DECLARATION

I declare that the work which has been presented in this thesis entitles **"Effects of Rural-Urban Road Characteristics on Traffic Safety of Urban Area(A Case study in Jimma Town)"** is original work of my own, and It has not been presented for a degree in any other university.

Submitted By:

Shewit G/hiwot ____________ ___________

Student **Signature** **Date**

As Master's Thesis Advisors, we hereby certify that we have read and evaluated this MSc Thesis prepared under our guidance, by **Shewit G/hiwot** entitled: **Effects of Rural-Urban Road Characteristics on Traffic Safety of Urban Area (A Case study in Jimma Town).**

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

Prof. Emer T. Quezon, P.Eng ___________ 19/03/2018

Advisor **Signature** **Date**

Engr. Mesfin Dinku ____________ ____________

Co- Advisor **Signature** **Date**

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ABSTRACT

Characteristics of roads have great discrepancy in a regional road network in terms of pavement dimensions including shoulders and drainage system. The study had attempted to investigate the effects of rural-urban road characteristics on traffic safety of urban area.

The study identified two roads linking Jimma town. These are sub parts of Jimma to Agaro road and Jimma to Addis Ababa road. These two roads are characterized by the incidence of traffic accidents due to increasing number of vehicles, and pedestrian movements. In other words, there was no adjustment made by the road agency, in which the existing geometry of the road considered as one factor causing traffic accidents and delays for the road users.

*This research has evolved to find the deficiencies of rural-urban roads by comparing the geometric parameters with ERA manual. The total number of accident of these stretch's taken from police record. The values of geometric parameters about these sub-sections are obtained from asbuilt road design and direct measurement of carriageway width. Finally, correlation & linear regression analysis is made between the selected geometric parameters and a total number of accidents. From the selected 5.5 km, the correlation is established in the form of an equation of a total number of the accident (TA) with a total number of an accident with carriageway width: TA=173.850 - (15.900 * CW) with Rsqr = 0.918. A total number of the accident (TA) with a total number of an accident with grade: TA = 48.966 - (3.607 * G).*

The accident black spots were identified and prioritized based on the developed criteria, and accident rates were calculated. Therefore, it is concluded that the frequency of occurrence of road traffic accidents and the number of casualties are increasing from time to time in both stretch of roads & When the carriageway width increases the traffic accident decrease and the carriageway width decrease the traffic accident increase. Hence, redesigning the road elements based on the prevailing and future traffic condition is recommended to reduce the number of road accidents at identified black spots and other sections in the study area.

Key words*: Rural-urban road characteristics, safety, Accidents, Linear regression, Ethiopia, Jimma*

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ACRONYMS

AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
CW	Carriageway Width
ERA	Ethiopian Road Authority
ETRADA	Ethiopian Road Accident Data Acquisition
FHWA	Federal Highways Administration
GIS	Geographic Information System
PDO	Property Damages Only
RSDP	Road Sector Development Program
RTA	Road Traffic Accidents
SPSS	A statistical Package software for Social Science
SRT	Stretch
TA	Traffic Accident
TRB	Transportation Research Board
TRL	Transport Research Laboratory

CHAPTER ONE

INTRODUCTION

1.1 Background

Good road network is a factor on which the economy of a nation depends and the planning of the effectiveness and optimum utilization of the roads must be a continuous process.

Rural roads are the basic infrastructure requirement and play a vital role in the socioeconomic up liftment of rural communities. They contribute significantly in rural development by creating opportunities to access goods and services located in nearby villages or major town/market centers. Provision of rural roads increases mobility of men and materials, thus facilitating economic growth. These, in turn, assist in reducing poverty and leads overall social development. The need to investigate the road geometric relationships is underscored by recent trends in the highway administration environment such as the need for effective management and operational accountability of highway assets and issues of funding and tort liability of the various road classes on the state roadway network, the rural two-lane state highway and county road systems are obviously most vulnerable to tort, due to their relatively poor geometric standards [1].

