26.55	1,452,800
Total	**354**	**100**	**8,583,285 ETB**

Source: -Burayu town traffic Police office

The number of the accident along the road segment had increased from 52 to 94 between September 2015 and August 2019. In addition, the total property damage in Ethiopian birr was **8,583,285 ETB** within a period of five years. The total property damage in each year certified that the country had lost a huge amount of economy every year.

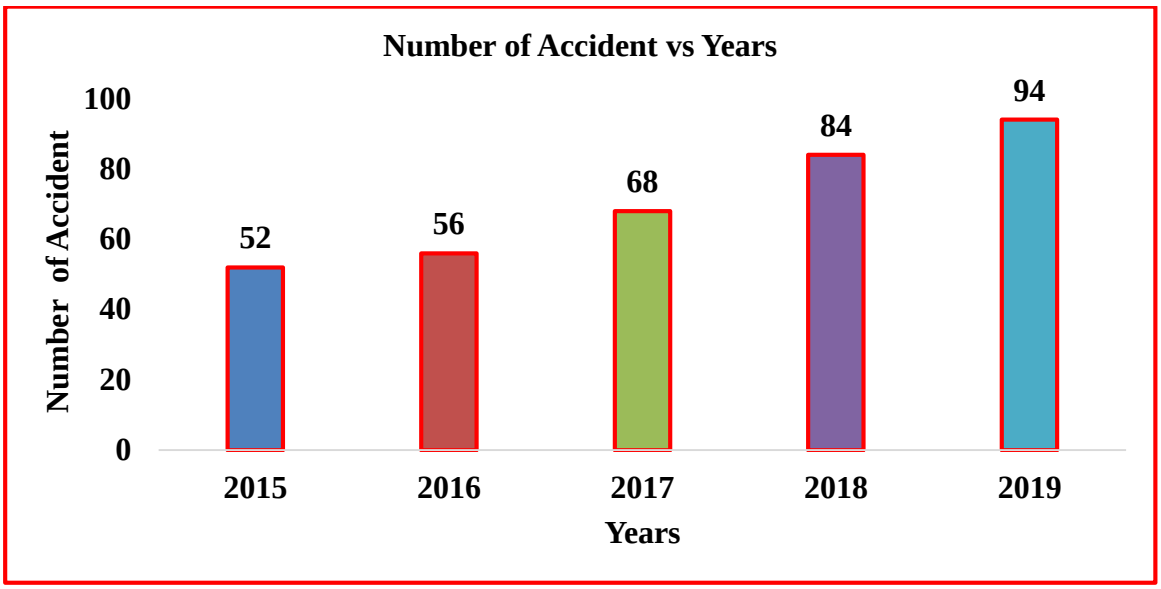


Figure 4. 1Total Traffic accident occurred in five years

From fig. 4.1The the highest traffic accident was recorded in 2019 and followed in 2018. In the rest, three years its minimum compared to 2018 and 2019. Hence road traffic accident becomes more serious in 2019 due increment of traffic volume and pedestrian on the road.

4.1.1 Variations of RTA by Severity Classes

This method involves listing each accident occurring at a site under one of the following Severity classes: Fatal accident, serious Injury, slight Injury, and Property Damage (PD). Among all road traffic accident reported in 2015 to 219, the percentage distribution by severity class was (20.34%) of fatal accident (15.26 %) serious injury, (16.67%) slight injury and (47.74%) property damage, respectively. As indicated in Figure 4.2, the total number of people died was very high relative to injured because of the accidents. The total number of property damage by the accidents along the road showed high increment, even if the number of death was maximum in all the five years in terms of cost.

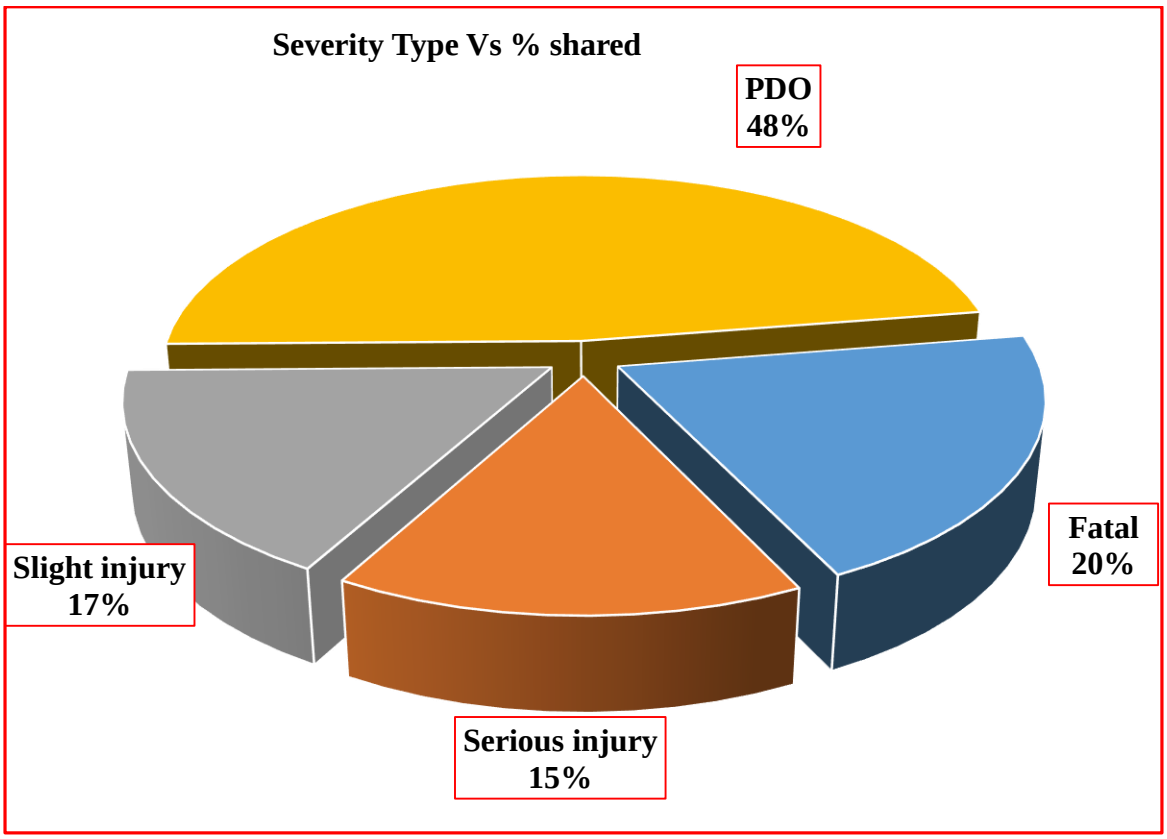


Figure 4. 2 The severity Type Vs % shared

In Figure 4.2, showed that, the severity of accidents among the five years was increases from time to time. The result implies that, accidents in terms of severity in 2018 and 2019 were observed more serious than in all five years. In the other hand, severity of accidents in 2015, 2016, and 2017 was less as compared to 2018 and 2019.

4.1.2 Cost of the Traffic Accidents of the Property Damages

Road accidents cause injury, death, loss of property, and damages to vehicles. All these involve a monetary loss to the economy. The general cost of the road traffic property damage is shown in the following Figure 4.3. The property damage costs in the study site estimated over the five years of period **8,583,285** ETB. The highest estimated RTA cost has been recorded at ETB 3,262,300 (38.01%) in 2015 while the lowest at ETB 1,028,239 (11.98%) in 2016. The years 2016, 2017 and 2018 exhibited ETB 1,028,239 (11.98%), ETB 1,333,846 (15.54%), and 1,506,100 (17.55%) RTA cost respectively. The cost of the property damage lays its negative impact on the country's economic background and social interactions in developments. The cost of the Property damage ensures that loss of economy by indirect influence to the pedestrians, animal, and the motorists passing through the route [55].

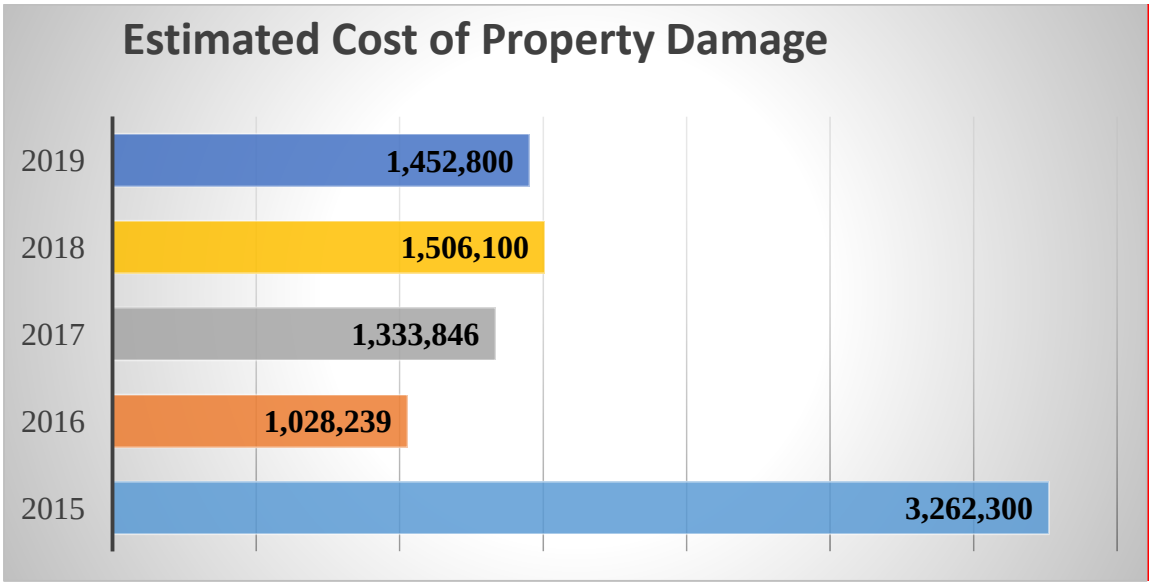


Figure 4. 3 Estimated cost of property damage (2015 to 2019)

4.1.3. Traffic Accidents on Days of the Week

From fig 4.4 below, it could be seen that the most serious accidents occurred was during the day of the week on **Saturday** and estimated to 20 percent. This was because of the day is marked as a market time in which the population of the road congested by the road users and Monday to Friday was the school period in which student fill the roads during morning, at noon and afternoon as well as it is the time in which the workers go to their workplace on this day in most of the Burayu Town.

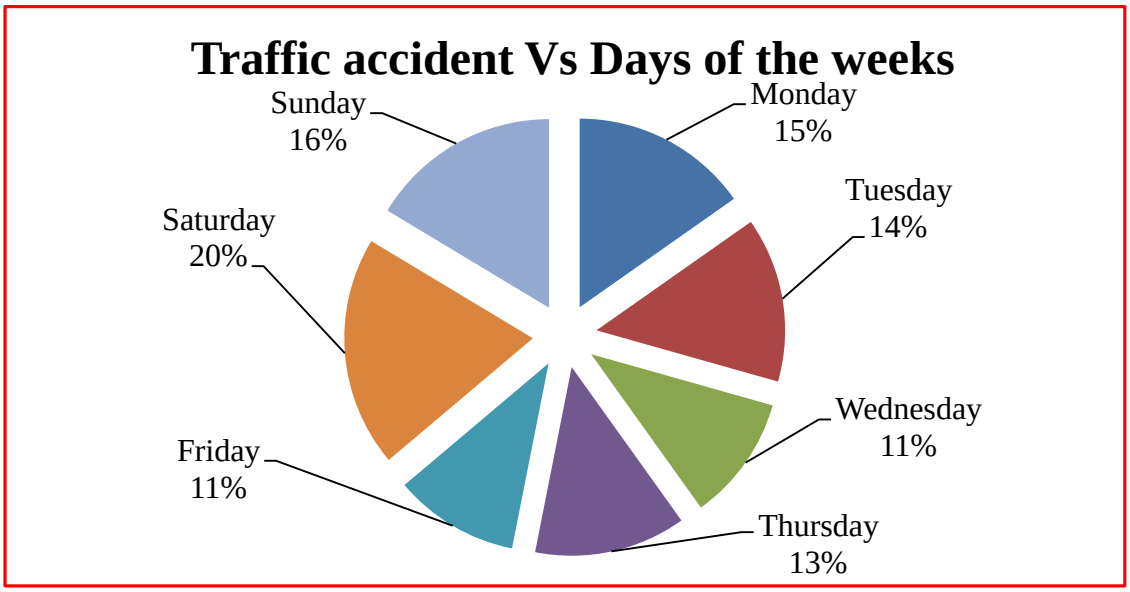


Figure 4. 4 Road traffic accident Vs day of week

As a result of these common factors, the day of the week resulted in the utmost accident causality. On Saturday, Sunday and Monday the accident percentage reached about 20% ,16% and 15% from the total day of week. Saturday is the market day for the society around their and Sunday is the recreational day for most of the workers in which they get rest time, and for money Christian, it is an entreaty day. Probably the result come from different reason such as, during the market day, the pedestrians' traffic intensity increases more than the other days, the drivers drive very fast beyond the limit of the speed recommended by the law and Monday was the working period of the week so that the population number on the roads increased.

4.1.4. Hourly Roads Traffic Accidents Rate

The road traffic accident rate varies from time to time in the world and particularly in our country. The variations of the accident rate depend upon the situation that the activities are very frequent. When there are many activities, the accidents measured were very high. The factors which are contributor to the occurrence of the accident is that the situation of the school, working hours, driving hours, market conditions. At early morning, at peak hours, afternoon most of the roads are congested and occupied with more traffic intensity. During these periods, the accident rates increase because workers, marketers, students can go or back from their purpose places. So the concentration of road traffic increases in such situations.