Rural-urban linkages can be defined as the structural social, economic, cultural, and political relationships maintained between individuals and groups in the urban environment and those in rural areas. The process whereby a society changes from a rural to an urban way of life is called urbanization. Urbanization and its associated transportation infrastructure, define the relationship between city and countryside. Urbanization, expressed as the proportion of people living in urban places shows a recent but explosive growth reaching values around 80% in most European countries. Simultaneously the countryside becomes abandoned. Thinking, valuing and planning the countryside is done mainly by urbanites and future rural development is mainly focused upon the urban needs. Thinking of urban places with their associated rural hinterland and spheres of influence has become complex. Clusters of urban places, their situation in a globalizing world and changing accessibility for fast transportation modes are some new factors that affect the change of traditional European cultural landscapes. Urbanization processes show cycles of evolution that spread in different ways through space. Urbanization phases developed at different speeds and time between Northern and Southern Europe [2, 3].

Apparently, most of the developed countries have adopted road geometry improvement technologies and traffic safety management systems to further enhance and strengthen transportation sector services for the well-being of their economic growth [4]. As a result, in these countries the potential improvement and advancement of road geometric design technologies are becoming virtually unlimited. But as for the developing countries, especially Ethiopia, there has been a huge gap between the ratio of the underlying transportation service demand to the service available and quality of constructed roads on traffic safety issues [5]. Hence, poor provision of road infrastructure facility needs an immediate remedy as for having faster economic growth and allow safe and free movement of people and goods throughout the country.

In Ethiopia like many other countries, road expansion is facilitated and rural-urban roads are also expanding all over the country. Jimma town is, located in the Oromia National, Regional State and is also being dominated by rural-urban road network. As the country is experiencing a radical rate of urbanization, the use of rural two lane roads in the urbanizing areas is being facilitated at the same rate. Since the rural two lane roads don't fulfill the requirements of urban road design, their use as an urban road is being a cause to a lot of solution demanding problems. The rural two lane roads were originally designed to allow the passage two vehicles at the same time and no spot was left intentionally for pedestrian purpose. As a result, these rural two lane roads have no walkway, a parking lane and enough lane width. Use of these rural two lane roads in the urbanizing areas is being a cause to pedestrian discomfort and many traffic accidents after all.

Since in the past four years there was a steady and continuous growth rate in the use of vehicles. Total number of 41 accidents occurred in stretch one in the year 2009 of which 7 were fatal, 12 were serious, 10 were slight & 12 PDO.In the case of stretch two a total number of 45 accidents occurred in the year 2009 of which 9 were fatal, 8 were serious, 9 were slight & 19 PDO.

1.2 Statement of the problem

Geometric characteristics of rural two-lane roads, the current situation leaves much to be desired. In the United States, most of such roads have operational and safety deficiencies arising from inadequate road geometry, driver information deficiencies, lack of passing opportunities, and traffic conflicts due to drive ways. In fact, most rural two-lane roads are several decades old (since construction) and need pavement and shoulder replacement or repair, among other improvements. Urbanization is one of the most important elements for one country development. Inadequate poor maintenance and design of road affects the society and the expansion of the town. The quality of urbanization is mostly determined by the road networks [1].

If the rural development lies within the two-mile jurisdictional area adjacent to a city, further problems are possible due to the differing public improvement standards between the county and the city. Cities generally require significant public improvements, such as curbed streets, storm sewers, other underground utilities, and sidewalks, which encourage smaller lots. Counties generally allow larger lot developments without usual urban public improvements. Generally, rural subdivisions have roads with shoulders, ditches for drainage control, and no curbs [5].

In Jimma, a town with a number of road networks and urbanizing areas, the rural-urban roads are also being used. Due to the poor road maintenance activities, those road are causing a problem on the road users and affect traffic safety. Rural-urban roads have now become the major threat by restraining the free mobility of road users that leads to traffic accident, injury and delay.

From the above mentioned problems it is clear that rural-urban road characteristics become the major problem in developing countries like Ethiopia which needs special and organized consideration to overcome the problem that result. Therefore, this research focuses on the effects of rural-urban road characteristics on traffic safety of urban area in Jimma town to identify and recommend necessary solutions.

1.3 Research Question

1. What are the rural road characteristics deficiencies on urban area according to ERA standard ?
2. What are the effects of rural road deficiencies on traffic safety?
3. Which locations of the study road sections identified as black spot areas?
4. What are the possible engineering measurements on rural road problems?