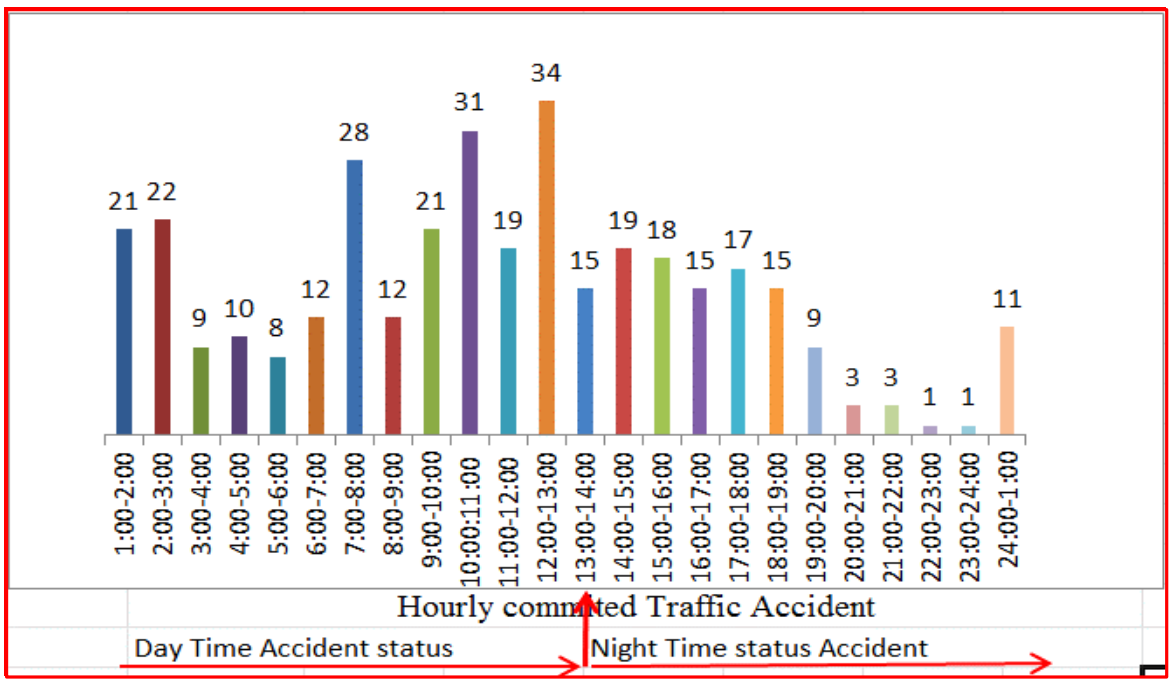


Figure 4. 5 Hourly Vs road traffic accidents registered

fig 4.5 shows us that more accidents recorded during the day time of 2.00-3.00, during the peak period of 6.00-8.00 in the day time and 10.00-12.00-day time due to the times are here the rush time when students, workers run to the workplace, school and again come back to home for lunch or for the night walk or home as well as during the night time of 13.00-15.00 because of the people are taking recreational walks, or running to their home from different work and purpose. The accidents are more at these times due to the workers are flowing to the workplace and the students going to school and back. The time in which the accident is the highest during the peak times of the work and purpose because many people are going home from the workplace and school or market and some considering these times as recreational periods after a job at these moments. The minimum accident rate is registered in the middle of the night time and the quarter of the night, as it is depicted in fig 4.5 above. These are because of the time in which all the activities halted in the environment and take rest.

4.1.5. Distribution of RTA by Drivers age

Human beings are the primary causes of RTA. Several studies have witnessed that the age of drivers has a greater impact on the occurrence of RTA scenes. This was due to the fact that the age of drivers affects their driving behavior, concentration, sense of responsibility, and patience. These are because they drink alcoholic drinks, speed over the recommended, think as youngsters, and carelessness for their life and others. Most of the time, the accidents are committed by the driver in the age range of 18- 30 years.

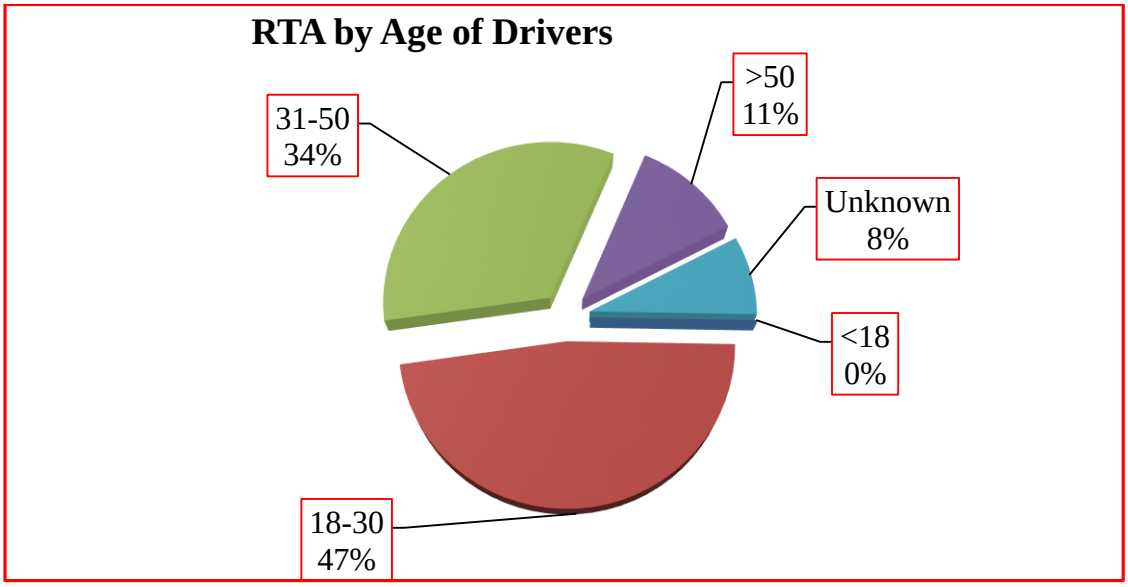


Figure 4. 6 The traffic accidents caused by the driver's age category

From fig 4.6, it indicated that, the maximum traffic accident is committed by the drivers 'age ranging from 18-30 years old contributes an accident of 47.46% of the injuries within the five years. This was because these aged drivers are very speedy, hot, and addicted to stimulants (such as drug, Chat or plant leaves, cigarettes, and drunk) so that they are stimulated and drive carelessly. This investigation supported by one study, Speed is one of the major parameters in cross sectional elements and it one of contributing factor of road traffic accident [56]. The second groups were composed of drivers who are aged from 31-51 years are also committed to accidents and contribute about 33.62% of the total accident. This is because the age of this area is in which most of the fire and adolescence stage seen. The drivers are very careless to life and property damages. Sometimes they act as the only excellent drivers. They also support their driving state with drinking alcoholic things. When we compare the accident between different age in the five years' period, the drivers- in age group 18-30, shear the highest number of accident with increment from 2015 to the 2019 year. It could be due to lack of awareness, and the control over the drivers is poor by traffic polices and the society or community.

4.1.6 Educational Backgrounds of the Drivers

Most of the time, the educated drivers are expected to drive with a minimum cause of accidents that they do not commit accidents more than those of illiterate drivers could commit. The statement may be some times wrong when they are addicted to some alcoholic drinks. But if these are not, they are better to drive at concentrated thinking and care regardless of some barriers. When drivers are trained and cultivated well before they start driving both in the higher education system and driving license system, they can reduce the accidents that can be easily committed. Because they pay attention as education in any way reshape human being mined psychologically to keep his balance. Therefore, education plays a big role.

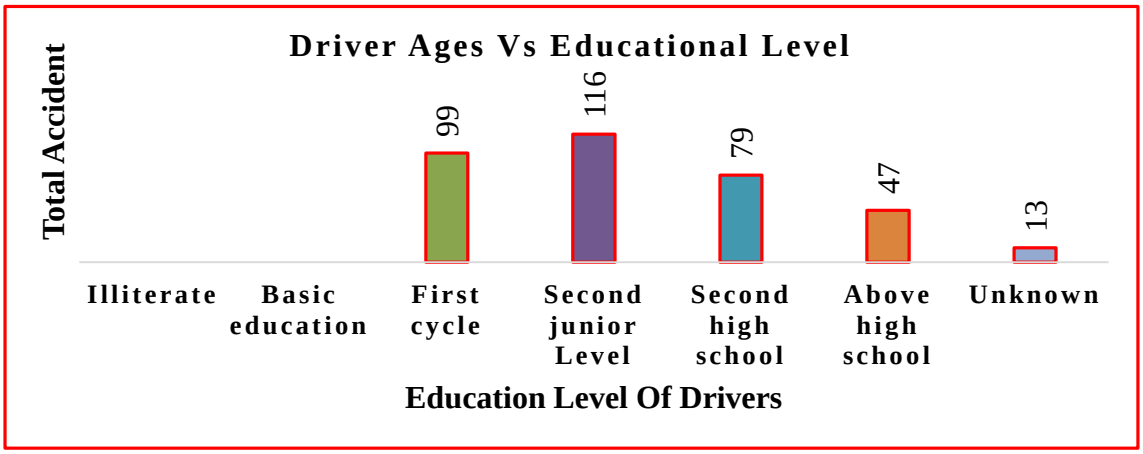


Figure 4. 7 The Accident rates by the educational background

The Accident rates by the educational background Most of the accidents caused by the drivers who have completed secondary high school level and from 1st cycle to secondary highs school level the accidents committed were more than 83.6 percent. The reason for the severity of accidents committed in the group of 1st cycle level, junior secondary level, and secondary high school levels is because when they finish school programs and lose the chance of joining universities, they need to have a license to be drivers. These stages of educational background are uncontrolled; it contributes and causes the drivers not to have the technical effectiveness in his or her educational level. The other thing people who are in these three most important stages are very addicted to chat chewing and alcoholic drinks that stimulate them to drive at the highest rate of unlimited speed. In the above graph, we see that most of the accidents are contributed by the drivers in the school status of the first cycle, the secondary and junior and secondary high school. The above analysis shows where and how to attempt the licensing methods.

4.1.7 The Drivers Experience and Related Accidents

It is believed that the experience of drivers plays a paramount role in road crashes. The distributions of a road crash in Burayu town are also affected by the driving experience. In fig 4.8, it can be compared the traffic accidents of the five years from the perspective of the driver's experiences. Drivers with 5-10 years' experience committed about 48.01percent of the total accidents of these years. The second is drivers within the range of 1-2 years experienced also committed accidents of about 29.8 percent. This indicates that the accidents were most probably committed by the drivers of experience of 1- 10 years in general.

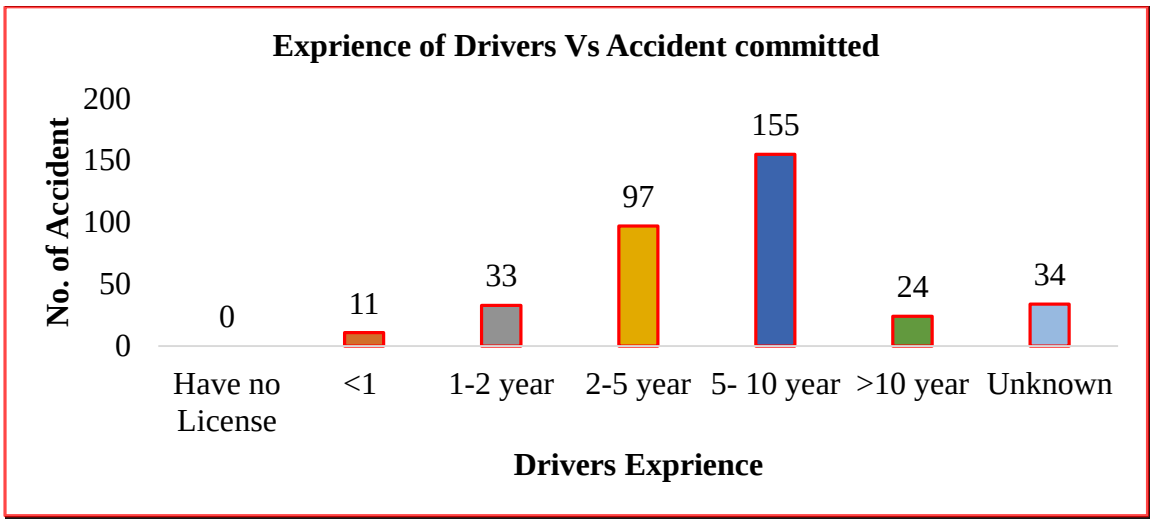


Figure 4. 8 The drivers' experiences Vs accidents

The accident rate was less to the experienced drivers less than years due to less confidence and then increased to the drivers of experienced from 2-10 years.

In total, when we see the accident causality by the driver's experiences category, it was in the experience of 2-10 years of the drivers' experience. These are most probably due to the high confidence of the drivers.

4.1.8. collision Types and road accidents

The collision types desired for the analysis include Face to face, Face to the back collision, face to the side, side to side, animals, Collision of pedestrian, Collision of standing vehicle, and others. These collision types were calculated as percentages of the total number accidents on the below table 4.2.

Table 4. 2 Collision Types and road accidents(2015 to 2019)

Year	Crash Types	No. of accident	Percent Shared(%)
2015-2019	Face to face	68	19.21
	Face to back collision	52	14.69
	face to side	49	13.84
	side to side	72	20.34
	Turning over	25	7.06

	Collision of pedestrian	78	22.03
	Falling from vehicles	0	0
	The collision of a standing vehicle	10	2.82
Total		354	100

Source: Burayu Traffic Police office

In the above table 4.2 presents that the percentage of road accident with collision type. The result implies that, the highest number of accident were recorded on Collision of pedestrian which is 78 and followed by side to side collision 72. However, the lowest percentage of accident were recorded on the collision of a standing vehicle type. This is due to awareness pedestrian, narrowness of lane width and missing shoulder. This result was supported by another study, this positive trend is proved up to a certain lane width, wider cross sections are characterized by a lower safety benefit or even by increasing accident risk [57]. The effect of shoulder width and type has been pointed out by different studies as an important aspect in crash frequency [58].

4.1.9. Effect of Road's Conditions on road traffic Accidents

Road environments such as dryness, moistness, muddiness, and others can affect the occurrence of road traffic accidents.

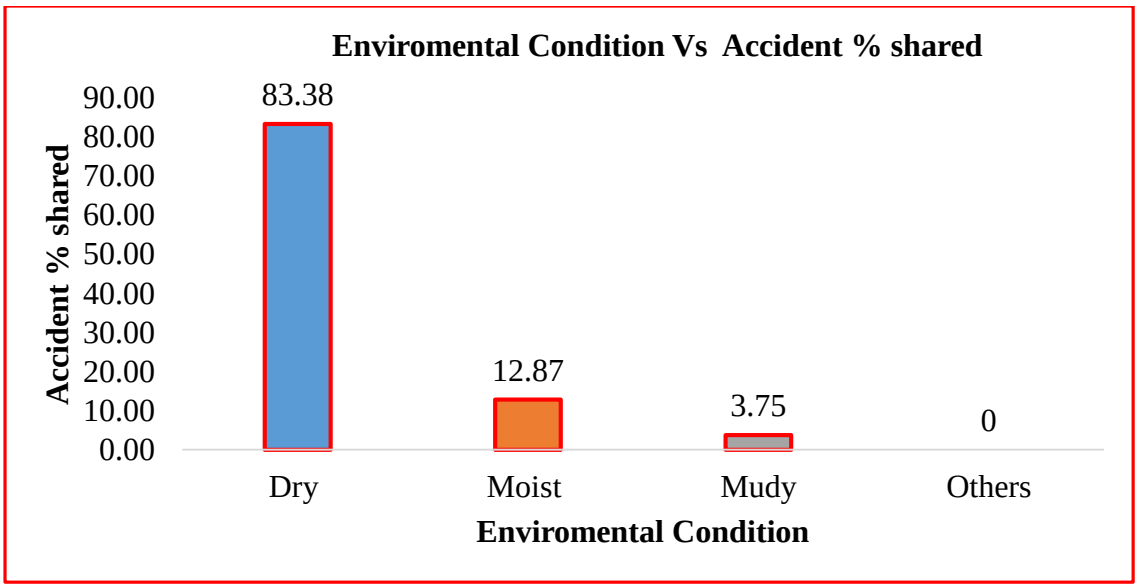


Figure 4. 9 The road's environmental conditions Vs Accident % shared

On the above figure 4.9 depicted that, the effect of road condition on traffic accident road. The result implies, most serious accident was occurred in dry conditions which recorded about 83.38% and minimum roads problem occurred muddy, moist, and others in of the situation.