1.4 Objective of the study

1.4.1 General Objective

The general objective of the study is to assess the effect of rural-urban road characteristics on traffic safety of urban area in Jimma town.

1.4.2 Specific Objective

- To identify deficiencies of rural road characteristics on urban area according to ERA standard.
- To analyze the effect of rural road on traffic safety.
- To identify locations of black spot areas.
- To suggest engineering measurements on rural road problems.

1.5 Significance of the study

The significance of this research is to address the problems that result from rural-urban road characteristics on traffic safety, and to obtain the best solutions for the indicated problems in the study area. Besides, this research will be addressed to have effective and proper road network in proper place based on the geographical area and geometric design. As a result safety, economy and comfort of the pedestrian on urban and rural area will be secured. Hence, the current study has the importance of adding knowledge on the gap created around the issues and signaling and motivating the various stakeholders to take appropriate actions by incorporating the issue in their policies and strategies. This study uses as literature review for researchers who study regarding to traffic safety rural urban road at different stages of their works.

1.6 Scope of the study

The scope of this research is limited only to investigate the effect of rural-urban road characteristics on traffic safety through collecting accident and road geometric design data from different institutions. Field measurements at accident locations have been extracted and recorded together with the traffic accident data reported by traffic police officials in order to compare the results with the existing as built road geometric design values. Due to lack of the exact point location of accident, there may have limitation of in accuracy. Final decision have been reached on which of the chosen parameters (carriageway width, zebra cross, light, traffic sign and grade) affect traffic safety of the area. Countermeasures are proposed for the chosen road geometric parameters.

CHAPTER TWO

REVIEW OF RELATED LITERATURES

2.1 Introduction

This chapter presents a comprehensive review of various literatures 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 rural road characteristics on traffic safety. 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 road traffic safety 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 effect of rural road characteristics on traffic safety of roads including geometric requirement of roads such as lane width, nature of curves, super elevation and gradients, length of roadway alignment, parking area and identifying accident prone locations using GIS software.

Conscious efforts have also been made to incorporate and utilize the information obtained in the context of the current situation in Ethiopia with particular to the road segments of Stretch's selected for the case study as it will give an opportunity to deal with problems and provide remedial measures for the effects of rural road characteristics constituents on traffic safety.

2.2 **Review of Previous Studies**

Traffic safety is the result of a balance between the type of the road and neighborhood characteristics. The imbalance results in statistically significant differences in concentrations of accidents. Many traffic accidents are the product of several factors such as human error, weather conditions, surrounding vehicle and road conditions [5].

Urban and rural area have fundamentally different characteristics with regard to density and types of land use, density of street and highway networks, nature of travel patterns, and the way in which these elements are related. Consequently, urban and rural functional systems are classified separately. Rural areas are those outside the boundaries of areas. The roads making up the functional systems differ for urban and rural areas. The hierarchy of the functional systems consists of principal arterials (for main movement), minor arterials (distributors), collectors, and local roads and streets; however, in urban areas there are relatively more arterials with further functional subdivisions of the arterial category whereas in rural areas there are relatively more collectors with further functional subdivisions of the collector category [6].

The use of a particular cross-section, either rural or urban, should be decided with consideration of the desires of the developer and the location of the road with respect to the designated growth area of the nearest urban area. Converting or reconstructing a rural roadway to an urban roadway as areas are annexed into the adjacent city is very difficult because of the characteristics related to the elevation of the road with respect to the surrounding properties and the drainage methods used. This is especially critical on higher-volume roads that may be two-lane facilities in the rural area; however, as the land is annexed and urban growth occurs in the area, a multiple-lane road is needed to meet the traffic demands [7].

Numerous studies have been conducted to determine the effects of lane width, shoulder width, and shoulder type on crash experience. Quantified the effects of lane width, shoulder width, and shoulder type on highway crash experience based on an analysis of data for nearly 5000 miles of rural two-lane highways from seven states. Crash types found to be related to lane and shoulder width, shoulder type, and roadside condition include run-off-road (fixed object, rollover, and other run-off-road crashes), head-on, and opposite- and same-direction sideswipe crashes, which together were termed as “related accidents.” An accident prediction model was developed and used to determine the expected effects of lane- and shoulder-widening improvements on related accidents. The study found that lane widening of 1 ft (e.g., from 10-ft to 11-ft lanes) is expected to reduce related accidents by 12 percent.