4.1.10. The Light Condition and the Accidents Occur

Understanding the light condition of the environment and the vehicles are very important for the reduction of accidents.

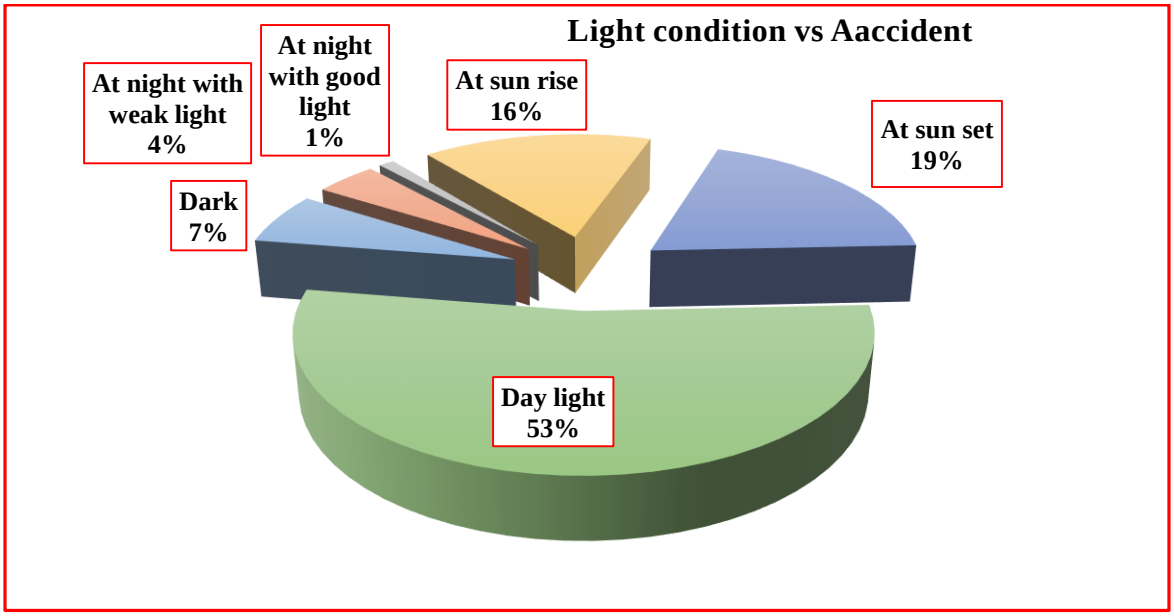


Figure 4. 10 The light conditions and committed accidents

In the figure 4.10 above, it could be expressed that about 53% of the injuries occurred due to the daylight or good light. Therefore, in this sense, we can say that the road accident occurred is not due to the problem of light. There is another factor behind these. Commonly, accident is happened at the sunset and sunrise; because the population of roads is very dense at this time as the people leave /get from /to the workplaces. The most notified accident is during the day time of the travel.

4.2. Vehicles Motion and Number of Accidents

The other factor that has to be seen thoroughly during the study is that the accidents from the perspective view of the motion of the vehicle on the roads. Some of the motion of the vehicle is the entrance to the joining roads, turning both right and left, passing over the other vehicles, straight traveling, getting out of the home, offices, celebrations, stopping, u-shape turning, etc. The activity of a vehicle has an effect on accident occurrences while it is in different state. In the figure 4.11 below, we can see that, the most accidents happened

due to the motion of vehicle during Straight forward traveling 60.73% and followed by Passing over the other vehicle 23.73%. This tells that the greatest occurrence of accidents arises from the narrowness of lane width, missing of median, speeding up of the drivers and carelessness of the drivers, losing awareness not to give priority than moving straight forward. Recent study found that, narrowness of lane width was greater effect on crash rate [54], Another study [59] found that type of median and nature of land use affect crash rate significantly.

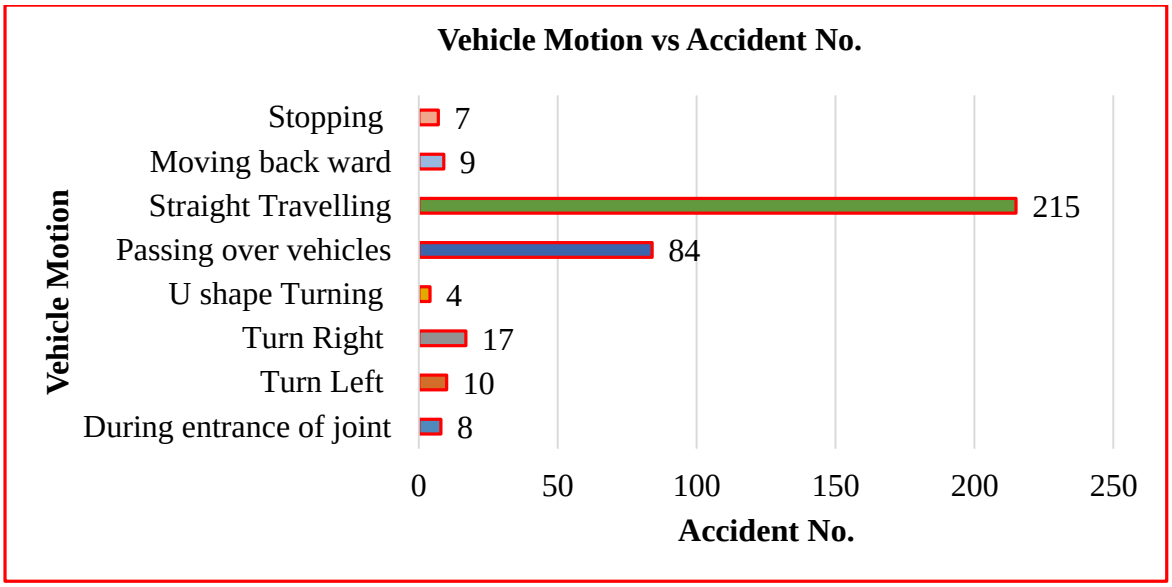


Figure 4. 11 The vehicle motion status Vs Accident No.

4.3 Effect of Road Alignment on road traffic accident

An accident is always characterized by multiple causes. The alignment of road is one of important influence factor for road traffic accident. The relationship between some characteristics of these elements and traffic accidents, including studies made in different countries are classified into groups: Cross-section effects and Alignment effects.

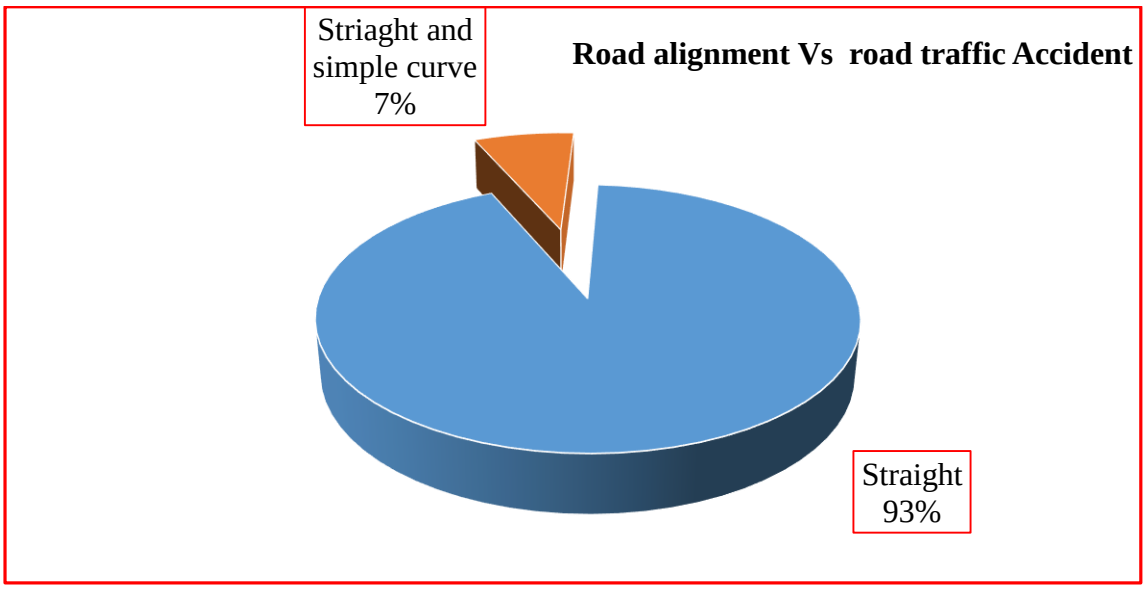


Figure 4. 12 Accident happened on road alignment

As depicted on the above Figure 4.12 effect of road geometric alignments (straight and simple horizontal curves) on road traffic accident in the study area. The highest road traffic crashes were recorded on straight roads with a percentage of 93% and followed by simple horizontal curves 7% only across the study road segment. According to traffic police crash data and report, the main reason of the accident was due to narrowness of lane width, high traffic volume and over speed of drivers along the study area. Straight line alignment of road highly chartered by cross sectional element effect. The widths of the various cross section elements affect the capability of driver to perform evasive maneuvers and determine the lateral clearances both between vehicles and between vehicles and other road users and Speed could be the main reason for road traffic crashes happened on straight and leveled road alignments [56].

4.4. Locations and features of the hazardous sections (Black spot location)

A total of Nine black spot locations is identified within the study area. Table 4.3 shows the list of blackspot locations together with accident shared and the rank orders. The top four results indicate more than 19.21% of accidents frequently happened in the last five years in industrial Zone while 12.71% happened in Gujje,11.86% in Bofata, 10.73% in kersa and the low accident occurred at Small Akaki Bridge and T-share respectively as shown in the table below.

Table 4. 3 Locations and features of the hazardous sections (Black spot location)

S.No	Location	No. of accident	% shared	Rank
1	Small Akaki bridge	25	7.6	9
2	Kersa	38	10.73	4
3	St. Gebriel	37	10.45	5
4	Around Tabot Madera	34	9.6	6
5	Industrial Zone(Tatek)	68	19.21	1
6	Gujje	45	12.71	2
7	Bofata	42	11.86	3
8	Kella	35	9.89	7
9	T-share	30	8.47	8
	Total	354	100	

Source: -Burayu town traffic Police office

In looking for the feature of the locations in the all black spot location of road segment is characterized by missing of shoulder, road sign, median, zebra and narrowness of lane width improper road sign post. For the road side environment there is no any barrier which limits the visibility along curves. Concerning the traffic regulation and road markings, at the entry to the section there is no speed limit post and a road mark which shows the division cross sectional elements of the road is invisible. The following figures shows some of the features of the road stretch.

Figure 4. 13 Missing of zebra and invisible road sign post at Gujje

Figure 4. 14 Improper side and cross drainage at Kersa

Figure 4. 15 Missing of median and narrowness of shoulder at Bofata

4.5 Causes and types of road traffic accident in hazardous locations

In relation to the survey made and traffic report from polices station concerning the general features of the hazardous location, the cause for the crash also identified in each sections. The following table 4.4 shows the detail cause of road traffic accident at each sections. Among all the causes, narrowness of lane width, shoulder, carriage way, speed, ignoring warning posts, improper drainage, absences of road mark, road surface condition such as deterioration of pavement road side, environment such as existence of fixed object which limits the accessibility of road users at the hazardous sections. Road related causes of road traffic accidents which are common for all road hazardous locations. Not only these roads related are the causes leading to loss of life and damage of property. Some of the causes are related to diver and road user behavior. These includes over speed, improper overtaking, improper pedestrians crossing and illegal road side trade. All of these listed causes are the major causes of road traffic accidents in hazardous sections located in the study area

Table 4. 4 Causes of road traffic accident at hazardous road segment

No	Location	Cause of road traffic accident
1	Industrial Zone	Missing of shoulder, Narrowness of lane width ,crowdedness of roads by labors
2	Gujje	Narrowness of lanes width, Missing of shoulder, zebra,
3	Bofata	Over speed, Narrowness of lanes width and shoulder, improper overtaking
4	Kersa	deterioration road side, missing road sign, ignoring warring post,

5	St. Gebriel	illegal road side trade, missing zebra, Narrowness of lanes width, Missing of shoulder
6	Tabot Madera	Narrowness of lane width and ignoring warring post
7	Kella	illegal road side trade, improper turning, unsafe lane change,
8	T-share	Absence of road side walk and zebra crossing
9	Small Akaki bridge	Narrowness of lane width, carriageway and improper drainage

Source: -site visit, questionnaires, Interview and Traffic police report

4.6 Types of Vehicles and Numbers of Accident

The vehicle type by itself has its own contribution to road traffic accidents in any world. The types of the vehicles which can cause accidents are Heavy load capacity known by their trademark of Isuzu, the public transport of 12 sit capacity and, heavy truckloads of 11-40,41-100 quintals loading capacity, taxes, special trucks with trailers, pickup, station wagons, bus, etc. Public transport with 12 loading capacities had much of the accidents than others relatively and it shares about 19.50% of total accident. On the other hand, heavy load trucks carrying capacity 41-100 quintal and pick up shares about 19.21 % road traffic accident. Thirdly the heavy load of 11-40 quintal also contribute about 15.25% from the total of accident. This is due to over speed and improper overtaking drivers.