Widening lanes by 2 ft, 3 ft, and 4 ft will reduce related accident types by 23 percent, 32 percent, and 40 percent, respectively. Factors are also available for paving shoulders and combining reductions for multiple treatments [8].

Challenges often arise on two-lane rural highways when these facilities transition from rural environments into more developed areas. These more urbanized areas can range from the town center of a small rural town to urbanized areas with populations greater than 5,000. The transition is the portion over which the context of a segment changes from a higher speed rural environment into a lower speed and more developed environment. When traffic transition from higher speed rural environments into more developed areas, speed limits and visual features in the road environment assist the driver in making appropriate speed reductions across the transition area. These transition segments are often characterized by changes in land-use, increase in access densities and the introduction of more developed features such on-street parking and pedestrian facilities. Instead of primarily providing for mobility, the role of the facility changes to a larger focus on accessibility.

The term “urbanization” has been given different interpretations and definitions. “urbanization as the physical growth of rural or natural land into urban areas as a result of immigration to existing urban areas”. While United Nation defined urbanized as movement of people from rural to urban areas with population growth equating to urban migration but to “An introduction to the Geography of the tropics “defined urbanization in two terms; economically and demographically. Economically, “urbanization is a process of economic development where people move from an agricultural community into nonagricultural one”. To him “the process reflects relative growth of secondary and tertiary component of the economy at the expense of primary production”. Demographically, “urbanization is the process of population concentration. Here “It represents a way of ordering the population of a general area for the purpose of attaining higher levels of subsistence and security [9].

With the increasing urbanization, improved transportation technology and an expanding economy, additional roads and highways are built, in an effort to balance roadway capacity and demand. At the same time, traffic volumes and travel distances continue to increase, and the new roadway facilities get filled up shortly after completion. Traffic congestion and safety are serious problems, impacting on the economy, environment and quality of life in our cities. In designing highways, traffic engineers must anticipate the amount and type of traffic that will use the road, in order to make the highway match its anticipated use. The capacity of a highway is defined as the number of vehicles that can reasonably be expected to pass a point or section of the highway during a given period of time under prevailing roadway, traffic, and control conditions [10].

The urbanization and urban traffic depend on and help each other. Urban traffic situation is an important condition for urban life and production, as well as a part of the city and its dynamics process. The development of urbanization includes the development of urban traffic, also drives and stimulates the relative improvement of urban traffic which will in turn satisfy the demand of urbanization. The study of the relation between urbanization and urban traffic is for improving the healthy sustainable development between them [34].

Road development in Nigeria could be said to have started with the need to connect one community to another through foot paths as the need for trade and commerce, inter dependence grew. It was an era when settlements started to discover that there were social-economic needs that could only be met by other settlements which must be approached for such facilities. In the early days of road network development in Nigeria, vehicular traffic was spatially distributed across the available road network. All components that make functional road traffic environments such as road signs, markings, painting, cycle path. Pedestrian, walkways and zebra / pelican crossings were adequately provided and also maintained regularly by the authority, especially in urban centers. More roads were constructed but without the components that make traffic environments safe and without care full plan for maintenance and soonest its overshadowed by bushy road potholes, signs that are often pulled down by inexperienced drivers. The impact of road development and expansion of urban cities [11].

Numerous studies have been conducted to determine the effects of lane width, shoulder width, and shoulder type on crash experience. Quantified the effects of lane width, shoulder width, and shoulder type on highway crash experience based on an analysis of data for nearly 5000 miles of rural two-lane highways from seven states. Crash types found to be related to lane and shoulder width, shoulder type, and roadside condition include run-off-road (fixed object, rollover, and other run-off-road crashes), head-on, and Opposite- and same-direction sideswipe crashes, which together were termed as “related Accidents.” An accident prediction model was developed and used to determine the expected effects of lane- and shoulder-widening improvements on related accidents [12].

For roads within developments outside of the designated growth area of a city, the selection of rural versus urban cross-section is not as critical. The option could be left to the developer to select the type they would like to propose, as long as good regulations are in place for both types. The amount of land required for right-of-way, the characteristics of the land (soils, slope, wooded area, etc.), and the type of drainage facilities to be used are elements to consider in the decision. It is recommended that the rural cross-sections be used as a default and the developers be allowed to propose other cross-sections if they so desire [13].