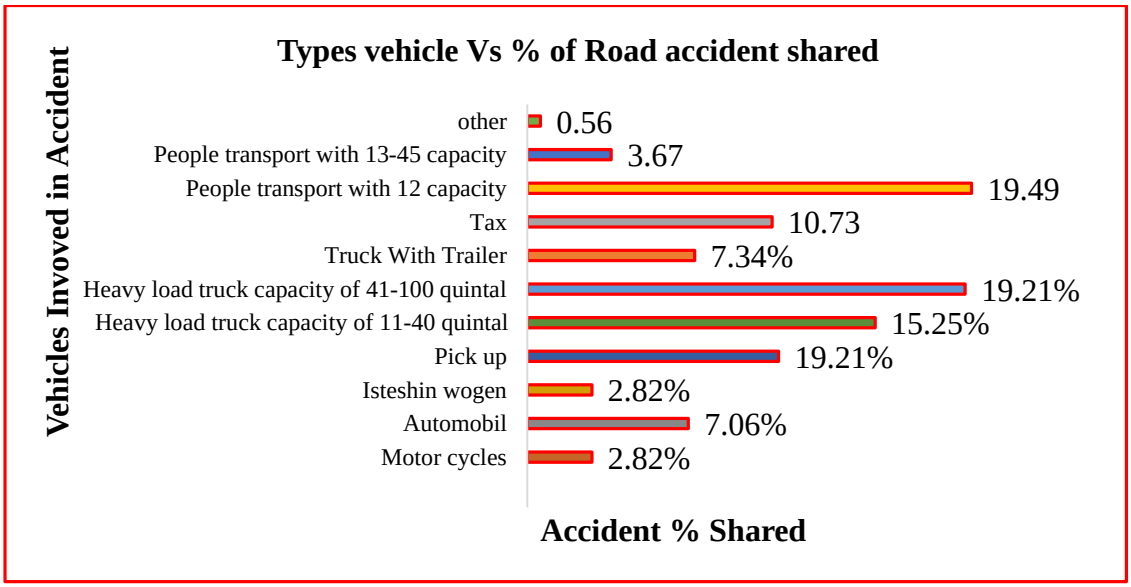


Figure 4. 16 Types vehicle Vs % of Road accident shared

4.7 Major Causes Contributing to Road Traffic accidents

4.7.1 Primary Causes Reported by Police

Accidents commonly had multiple causes, in that they stem from a number of adverse circumstances. The Ethiopian traffic police are responsible for completing the traffic accident forms. As indicated on a report from the federal police, more than 80 percent of the total traffic accidents were caused by human error (drivers and pedestrians) and appeared to be a serious problem as reported by the police. The contribution of vehicle defects to road traffic accidents as identified by the police is small percent, which was lower than as one could expect from vehicle accidents. Moreover, the contribution of road factors is not well identified by the police as the causes of traffic accidents. Analysis of the police statistics shows that the main causes for all accidents that are related to driver's error include excessive speeding, failure to give way for vehicles and pedestrians, and improper overtaking. According to analyzing accident report from 2015 to 2019, it was found that of all accident, 73.18 percent were caused by driver error,8.28 percent were caused as the result of the pedestrian error,5.63 percent were caused as the result of vehicle defects and the rest of 12.91percent result of others and unknown factors.

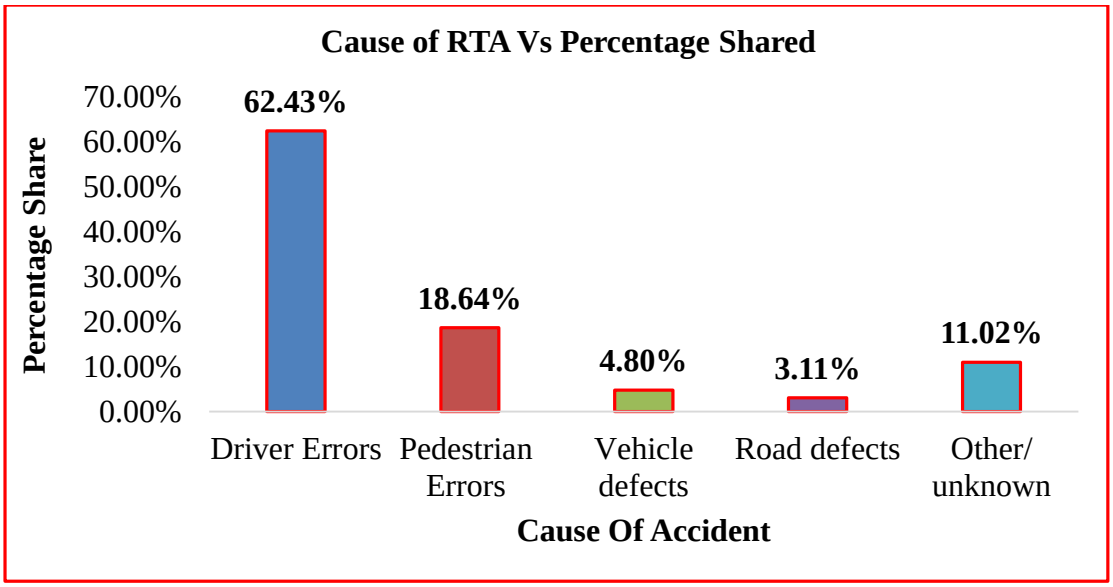


Figure 4. 17 Cause of Accident Reported by Traffic Police Vs % shared

4.7.2 Observed and Questionnaire Surveyed Based Factors that Contribute to RTA

The police traffic accident statistics in Burayu Town indicated that road defect, driver problems, and pedestrian problems are the main causes of the great majority of road accidents in the road. Higher accident occurrences correlated to the road defect can be explained by many factors, including road sign, marking, and narrow shoulder, Lane, Carriageways, and

inadequate understanding of the value and use of traffic regulations. These are being believed to be the major causes of the higher accident rates by drivers in Burayu road.

Table 4. 5 Questioners for drivers

Questioners for drivers	**Alternatives response**						Total No. Respondent
	High		**Medium**		**Low**		
	No	%share	No.	%share	No.	%share	
1. What is the general characteristic of a road traffic accident in Burayu?	35	77.7%	10	22.2%	0	0	45
2. How do you rate pedestrian respecting for vehicles in giving priorities where necessary?	**Good**		**Moderate**		**Poor**		
	5	12.5%	10	25%	30	66.6%	45
3. When you drive, have you give way to the pedestrian as required by law?	**Always**		**Sometimes**		**Never**		
	32	71.1%	8	17.7%	5	11.1%	45
4. At what section of road was most of the time accident occurred?	Straight(Tangent)				Simple horizontal curve		
	38		84.44%		7	15.55%	45

As shown on the above table, the majority of drivers answer (77.7% percent) of the total responded all most all that road traffic accident was big problem in Burayu Town, (22.2) percent answered as medium problem and for the second question the majority of drivers 66.6% confirms with poor ranking while only 12.5% give first for pedestrian. Among the total respondent, 25% of drivers were medium on give priority for a pedestrian on the road. From the above table more road traffic accidents were happen on tangent road which counted about 84.44% from total accidents. Thus the drivers blame the pedestrian characteristics in applying the laws, rules of traffic and due to narrowness of lane width missing of median and etc. To compare the idea discussed above, the researcher has

prepared another question to study the characteristics of drivers by taking sample pedestrians as presented below.

Table 4. 6 Questioners for pedestrian

Questioners for pedestrian	**Alternatives response**						Total No. Respondent
	Always		**Sometimes**		**Never**		
	No	%share	No.	%share	No.	%share	
1. Are drivers slow down or stops in pedestrian crosswalks when you are crossing?	7	15.5%	5	11.1%	28	62.2	45
2. Is there proper pedestrian Crossing ?	**Yes**		**No**				
	38	84.4%	7	15.55%			45
3. Who do you think about how should be the most responsible for a traffic accident?	**Drivers**		**pedestrian**		**Government**		
	17	42.5%	10	25%	18	40 %	45

For the first question, 62.2% of the respondent said "Never," and 11.1 % answered as "sometimes." This shows that few drivers were prepared to stop or slow down for pedestrians while crossing the roads.

For the second question, the majority of the surveyed pedestrians, 84.4 %, indicated that they agreed that there are no proper pedestrians crossing. Therefore, it can be concluded that pedestrians at crossing points can be at great risk due to missing of zebra. In addition, there is a lack of appropriate discipline among drivers in the traffic system when overtaking, changing lane, crossing, or entering a road. It is common to see a driver almost widely turning the vehicle without giving priority and signs to other road users in the traffic system of the town. Therefore, respect for traffic regulations in the town is very much dependent on the physical presence of traffic police.

4.8: Cause of road Traffic Accidents Based on traffic police response

From the main causes of road traffic, the drivers take place in the first place. Some of the factors for the drivers' accident commitments are the following.

1. Driving beyond the speed limit
2. Denial of passenger's priority
3. Loading beyond capacity
4. Loading people on material carrier trucks
5. Negligence problem
6. Carelessness where there are animals and people in density
7. Rejecting traffic signs and regulations
8. Lack of driving or behavioral problem

4.9 Factors that affect traffic accidents rate

There are money factors that affect traffic accident rate. Among them, the most common rate factor on these roads are the drivers, the vehicle problem, and the roads network.

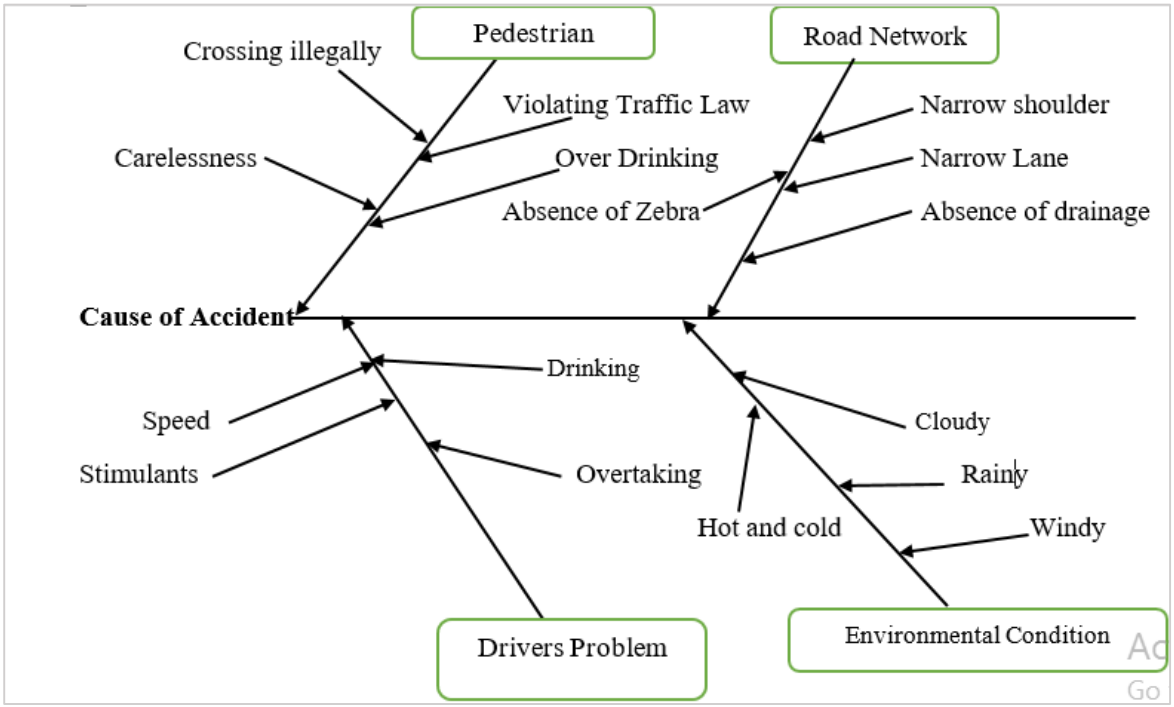


Figure 4. 18 Factors that affect traffic accident

The above figure 4.18 indicated that, factors which are affect traffic accident rate. This result implies that, factors which rates pedestrian problems are crossing illegally, carelessness and violating traffic law along the road segment. Another factor which rate traffic accidents are road condition which identified from the site visit using road checklist

audit are; narrowness of lane width, shoulder and absence of zebra etc. Drivers problem is the other major factors in rating road traffic accidents which results from over speeding, improper over taking and using stimulants.

4.10 Effects of road cross-section element on the road traffic accident

4.10.1 During site visit

Cross-sectional elements play an essential role in defining the operational traffic efficiency of any roadway. Key cross sectional elements that influence traffic operations include the number and width of lanes, the presence, and widths of shoulders and highway medians. The existing values of cross-section elements for the audit road have been measured and compared with the ERA geometric design manual, as shown in the table below. In order to check the design standard of the cross-section of the road of the study area, the researcher should have to know the standard design of the road.

Table 4. 7 Comparison between ERA Standard and Observed value

No.	Roadway Elements	ERA standard	Observed value
1.	Traffic volume	DS4(traffic volume)	Traffic volume close to the high capacity of a DS1
2	No of Lanes	Two-Lane	Two Lanes
3	Carriageway width	6.5-7m	5.8-6.46
4	Shoulder width	1.5-3m	0.1-1.1
5	Design speed	25-70 km/hr.	80-120km/hr
6	Pedestrians cross	controlled	uncontrolled
7	Median	painted	Not exist
8	Drainage system	controlled	Not properly work
9	Road side light	controlled	Not work properly
10	Guard rill	controlled	Improper

11	Roadside traffic sign	controlled	Not exist
12	Roadside Traffic mark	marked	faded

Source: - ERA manual 2002

From the above table observed that, almost all the sections of the road found during the safety audit are missing of road markings and shoulder, narrowness of lane width, damage guardrails and the road signs such as warning signs were also completely worn out, invisible and some were improper placement at some sections of the road.

4.10.2. Correlation Analysis

The correlation analysis coefficient(R) measures the degree of the linear relationship between two variables. This value can also be viewed as the strength of the linear relationship. It takes values from -1 to 1. A value of 0 means that there is no linear relationship between the two variables. Positive values of the correlation coefficient indicate that the two variables tend to be both large or both small at the same time. Negative values indicate an inverse relationship [60].

4.10.2.1. Independent Variables (Selected Cross Sectional Elements)

Independent variables, or explanatory variables, include those characteristics of the road segments that have a possible correlation with safety (or dependent variables). It was important to consider as many characteristics as possible at the onset, to be able to properly account for any variables influencing the accident histories of the segments. Independent variables collected in this database included lane width, shoulder width, Age of driver's Carriage width, Roadways and traffic volume. Correlation coefficients were calculated for each pair of variables to determine if the use of any variable was redundant [60].

Table 4. 8 Correlation Between Selected Cross Sectional Elements

Independent variables	shoulder width (m)	Lane width (m)	Carriageways(m)	Roadways (m)	AADT (No)
shoulder width(m)	1.00				
Lane width (m)	**-0.99**	1.00			
Carriageways(m)	**-0.99**	1.00	1.00		
Roadways(m)	**-0.96**	**0.99**	**0.99**	1.00	
Traffic volume	**-0.79**	**0.70**	**0.70**	**0.59**	1.00

Table 4.8 shows the correlations between all cross sectional elements. The independent variables showed a substantially high positive or negative correlation to each other, which means that all independent variables (cross sectional elements) have been considered in the investigation. As indicated in the above table, all independent variables have a strong relationship with each other because all correlation coefficient (R – values) are closest to +1 or -1.

4.10.2.2 Relationship Between Cross Sectional Elements and Traffic Accident

Dependent variables (road traffic accident), or response variables obtained for this database was traffic accidents. The correlation coefficients (R) between selected cross-section elements and road traffic accidents are illustrated in Tables 4.9 below, respectively.

Table 4. 9 Correlation of road cross-section with Accident occurred

Shoulder width(m)	**Accident committed**	**Width of Lane (m)**	**Accident committed**
0.1	68	2.8	68
0.2	45	2.9	45
0.3	42	2.95	42
0.35	38	3	38
0.4	37	3.1	37
0.6	36	3.13	36
0.95	35	3.15	35
1	30	3.2	30
1.1	25	3.3	25
R=-0.79		R=-0.91	
Carriageways(m)	**Accident committed**	**Roadways(m)**	**Accident committed**
5.6	68	5.8	68
5.8	45	6.2	45
5.9	42	6.5	42
6	38	6.7	38

6.2	37	7	37
6.26	36	7.46	36
6.3	35	8.2	35
6.4	30	8.4	30
6.6	25	8.8	25
R=-0.91		R=-84	

Almost all independent variables, the shoulder width, lane width, Carriageways, and Roadways, have a negatively strong correlation with a road traffic accident.

Table 4. 10 Age of drivers and Road traffic accident occurred

Age of Drivers	**Accident occurred**
<18	0
18-30	168
31-50	119
>50	39
Unknown	28
R= -0. 17	

Source: -Burayu Town traffic Police Office

However, the age of drivers had lower correlation coefficients with a road traffic accident. The negative sign indicated that they have an inverse relationship, which means explanatory variables become increase, the response variable becomes decrease and vice versa. Therefore, from the result concluded that, excluding the age of drivers all cross sectional elements are proposed for regression analysis to check their significance.

4.11 Regression Analysis

To determine whether there was a statically significant relationship for the 95-percent confidence interval (significant level of a = 0.05). Regression coefficient (R)Value indicated that the strength of association between independent variables and dependent variables, R-square (R^2) showed impact percentage of independent variable on dependent variable and SS indicated the fitness of models [60]. The analysis made between each road cross-sectional elements with Traffic accident.

Table 4. 11 Regression analysis between independent variables and dependent variables

S.No	Independent variable(M)	Regression out put					
		R	R^2	Standard error	SS		Significance
					Regression	Residual	
1	Shoulder	0.79	0.63	7.94	749.02	441.21	0.02
2	Lane	0.91	0.82	5.46	981.45	208.77	0.00
3	Carriageways	0.91	0.82	5.46	981.45	208.77	0.00
4	Roadways	0.84	0.70	7.08	838.97	351.25	0.00
5	ADDT	0.94	0.89	6.94	1148.20	144.6	0.02
6	Age of driver	0.18	-	-	-	-	0.8

shown in table above indicated that, there were strong relationship between two variables (dependent and independent) and the model is fit. Finally, except age of drivers, all independent variables had significant impact on dependent variables, which indicated the value between 0-0.02. It fulfills the requirement of P-value. The correlation was considered significant if (P) is zero or 0.05 percent different from zero [52]. However the age of diriver was out range.

4.11.1 Relationship between shoulder width and accidents

More of selected road segment had no shoulders. Only some parts of road segment have narrow shoulders. Shoulder widths in the proposed road segment were categorized as no shoulder and 0.1-1.1m range width.

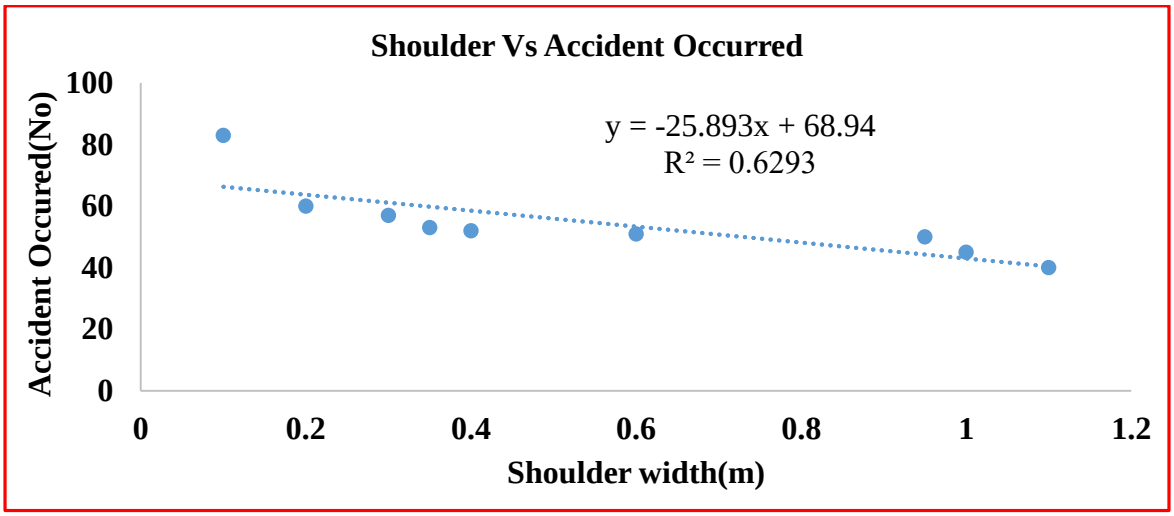


Figure 4. 19 Regression analysis of shoulder with Accident Occurred

The above figure showed that, the relationship between shoulder and road traffic accident by using regression analysis. It indicated that shoulder-width had a strong relationship (negatively correlated) with traffic accidents, which means the shoulder has a significant impact on a traffic accident. This result supported by another study, decrease the shoulder width is associated with increasing in traffic accident by 21% [28]. So in this investigation shoulder width have about 62% contribution on the occurrence of road traffic accident.

4.11.2 Relationship between Lane width and road traffic accidents

In the proposed study area all length of road was one lane two direction. During filed measurement using road safety audit checklist the road segment was characterized by narrow lane width, which is ranged between 2.68-2.85.

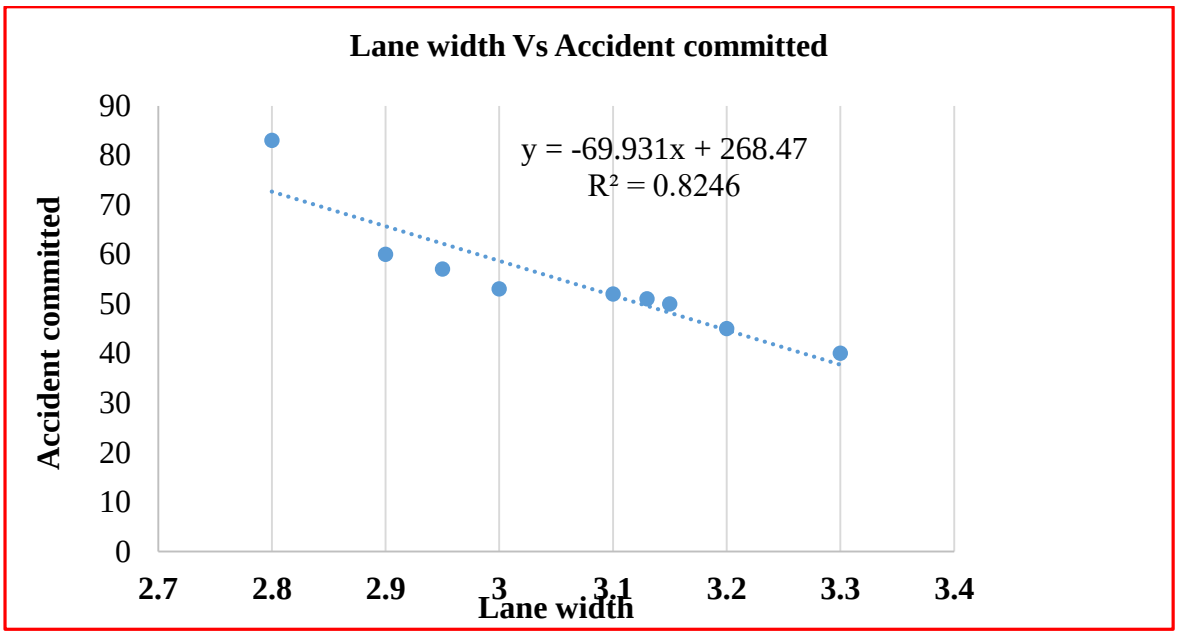


Figure 4. 20 Lane width relationship with a number of accidents.

The above figure showed that, the relationship between Lane width and road traffic accident by using regression analysis. It indicated that Lane width had a strong relationship (negatively correlated) with traffic accidents, which means the lane width has a significant impact on a traffic accident. One study investigated that, lower accident rates are attributed to wider lanes. But it seems that there is an optimal lane width around 3.5m [22]. In another related study, increase lane width by 1m reduce road traffic accident by 14-34% [61]. So in this investigation lane width have about 82% contribution on the occurrence of road traffic accident.

4.11.3 Relationship between carriageway width and road traffic accidents

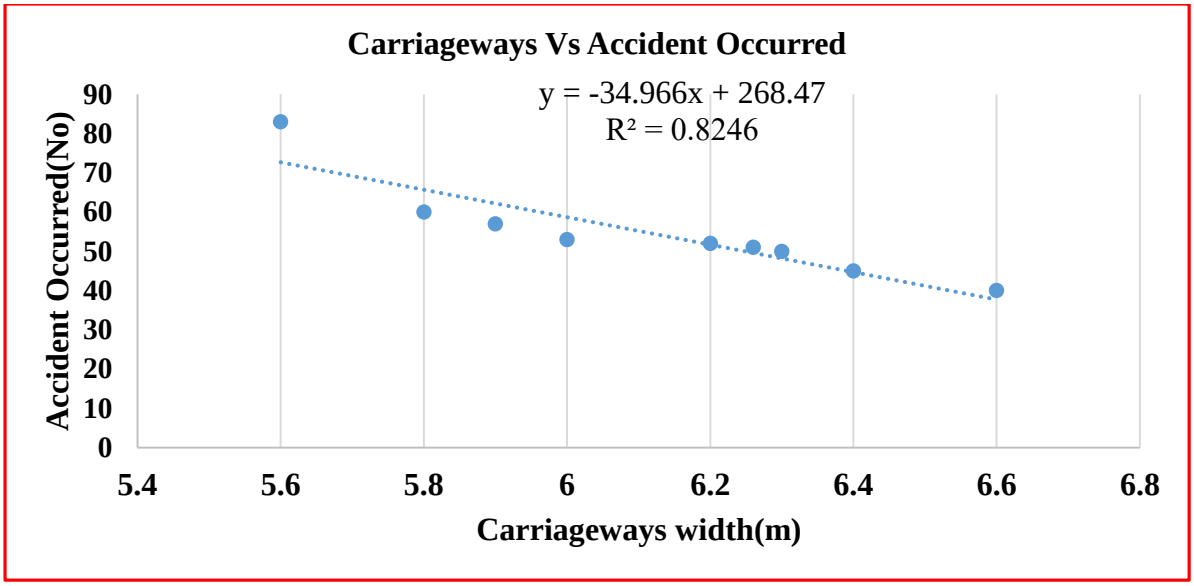


Figure 4. 21 carriageways Vs Accident Occurred

Again the above analysis showed that the width of carriageways had a negatively strong correlation with the occurrences of a traffic accident. Therefore, as described in the above figure the carriageway width have about 82% impacts on traffic accidents.

4.11.4 Relationship between Roadway width and road traffic accidents

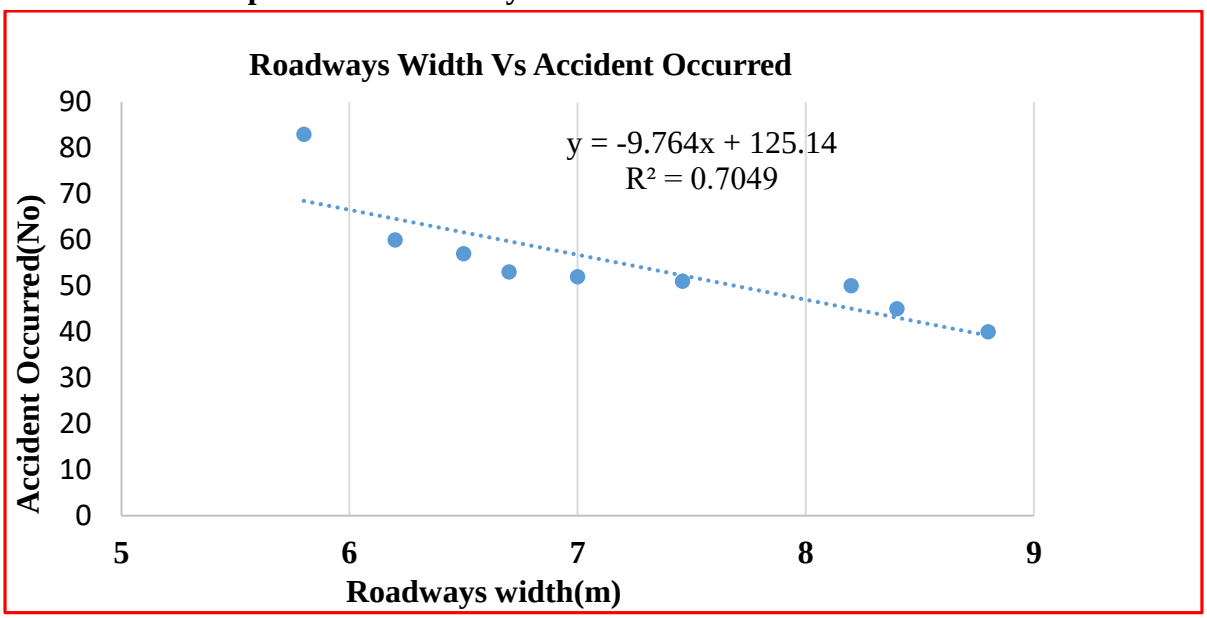


Figure 4. 22 Roadways with accident Occurred

As indicated on the above figure the width of road way had a negatively strong correlation with the occurrences of a traffic accident and it contributed about 70% for the occurrence of road traffic accidents.

4.11.5 Relationship between Traffic Volume and road traffic accidents

Traffic volume is very important parameter in of geometric design and take consideration as criteria during design period, the Average annual daily traffic was recorded about 989, which is categorized under DS4, However the current traffic volume was 10275, which is categorized under design standard of DS1.