A major distinction between the assessment of urban and rural road safety is the importance of road features in determining the likely crash rates in rural areas. The distinction makes itself apparent in the greater number of single-vehicle crashes on rural roads, and in the influence that road features have on both the likelihood and severity of these crashes. In an urban environment, drivers are usually more constrained by speed limits and other road users. At the higher speeds found on rural roads, sight distances also become more important when considering crashes involving multiple vehicles or unexpected obstructions [14].

Table2. 1: Hypotheses on the effect of road characteristics on accident density on rural two lane roads .

Variable	Hypotheses
Annual average daily traffic	Increase in AADT → Increased Accident density
Carriageway width	Increase in width → Decreased Accident density
Width of shoulder	Increase in width → Decreased Accident density
Density of intersections	Increase in density → Increased Accident density
Density of road access	Increase in density → Increased Accident density
Bicycle path	Presence of path → Decreased Accident density
Road marking	Increase in marking → Decreased Accident density

2.2 Geometric Design of Highway

Geometric Design is an essential component in the design development of a highway. This Geometric Design Manual is prepared under the direction of the Ethiopian Roads Authority to establish basic design techniques for economical design of highway geometric including typical sections, horizontal and vertical alignment, and design of junctions. It is intended for use in the design of all roads in Ethiopia. Geometric design the process whereby the layout of the road through the terrain is designed to meet the needs of the road users. The principal geometric features are the road cross-section and horizontal and vertical alignment.

2.2.1 ERA Design Consideration

2.2.1.1 Design Controls

1. Design Traffic Volume

A further factor influencing the development of road design standards, and in particular the design speed, is the volume and composition of traffic. The design of a road should be based in part on factual traffic volumes. Traffic indicates the need for improvement and directly affects features of design such as widths, alignments, and gradients. Traffic data for a road or section of road, including traffic trends, is generally available in terms of annual average daily traffic (AADT).

Using road functional classification selection and design traffic flow, a design class, or standard, is selected with reference to the design parameters associated with that class. The functional hierarchy is such that traffic aggregates as it moves from feeder to main collector to link the trunk roads. However the actual flows will vary from region to region and it is important that the designation of a road by functional type should not give rise to over-design for the traffic levels actually encountered. Design classes DS1 to DS10 have associated bands of traffic flow . The range of flows extends from less than 20 to 15,000 motorized vehicles per day (excluding motorcycles), and covers the design conditions for all single and dual carriageway roads.

Although the levels of flow at which design standards change are based on the best current evidence, the somewhat subjective boundaries should be treated as approximate in the light of uncertainties inherent in traffic estimation and future forecasting. Therefore, the Design Traffic Flow shall normally be limited to be no more than one Design Class step higher than the average daily traffic (AADT) in the first year of opening.

It may be desirable, especially for primary roads, to develop geometric standards that are consistent despite variations in traffic volumes. Conversely, a policy dependent on AADT would result in a more economical allocation or resources. This dichotomy requires a special attention of the engineer in choosing the geometric design parameters [15].

2. **Design Speed**

The Design Speed is used as an index which links road function, traffic flow and terrain to the design parameters of sight distance and curvature to ensure that a driver is presented with a reasonably consistent speed environment. In practice, most roads will only be constrained to minimum parameter values over short sections or on specific geometric elements. Design elements such as lane and shoulder widths, horizontal radius, super elevation, sight distance and gradient are directly related to, and vary, with design speed. Thus all of the geometric design parameters of a road are directly related to the selected design speed.

3. Cross Section Elements

Cross-section will normally consist of the carriageway, shoulders or curbs, drainage features, and earthwork profiles. These terms are defined in the Definition portion of the manual text;

- Carriageway- the part of the road constructed for use by moving traffic, including traffic lanes, auxiliary lanes such as acceleration and deceleration lanes, climbing lanes, and passing lanes, and bus bays and lay-byes.
- Roadway- consists of the carriageway and the shoulders, parking lanes and viewing areas.
- Earthwork profiles- includes side slopes and back slopes

Lane Widths: -A feature of a highway having great influence on safety and comfort is the width of the carriageway. Lane widths of 3.65m are used for Design Classes DS1 and DS2. The extra cost of 3.65 m above that for 3.0 m is offset to some extent by a reduction in cost of shoulder maintenance and a reduction in surface maintenance due to lessened wheel concentrations at the pavement edges. The wider 3.65m lane also provides desired clearances between large commercial vehicles on two-way rural highways.