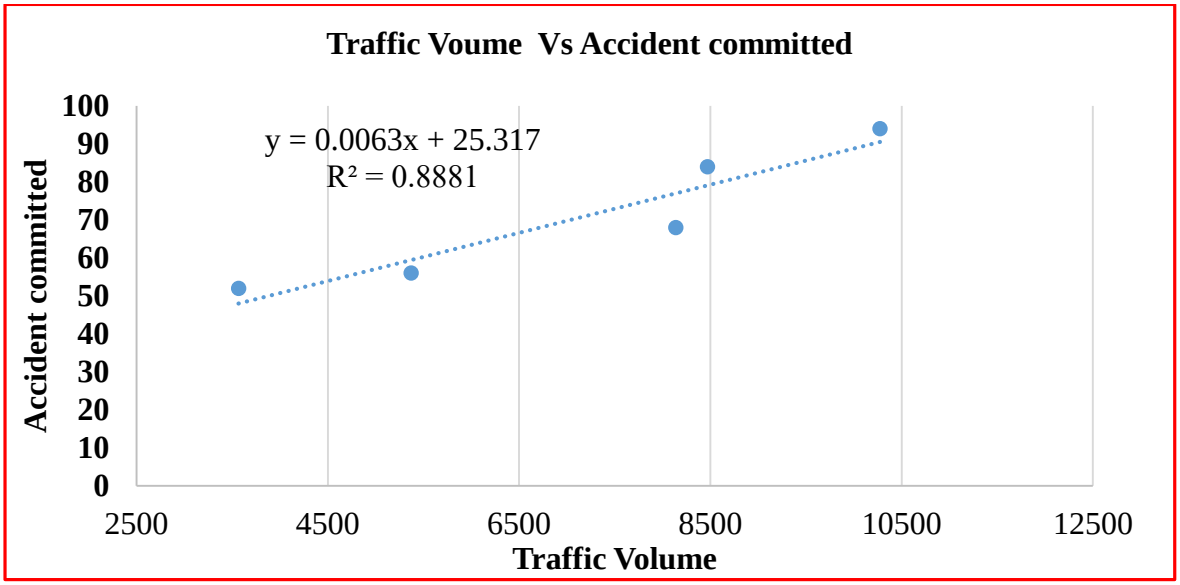


Figure 4. 23 AADT and number of accidents

As indicated on the above figure, road traffic accident has directly proportional to traffic volume and it has a significant impact on a traffic accident by 88%.

Generally, all Road cross-section elements selected for this analysis had strong relationships with a traffic accident and had a significant impact on the occurrences of traffic accidents.

4.11.6 Relationship between driver age and road traffic accidents

Table 4. 12 Regression analysis of driver age vs. accident Occurred

Correlations

		Age of driver	Accident No.
Age of driver	Pearson Correlation	1	-.179
	Sig. (2-tailed)		`.773
	N	5	5
Accident No.	Pearson Correlation	-.179	1
	Sig. (2-tailed)	.773	
	N	5	5

The above table showed that, the relationship between age of driver with road traffic accident. It indicated that age of drivers had a low relationship with a traffic accident, and it has insignificant impact on road traffic accident.

Table 4. 13 Regression model equation correlation coefficient and p-value less than 0.05

Types of regression	**Model No.**	**Formula**	**p-values**	**R**	**R^2**
Linear Regression	1	RTA=-25.893(sh.w)+68.94	0.01	0.79	62.93%
	2	RTA=-69.931(LW)+268.47	0.00	0.91	82.46%
	3	RTA=-34.966(C.w)+268.47	0.00	0.91	82.46%
	4	RTA=-9.76(R.W)+125.14	0.00	0.84	70.44%
	5	RTA=0.0063(AADT)+25.317	0.02	0.94	88.81%
	RTA: -Road traffic accident AADT: -Average annual daily traffic Sh. W: Shoulder width C.W: - Carriageways width R.W: -Roadway width				

4.12. General Crash Situations and Potential Countermeasures

After the field survey and site, the visit was conducted, and the observation time was compared with ERA Standards. Accordingly, the possible countermeasures are proposed for identifying the road design problem or hazardous location.

Table 4. 14 General crash situations and potential countermeasures

General Accident Situation	**Potential Countermeasure or suggestion improvement**
Pedestrian/vehicle conflicts	pedestrian/vehicle segregation (sidewalks or wide shoulders) raised pedestrian crossings speed control devices
Loss of control	road markings, delineation, speed control devices guardrails
Dis mantling of a road sign	Improve the road sign on the appropriate place
Improper design of the shoulder	Increase the right of way
Carriageway too narrow	Minimize median width and increase climbing lane
Improper drainage	Open the side inlet and outlet of the drainage and remove the soiled
Improper median opening and design	Minimize the width of median and only sign and close the median up to zebra
Light/heavy vehicle conflicts	Increase climbing lanes
Excessive Speeding	speed limits, enforcement, speed control devices

The above table indicates that improve the road infrastructures (road light, road marking traffic sign) and improve the problem of road design element are devices were proposed as a prime counter-measure to address the identified accident situation.

4.13. Comparison with standard

The existing values of cross-section elements for the audit road have been measured and compared with the ERA Geometric Design manual. (Two Rural road DS4 Paved) Highway) as shown in table 4.15 below.

Table 4. 15 Comparison of ERA standard and the observed value

No.	Roadway Elements	ERA standard	Observed value
1.	Traffic volume	DS4(traffic volume)	Traffic volume close to the high capacity of a DS1
2	No of Lanes	Two-Lane	Two Lanes
3	Carriageway width	6.5-7m	5.8-6.46
4	Shoulder width	1.5-3m	0.1-1.1
5	Design speed	25-70 km/hr.	80-120km/hr
6	Pedestrians cross	controlled	uncontrolled
7	Median	painted	Not exist
8	Drainage system	controlled	Not properly work
9	Road side light	controlled	Not work properly
10	Guard rill	controlled	Improper
11	Roadside traffic sign	controlled	Not exist
12	Roadside Traffic mark	marked	faded

4.14 Potential Countermeasures/ Suggestions for improvement

-Provide the markings on the road. -Provide the zebra crossings near the bus stand and junction for the safe crossing of the pedestrians. -Provide the speed limit signboards in the city -signs not located appropriate places	
-The pedestrian sidewalk should be constructed -Construct side ditch -Provide road marking	
-Provide shoulder	

-Provide proper drainage systems	
-Clear zone standards	
-Inadequate Traffic channelization to reduce conflict -Awkward differences in level on the main road and approach to and the junction road -Provide a signpost for the junction road	

4.15. Possible countermeasure for road cross-sectional element Existing Road

Road segment/location	Roadway element problems and others	Recommendation
New Ambo Road Small Akaki Bridge to	High Traffic volume	providing a higher capacity road DS1(link road)
	Clear zone	Additional wending
	Narrow shoulder	Widening and establish curbed

		shoulder
	Missing shoulder	Construct proper shoulder
	Narrow lane width	Provide appropriate Lane width
	Design speed	Installing speed Limit post
	Inadequate side ditch, surface drainage	Installing a proper drainage system
	Inadequate pavement marking	Installing road pavement marking
	Inadequate road sign	Installing a roadside signpost
	Missing of zebra	Installing zebra at the appropriate place

4.16. Possible countermeasure for driver

No.	Observed and through interview and questionnaire	Possible countermeasures
1	-Influence the drivers to the choice of speed.	Post the design the desired speed and speed limit for each section of the road appropriate to the function of the road according to the standard
2	Driving beyond the speed limit	Drive with permitted speed only
3	Denial of passenger's priority	Give away for pedestrian first
4	Loading beyond capacity	Load the permitted capacity only to safe life of a passenger
5	Carelessness where there are animals and people in density	Give attention to all things on the road during driving
6	Rejecting traffic signs and regulations	Obey rule and regulation
7	Lack of driving or behavioral problem	Respect humanity

4.17. Possible countermeasure for pedestrian's

No.	Observed and through interview and questionnaire	Possible countermeasure
1	Illegal pedestrian crossing	pedestrians avoid major conflicts with vehicular traffic
2	Awareness of pedestrians towards traffic law	Obeying traffic law
3	Carelessness while crossing the road	Using pedestrian cross

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The situation of a road traffic accident at the world level is getting worse. Despite a small number of vehicles operating in the country, the level of accidents recorded each day made the country one of the tops in the world. The Small Akaki Bridge to Menagesha road is the focus of this study, and all the data used in the study is collected from the traffic police office of Burayu town accidents registered on this road. The data was collected for accidents registered during the last five (5) years. Both qualitative and quantitative methods are used to analyze the data and interpret the results.

The traffic accident on the way from Small Akaki Bridge to Menagesha road varies according to different factors such as Severity type, Days of week, Age of the driver's, the environmental conditions, Educational background of drivers, drivers experience, collision type, Light condition, road alignments, vehicle Types and the vehicles situation. The roads are somewhat straight compared to the other roads of the countries, but the accidents on these roads are causing fatal of about 20.34%, 15.26% serious injuries, 16.67% slight injuries, and 47.74% property damages. It was estimated incurred cost of 8,583285 ETB on these the routes. On the other hand, 62.43% injury occurred due to driver's errors,18.64% due to pedestrian errors,3.11% due to vehicle defect, and 11.02% occurred due to unknown errors.

The highest number of accident were recorded on Collision of pedestrian which is 78% and followed by side to side collision 72%. However, the lowest percentage of accident were recorded on the collision of a standing vehicle type. This is due to awareness pedestrian, narrowness of lane width and missing shoulder.

The activity of a vehicle has an effect on accident occurrences while it is in different state. the most accidents happened due to the motion of vehicle during Straight forward traveling 60.73% and followed by Passing over the other vehicle 23.73%. This tells that the greatest occurrence of accidents arises from the narrowness of lane width, missing of median, speeding up of the drivers and carelessness of the drivers losing awareness not to give priority than moving straight forward.

The alignment of road is one of important influence factor for road traffic accident. The highest road traffic crashes were recorded on straight roads with a percentage of 93% and followed by simple horizontal curves 7% only across the study road segment. According

to traffic police crash data and report, the main reason of the accident was due to narrowness of lane width, high traffic volume and over speed of drivers along the study area.

The types of vehicle which are causing these most of the time are these People transport with 12 capacities such as minibus, taxis, the pickup trucks, heavy load trucks such as 11-41 quintal load carriers (ISUZU), heavy trucks of load carriers of 41-100 quintals, transportation bus of sit 13-45 types of vehicles are the most common on these roads to cause accidents.

The major causes of road traffic accidents as identified by the traffic Police Officers report, key information from the respondent(pedestrians car drivers, traffic office) through interview and questioner are: road design problems (narrowness of lane width ,shoulder, absence median, roadside mark, centerline), over speed, failure to give way for vehicles and pedestrians, overtaking , improper turning, speeding driving, lack of awareness of pedestrians towards traffic law, failure to respect the right-hand rule contributed much to the misery of road crashes in the road. According to analyzing accident report from 2015 to 2019, it was found that of all accident, 73.18 percent were caused by driver error,8.28 percent were caused as the result of the pedestrian error,5.63 percent were caused as the result of vehicle defects and the rest of 12.91percent result of others and unknown factors.

Cross-sectional elements play an essential role in defining the operational traffic efficiency of any roadway. Using correlation analysis coefficient(R) measures the degree of the linear relationship between cross sectional elements and road traffic accidents. The result implies that; all independent variables have a strong relationship with each other because all correlation coefficient (R – values) are closest to +1 or -1

Likewise, according to the regression model analysis, it was identified that traffic accidents have a high relationship with cross-sectional elements of roads at p-value less than 0.05. These variables have a determinant effect for an accident to happen. Based on the result of the regression analysis, accident predicting equation for Small Akaki Bridge to Menagesha road was defined using the independent variables stated above.

In general, it's clear that road accidents have been a serious problem in our everyday life. This study identified the causes of the accident using engineering measurements for the road segment. In addition, accident prediction models were developed through investigating factors contributing to the occurrence of the accident and that enlarge the severity of accidents on Small Akaki Bridge to Menagesha road using survey data obtained from Traffic Safety and Burayu traffic Police office.

5.2 Recommendations

Based on a deep understanding of the main causes of accidents, low-cost engineering measures were proposed. On the existing situation or identified causes, the improvement was suggested.

In general, the following recommendations should be implemented.

- ✓ Majority of the RTAs in Burayu Town road are occurring at day. Hence, the Traffic polices should be assigned properly.
- ✓ Increase lane width, shoulder, right of way, provide proper median) and develop the road infrastructures (road light and marking, traffic sign, sign inventory like speeds limit).
- ✓ Road safety audit surveys should be done for short intervals to observe changes in the road structure and equipment as well as the road environment.
- ✓ Trainings should be provided to traffic officers on how to use GPS to specify where the accident has occurred and the data can easily be used to map and take countermeasures in the RTA risk areas.
- ✓ Strict traffic police enforcement and speed control
- ✓ Giving training regards traffic laws for both pedestrian and drivers regularly
- ✓ providing pedestrian sidewalk and zebra
- ✓ Providing appropriate drainage systems
- ✓ Final training should be given for traffic police on how they have record data, preparing format used for data record and controlling road traffic accident well.

References

[1]. Dipo T. Akomolafe Akin bola Olutayo, “Using Data Mining Technique to Predict Cause of Accident and Accident Prone Locations on Highways," American Journal of Database Theory and Application 2012, 1(3): 26-38.

[2]. WHO, World report on road traffic injury prevention, Switzerland, Geneva, 2013.

[3]. William Eckersley, Ruth Salmon, and Mulugeta Gebru, “Khat, Driver Impairment and Road Traffic Injuries: A View from Ethiopia," Jerusalem Children and Community Development Organization, Addis Ababa, Ethiopia, January 2010.

[4]. Ethiopian Road Authority, “How safe are Ethiopian roads?”, Unpublished road safety report, Addis Ababa, Ethiopia, 2005.

[5]. Chen, G. (2009). Road Traffic Safety in African Countries: Status, Trend, Contributing Factors, Counter Measures and Challenges; Unpublished Final Report, University Transportation Research Center, New York.

[6]. S. I. a. M. E. A.F. Iyinama, "Analysis of Relationship Between HighwaySafety and Road Geometric Design Elements: Turkish Case".

[7]. G. Segni, "Causes Of Road Traffic Accidents And Possible Counter Measures On Addis Ababa-Shashemene Roads," April 2007.

[8]. The Federal Democratic Republic of Ethiopia, Ethiopian Roads Authority. Road,Sector Development Program (1997 - 2007): Second Draft Final Report; Addis Ababa January 1996.

[9]. Federal Democratic Republic of Ethiopia: Ethiopian Roads Authority. Road safety audit manual, September 2004.

[10]. United Nations. Case study: Road safety in Ethiopia, 2009. [Cited 23 August, 2013].

[11]. Association for Safe International Road Travel. Road travel report in Ethiopia, 2004.

[12]. World Health Organization report (2013)

[13]. WHO. Global Status Report on Road Safety. Geneva: WHO; 2013.

[14]. Douglas, W., Joseph, E., and Kelth, K., "Operational and Safety Effects of Highway Geometrics at the Turn of the Millennium and Beyond," TRB, National Research Council, Washington, D.C, 2000.

[15]. Sonowal, A. G. (2009). A Statistical Analysis of Road Traffic Accidents. Dibrugarh City, Assam, India.

[16]. Kamal et al. (2008). Accidents black spots on highways and their low-cost remedial measures; University of Engineering and Technology, Taxila, Pakistan.

[17]. Bhat and et al. (Nov-2013). Accident Prediction Modelling for an Urban Road of

Bangalore. IJRET: International Journal of Research in Engineering a Technology.

[18]. Wang, C., M.A. Quddus, And S.G. Ison, “The Effect of Traffic and Road Characteristics On Road Safety: A Review and Future Research Direction”.

Safety of Science. 57: P. 264-275,2013

[19]. Rue Garridoa, *. A. (2-4 July 2014). Prediction of road accident severity using the I have ordered probity model — 17th Meeting of the EURO Working Group on Transportation, Sevilla, Spain.

[20] Asrat, Y. (February 2015). Descriptive Analysis of Road Traffic Crash. Addis Ababa.

[21] Zegeer, C., R. Stewart, F. Council, And T. Neumann. 1994. Accident Relationships of Roadway Width On Low-Volume Roads. Report No. Trr 1445. Washington, D.C. National Research Council. Transportation Research Board, Pp. 160-168.

[22]. Rovira, Ziang Allan c, Hansen. (2010).mechtronics and intelligent systems for off road vehicles.

[23]. Department of transport and main road management (2011)

[24]. Tyler and Francis (2012). Young And Unlicensed: Risky Driving Before Entering The Licensing System. Traffic Injury Prevention.

[25]. Blume, U., and M. Gaudry. (2000). The SNUS-2.5 model for Germany.

[26]. Garber, N.J., "The Effect of Speed, Flow, and Geometric Characteristics on Crash Rates for Different Types of Virginia Highways", Virginia Transportation Council, 2000.

[27]. Elvik, R., "To What Extent Can Theory Account For The Findings Of Road Safety Evaluation Studies? Accident Analysis & Prevention'', 36(5): P. 841-849, 2004.

[28]. Zegeer, C., R. Stewart, F. Council, And T. Neumann. 1994. Accident Relationships of Roadway Width On Low-Volume Roads. Report No. Trr 1445. Washington, D.C. National Research Council. Transportation Research Board, Pp. 160- 168.

[29]. AASHTO. A Policy of Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C., in 2004. (1)

[30]. Sarah Copsey. (2010). a review of accidents and injuries to road transport drivers, European

[31] Department for Transport (2013b) National road safety communications activity calendar: Department for Transport, London

[32]. Addis, Y. (2003). The Extent, Variation, and Causes of Road Traffic Accidents in Bahir Dar. MA in Geography, Addis Ababa University.

[33]. Ajit, G., and S. Ripunjoy (2004). A Statistical Analysis of Road Traffic Accidents in Dibrugarh city, Assam, INDIA.

[34]. ERA manual, 2002

[35]. Ministry of Interior (2011) Traffic Accidents Reports. Abu Dhabi, UAE.

[36]. Kumar A, Lalwani S, Agrawal D, Rautji R & Dogra T (2008) Fatal road traffic Accidents and their relationship with head injuries: An epidemiological survey of five years. *Indian Journal of Neurotrauma, 2008, Vol. 5, No. 2, pp. 63-67.*

[37]. Almqvist C, Brunt D, Fridlund B & Eke Bergh M (2010) Being first on the scene of an accident–experiences of doing‟ prehospital emergency care. *Scandinavian journal of caring sciences* **24**, 266-273.

[38]. Andersons AK, Carlson A, Petersons H & Hoek B (2013) Unobtrusive Breath Testing. In *International Conference on Alcohol, Drugs and Traffic Safety (T2013), 20th, 2013*: Brisbane, Queensland, Australia.

[39]. Nicholl J, West J, Good acre S & Turner J (2007) The relationship between distance to the hospital and patient mortality in emergencies: an observational study. *Emergency Medicine Journal* **24**, 665-668.

[40]. World Health Organization (2009) Global Status Report on Road Safety Time For Action. World Health Organization, Geneva.

[41]. The Government Accountability Office (2008) Traffic Safety: GAO-08-477. In *GAO Reports*, pp. 1: U.S. Government Accountability Office.

[42]. Constant A, Salmi LR, LA font S, Chiron M & Laagered E (2009) Road Casualties and Changes in Risky Driving Behavior in France Between 2001 and 2004 Among Participants in the GAZEL Cohort. *American Journal of Public Health* **99**, 1247-1253.

[43]. Pérez K, Marí-Dell'Olmo M, Tobias A & Borrell C (2007) Reducing Road Traffic Injuries: Effectiveness of Speed Cameras in an Urban Setting. *American Journal of Public Health* **97**,1632-1637.

[44]. Truong WH, Hill BW & Cole PA (2013) Automobile safety in children: a review of North American evidence and recommendations. *Journal of the American Academy of Orthopedic Surgeons* **21**, 323-331.

[45]. Fell JC, Todd M & Ova's RB (2011) A national evaluation of the nighttime and Passenger restriction components of graduated driver licensing. *Journal of Safety Research* **42**, 283-290.

[46]. Department for Transport (2013a) National road safety communications activity calendar: Department for Transport, London.

[47]. Karaka P & Ridgeway G (2010) Behavioral impact of graduated driver licensing on teenage driving risk and exposure. *Journal of Health Economics* **29**, 48-61.

[48]. Wang C, Quddus MA & Ison SG (2013b) The effect of traffic and road characteristics on road safety: A review and future research direction. *Safety Science* **57**, 264-275.

[49]. Navin F, Zein S & Felipe E (2000) Road safety engineering: an effective tool in the fight against whiplash injuries. *Accident Analysis & Prevention* **32**, 271-275.

[50]. Yahiya MN, Faulks IJ, Hambleton P & Wass C (2013) Development of an integrated road safety management system in Indonesia: Traffic police as lead agents in a Safe System approach. *The Australasian College of Road Safety* **24**, 28

[51]. Douglas, C.M. and George, C.R., Applied Statistics and Probability for Engineers, Third Edition John Wiley & Sons Inc., USA, 2003.

[52]. Wahlgren L. (2005), SPSS steg for steg. Studentlitteratur, Lund

[53]. Ethiopia federal police commission

[54]. Burayu town profile, 2015.

[55]. Teyba, W., Emer, T. Q., Murad, M. Analysis of Road Traffic Accident Related of Geometric Design Parameters in Alamata-Mehoni- Hewane Section. International Journal of Scientific & Engineering Research.2017, Volume 8, Issue 1.

[56]. O'Cinneide, D., "The Relationship Between Geometric Design Standards and Safety", University of College-Cork, 1995.

[57]. Department of Transportation, "Safety Handbook for Secondary Roads", USA, 2007.

[58]. Zegeer, Deen, and Mayes, " Effect of lane and Shoulder Widths on Accident Reduction on Rural Two-lane Roads", Transportation Research Board 806, P.P 33-34, Washington, D.C., USA, 1981.

[59]. Sawalha, Z., and Sayed, T., "Evaluating Safety of Urban Arterial Roadways", Journal of Transportation Engineering, 2001.

[60]. Nagham, N. M, " The Comparison between IHSDM and NSM to Assess the Safety Performance of Two-Lane Rural Roads"2012.

[61]. Elvik, R., and Vaa,T.,"The Handbook of Road Safety Measures", Amsterdam, Heidelberg (u.a.), Elsevier, 2004.

Appendix A: -

Tables of Accidents Statistics and Numbers

Table A -1 Total Traffic data of five years based on RTA and PDO

Year	**Number of Accident**	**Percentage share**	Estimated cost of property damage
2015	52	14.69%	3,262,300
2016	56	15.82%	1028239
2017	68	19.21%	1333,846
2018	84	23.73%	1,506100
2019	94	26.55%	1,452,800
Total	**354**	**100**	**8,583285 ETB**

Table A-2 Severity Type vs % shared

Severity Type	Year						
	2015	2016	2017	2018	2019	Total accident	% share
Fatal	11	13	14	14	20	72	20.34
Serious injury	8	13	15	12	6	54	15.26
Slight injury	11	14	20	10	4	59	16.67
PDO	22	16	19	48	64	169	47.74
Total	**52**	**56**	**68**	**84**	**94**	**354**	**100%**

Table A-3 Estimated cost of property damage (2015-2019)

Year	**Estimated cost of property damage**	**Percentage share**
2015	3,262,300	38.01%
2016	1,028,239	11.98%
2017	1,333,846	15.54%
2018	1,506,100	17.55%
2019	1,452,800	16.93%
Total	**8,583285 ETB**	**100**

Table A-4 Distribution of road Traffic Accidents on Days of the Week

Years	**Days of the week**	**No. of accident**	**Percent share**
2015-2019	Monday	54	15.25%
	Tuesday	50	14.12%
	Wednesday	38	10.73%
	Thursday	46	12.99%
	Friday	38	10.73%
	Saturday	70	19.77%
	Sunday	58	16.38%
Total		**354**	**100%**

Table A-5 Hours vs No of Traffic accident

Year	Time of accident(Hrs)	No. of accident
2015-2019	1:00-2:00	21
	2:00-3:00	22
	3:00-4:00	9
	4:00-5:00	10
	5:00-6:00	8
	6:00-7:00	12
	7:00-8:00	28
	8:00-9:00	12
	9:00-10:00	21
	10:00:11:00	31
	11:00-12:00	19
	12:00-13:00	34
	13:00-14:00	15
	14:00-15:00	19
	15:00-16:00	18
	16:00-17:00	15
	17:00-18:00	17
	18:00-19:00	15
	19:00-20:00	9
	20:00-21:00	3
	21:00-22:00	3
	22:00-23:00	1
	23:00-24:00	1
	24:00-1:00	11

Total	354

Table A-6 Distribution of RTA by Drivers age vs. Numbers of the Accidents

Year	**Age of driver**	**Total accident**	**percent shared**
2015-2019	<18	0	0
	18-30	168	47.46%
	31-50	119	33.62%
	>50	39	11.02%
	Unknown	28	7.91%
Total		**354**	**100%**

Table A- 7 The Driver's Genders vs. Accidents Committed`

Year	**Sex of Driver**			**NO. of accident**	**Percent Share**		
	Male	**Female**	**Unknown**		**Male**	**Female**	**Unknown**
2015	50	2		52	**90.68%**	**5.37%**	**3.95%**
2016	51	5		56			
2017	60	8		68			
2018	80	0	4	84			
2019	80	4	10	94	**100%**		
Total	**321**	**19**	**14**	**354**			

Table A-8 Educational Back Grounds of the Drivers vs. RTA

Year		**2015**	**2016**	**2017**	**2018**	**2019**	**Total accident**	**percent shared**
Education Level Of Drivers	Illiterate						0	0
	Basic education						0	0
	First cycle	28	33	23	5	10	99	27.97%
	Second junior Level	18	11	14	37	36	116	32.77%
	Second high school	1	4	16	27	31	79	22.32%
	Above high school		4	12	14	17	47	13.28%
	Unknown	5	4	3	1		13	3.67%

Total	**52**	**56**	**68**	**84**	**94**	**354**	**100%**

Table A-9 The Drivers and Vehicles Relationship vs. road Accidents

R.NO	**Relationship between and vehicle**	**2015**	**2016**	**2017**	**2018**	**2019**	**Total**	**percent share**
1	Owner of vehicle	1	3	4	6	9	23	6.50%
2	Employee	51	53	56	77	83	320	90.45
3	Others			3		2	5	1.41%
4	Unknown			5	1		6	1.69%
Total		**52**	**56**	**68**	**84**	**94**	**354**	**100%**

Table A-10 Drivers experience and related Accident

Experience of drivers	**No. of accident**	**percent share**
Have no License	0	0
<1 year	11	3.2%
1-2 year	33	9.32
2-5 year	97	22.32
5- 10 year	155	43.78
>10 year	24	6.78
Unknown	34	9.61
Total	**354**	**100percent**

Table A-11Environmental condition vs Accident committed

	2015	**2016**	**2017**	**2018**	**2019**	**Total**	**% shared**
Dry	52	39	56	70	94	311	83.38
Moist	0	17	12	14	5	48	12.87
Mudy	0	8	3	2	1	14	3.75
Others	0	0	0	0	0	0	0
						373	100

Table A-12 Light condition vs Accident committed

	2015	2016	2017	2018	2019	Total	% shared
Dark	3	7	6	3	6	25	7.06
At night with weak light	8		5	0	4	17	4.8
At night with good light		7	1	7	1	16	4.52
At sun rise	9	11	9	11	15	55	15.54
At sun set	14	8	20	17	18	77	21.75
Day light	18	23	27	36	50	154	43.5
Other						0	0
	52	56	68	84	94	354	100%

Table A-13 Activity of victims Vs Accident Committed

Activity of pedestrian		2015	2016	2017	2018	2019	Total	% shared
1	Farmers		1				1	1.2
2	Jobless		2	4	22		28	33.73
3	workers	24			1	3	28	32.53
4	Students		1	2	1	4	8	9.64
5	Unknown				7	12	19	22.89
							84	100%

Table A-14 Vehicle motion vs Accident committed

Vehicle Motion	2015	2016	2017	2018	2019	Total	% Shared
During entrance of joint		3	2	2	1	8	2.26
Turn Left		3	5		2	10	2.82
Turn Right	4	5	1	4	3	17	4.8
U shape Turning			3	1		4	1.23
Passing over vehicles	3	7	12	21	41	84	23.73
Straight Travelling	45	36	41	52	41	215	60.73
Moving back ward		2	1		6	9	2.54
Stopping			3	2		7	1.41
	52	56	68	82	94	354	100%

Table A-15 Crash by road alignment

Road alignment	**No. accident**	% shared
Straight	188	92.61%
Straight and simple curve	15	7.39%
Total	203	100%

Table A-16 Types of vehicle Involved in accident Vs No. Of accident

Types of vehicles involved in accident	No of accident						
	2015	2016	2017	2018	2019	Total	% shared
Bicycles						0	
Motor cycles	1	2	3	4		10	2.82
Automobile	6	5	4	6	4	25	7.06
station wagons(Minibus)	2	2	3	1	2	10	2.82
Pick up	5	7	8	10	9	39	11.02
Heavy load truck capacity of 11-40 quintal(Isuzu)	7	8	9	11	19	54	15.25
Heavy load truck capacity of 41-100 quintal	10	12	13	17	16	68	19.21
Train						0	
Truck With Trailer	1	2	4	7	12	26	7.34
Tanker				0		0	
Tax	6	7	9	8	8	38	10.73
People transport with 12 capacity	11	10	11	16	21	69	19.49
People transport with 13-45 capacity	3	1	4	3	2	13	3.67
Other				1	1	2	0.56
	52	56	68	84	94	354	100%

Table A -17: Cause of Accident Reported by Traffic Police

Accident Cause	Total accident	
	Number	Percent Share
Driver Errors	221	62.43
Pedestrian Errors	66	18.64
Vehicle defects	17	4.80
Road defects	11	3.11
Other/ unknown	39	11.02
Total	**354**	**100**