Shoulder: - A shoulder is the portion of the roadway contiguous to the carriageway for the accommodation of stopping vehicles; traditional and intermediate non-motorized traffic, animals, and pedestrians; emergency use; the recovery of errant vehicles; and lateral support of the pavement courses, and also shoulder width for urban and rural have different value

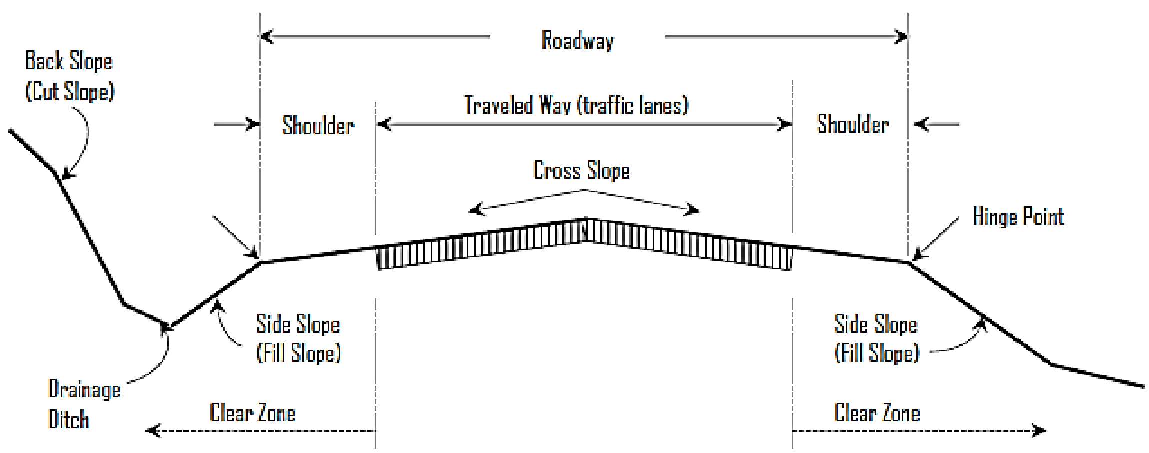


Figure 2. 1: Road way Cross sectional elements

4. Road Markings

The function of road markings is to encourage safe and expeditious operation. Road markings either supplement traffic signs and marker posts or serve independently to indicate certain regulations or hazardous conditions. There are three general types of road markings in use- pavement markings, object markings and road studs.

5. Traffic Sign

The extent to which signs and markings are required depends on the traffic volume, the type of road, and the degree of traffic control required for safe and efficient operation.

The safety and efficiency of a road depends to a considerable degree on its geometric design. However, physical layout must also be supplemented by effective traffic signing as a means of informing and warning drivers, and controlling drivers. Design of traffic signs and road markings is an intricate part of the design process.

Traffic signs are of three general types:

- ➢ Regulatory Signs: indicate legal requirements of traffic movement
- ➢ Warning Signs: indicate conditions that may be hazardous to highway users
- ➢ Informatory Signs: convey information of use to the driver

i) Urban Section

- ✓ For urban cross-sections, cross-section elements may also include facilities for pedestrians, cyclists, or other specialist user groups. These include curbs, footpaths, and islands. It may also provide for parking lanes. For dual carriageways, the cross-section will also include medians.
- ✓ The sealed shoulder width may increase to 3.5 meters in urban areas where a provision for a parking lane is required. The degree of urbanization determines whether a parking lane is required. In urban areas, the shoulders should be paved rather than sealed.
- ✓ For urban or peri-urban conditions, the design speed selection is influenced by other factors. In such areas, speed controls are frequently included. Traffic speeds are in fact influenced by the presence of other vehicles traveling in and across the through lanes, physical and right of-way constraints, together with pedestrian and safety considerations. However, of note is the fact that the present speed limit through

villages is 30 km/h. It is possible that this limit will be increased in the future. A design speed through peri-urban or urban areas of 50 km/h shall be used, although such segments are posted presently at 30 km/h. Legal speed limits should not necessarily be used as design parameters.