Appendix B

Correlation of independent variables vs accident committed

Table B: Road cross section with Accident committed

Shoulder width(m)	Accident committed	Width of Lane (m)	Accident committed
0.1	68	2.8	68
0.2	45	2.9	45
0.3	42	2.95	42
0.35	38	3	38
0.4	37	3.1	37
0.6	36	3.13	36
0.95	35	3.15	35
1	30	3.2	30
1.1	25	3.3	25
Carriageways(m)	**Accident committed**	**Roadways(m)**	**Accident committed**
5.6	68	5.8	68
5.8	45	6.2	45
5.9	42	6.5	42

6	38	6.7	38
6.2	37	7	37
6.26	36	7.46	36
6.3	35	8.2	35
6.4	30	8.4	30
6.6	25	8.8	25

APPENDIX C

Table C- Cross section elements vs accident for Regression Analysis

Shoulder width(m)	**Accident committed**	**Width of Lane (m)**	**Accident committed**
0.1	68	2.8	68
0.2	45	2.9	45
0.3	42	2.95	42
0.35	38	3	38
0.4	37	3.1	37
0.6	36	3.13	36
0.95	35	3.15	35
1	30	3.2	30
1.1	25	3.3	25
Carriageways(m)	Accident committed	Roadways(m)	Accident committed
5.6	68	5.8	68
5.8	45	6.2	45
5.9	42	6.5	42
6	38	6.7	38
6.2	37	7	37
6.26	36	7.46	36
6.3	35	8.2	35
6.4	30	8.4	30
6.6	25	8.8	25

Appendix D

Regression analysis and Scatter plot

Table D-1: Regression analysis of shoulder Vs. Accident committed

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.79				
R Square	0.63				
Adjusted R Square	0.58				
Standard Error	7.94				
Observations	9.00				
ANOVA					
	df	SS	MS	F	
Regression	1.00	749.02	749.02	11.88	
Residual	7.00	441.21	63.03		
Total	8.00	1190.22			
	Coefficients	Standard Error	t Stat	P-value	Lower 95%
Intercept	68.94	4.94	13.95	0.00	57.26
Shoulder width(m)	-25.89	7.51	-3.45	0.01	-43.65

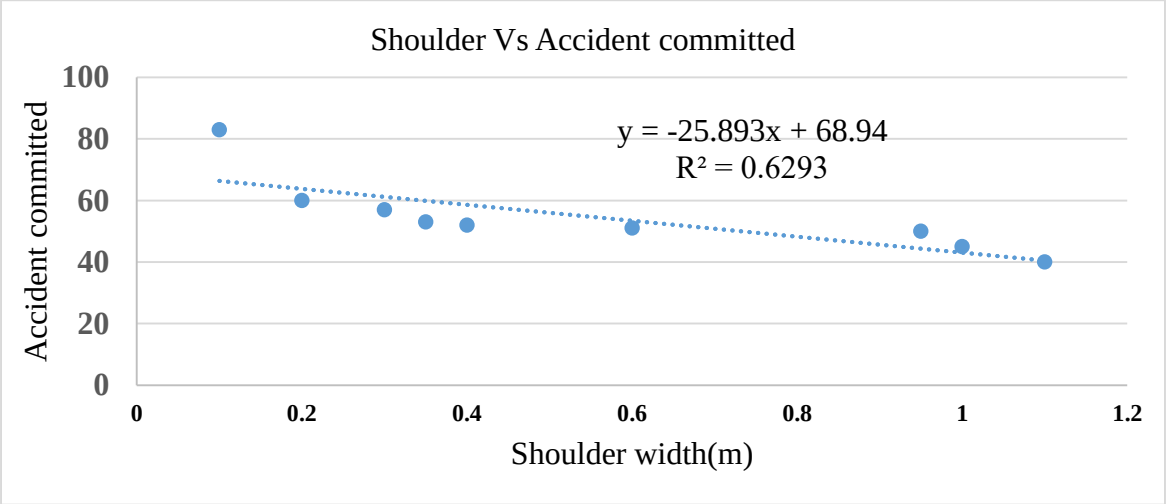


Table D-2: Regression analysis of Lanes Vs. Accident committed

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.91				
R Square	0.82				
Adjusted R Square	0.80				
Standard Error	5.46				
Observations	9.00				
ANOVA					
	df	SS	MS	F	Significance F
Regression	1.00	981.45	981.45	32.91	0.00
Residual	7.00	208.77	29.82		

Total	8.00	1190.22			
	Coefficients	Standard Error	t Stat	P-value	Lower 95%
Intercept	268.47	37.33	7.19	0.00	180.19
Width of Lane (m)	-69.93	12.19	-5.74	0.00	-98.76

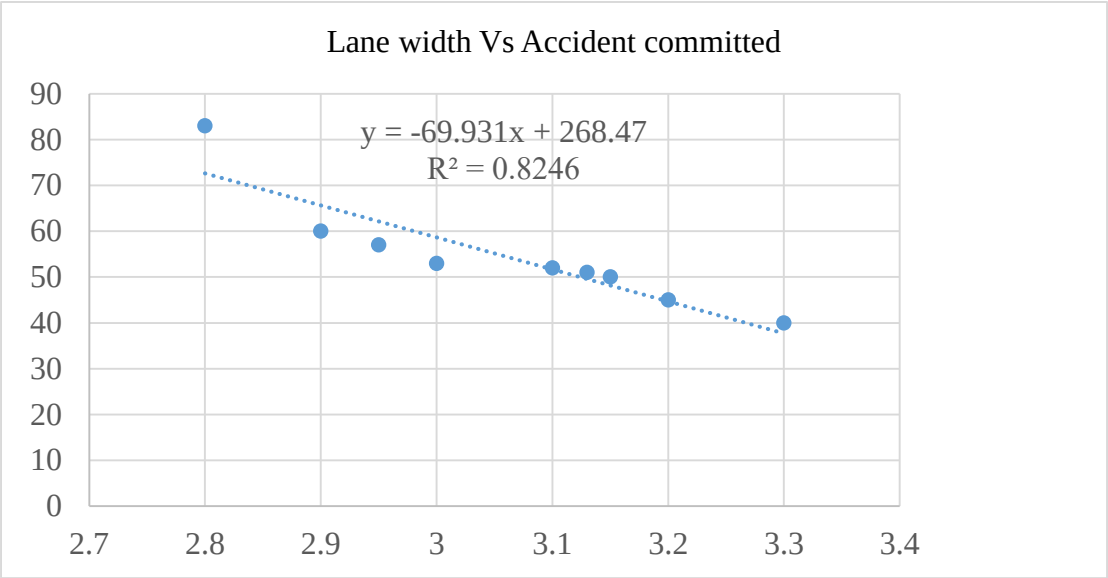


Table D-3: Regression analysis of Carriageways Vs. Accident committed

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.91				
R Square	0.82				
Adjusted R Square	0.80				
Standard Error	5.46				
Observations	9.00				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.00	981.45	981.45	32.91	0.00
Residual	7.00	208.77	29.82		
Total	8.00	1190.22			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	268.47	37.33	7.19	0.00	180.19
Carriageways(m	-34.97	6.10	-5.74	0.00	-49.38

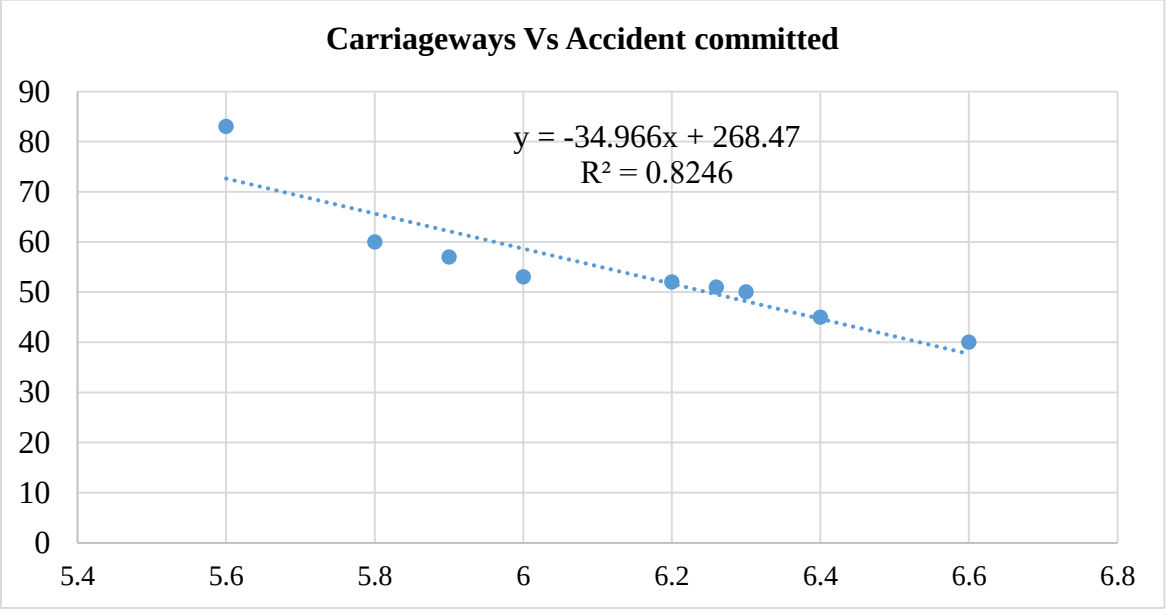


Table D-4: Regression analysis of Roadways Vs. Accident committed

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.84				
R Square	0.70				
Adjusted R Square	0.66				
Standard Error	7.08				
Observations	9.00				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.00	838.97	838.97	16.72	0.00
Residual	7.00	351.25	50.18		
Total	8.00	1190.22			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	125.14	17.42	7.18	0.00	83.94
Roadways(m)	-9.76	2.39	-4.09	0.00	-15.41

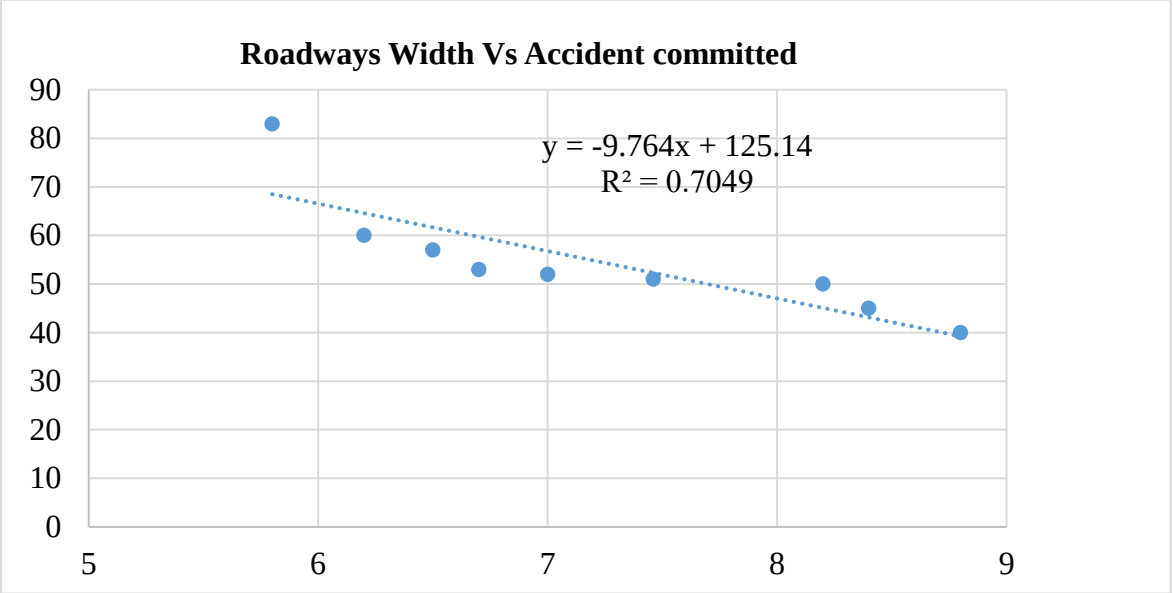
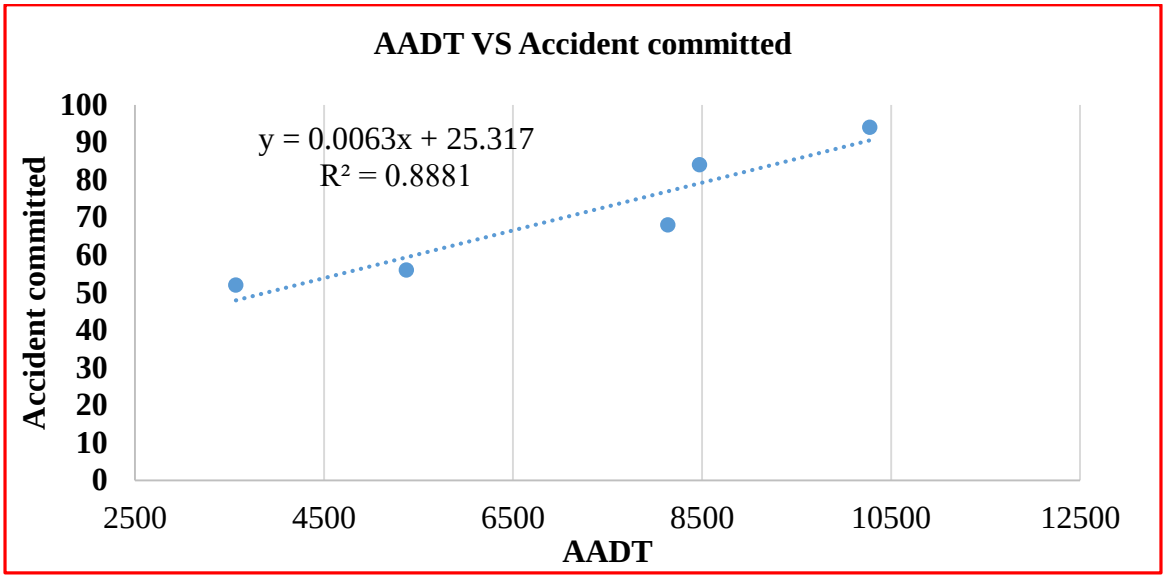


Table D-5: Regression analysis of Volume Vs. Accident committed

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.94				
R Square	0.89				
Adjusted R Square	0.85				
Standard Error	6.94				
Observations	5.00				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.00	1148.20	1148.20	23.82	0.02
Residual	3.00	144.60	48.20		
Total	4.00	1292.80			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	25.32	9.82	2.58	0.08	-5.94
Traffic volume	0.01	0.00	4.88	0.02	0.00


AADT VS Accident committed
y = 0.0063x + 25.317
R² = 0.8881
Accident committed
100
90
80
70
60
50
40
30
20
10
0
2500
4500
6500
8500
10500
12500
AADT