Table2. 2: Shoulder Width For Urban Section (ERA Design Manual 2002)

Design standard	Town section widths (m)			
	Shoulder	Parking lane***	Foot Way	Median[!]
DS1	n/a	3.5	2.5 (min)	5.0 (min)
DS2	n/a	3.5	2.5	Barrier[!]
DS3	n/a	3.5	2.5	n/a
DS4	n/a	3.5	2.5	n/a
DS5*	n/a	3.5[+++]	2.5	n/a
DS6**	n/a	3.5[+++]	2.5	n/a
DS7	n/a	n/a +	n/a +	n/a
DS8**	n/a	n/a +	n/a +	n/a
DS9**	n/a	n/a +	n/a +	n/a
DS10**	n/a	n/a +	n/a +	n/a

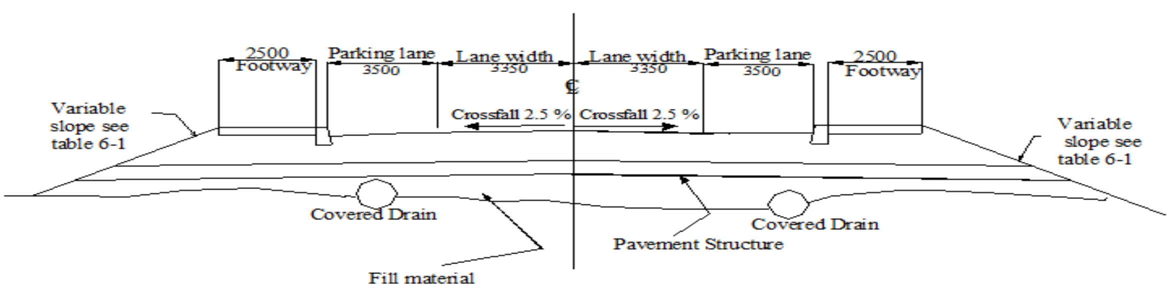


Figure 2. 2 Sample Design Of Urban Road (ERA Design Manual 2002)

Table2. 3 Guide Value for the minimum provision of passing sight distance

Design Standard	PERCENT PASSING OPPORTUNITY vs. TERRAIN				
	Flat	Rolling	**Mountainous**	**Escarpment**	**Urban/peri urban**
DS2	50%	50%	25%	0%	20%
DS3	50%	33%	25%	0%	20%
DS4	25%	25%	15%	0%	20%
DS5	25%	25%	15%	0%	20%
DS6	20%	20%	15%	0%	20%
DS7	20%	20%	15%	0%	20%

Table2. 4 :Minimum Radii For Horizontal Curve:4% Super elevation (Urban Streets)

Design speed V_D(Km/h)	20	30	40	50	60	70	85	100	120
Min.Horiz. Radius R .(m)	15	35	60	100	150	215	320	490	810
Max.Degree of Curve (B)	382	164	96	57	38	27	18	12	9
Side Friction Factor (f)	0.40	0.32	0.25	0.22	0.19	0.17	0.14	0.12	0.10

ii) Rural Section

Table2. 5: Shoulder Width for Rural Section (ERA Design Manual 2002)

Design Standard	Rural Terrain/Shoulder Width (m)			
	Flat	Rolling	Mountainous	Escarpment
DS1	3.0	3.0	0.5-2.5	0.5-2.5
DS2	3.0	3.0	0.5-2.5	0.5-2.5
DS3	1.5-3.0++	1.5-3.0++	0.5-1.5	0.5-1.5
DS4	1.5	1.5	0.5	0.5
DS5*	0.0	0.0	0.0	0.0
DS6**	0.0	0.0	0.0	0.0
DS7	1.0(earth)	1.0(earth)	1.0(earth)	1.0(earth)
DS8**	0.0	0.0	0.0	0.0
DS9**	0.0	0.0	0.0	0.0
DS10**	0.0	0.0	0.0	0.0

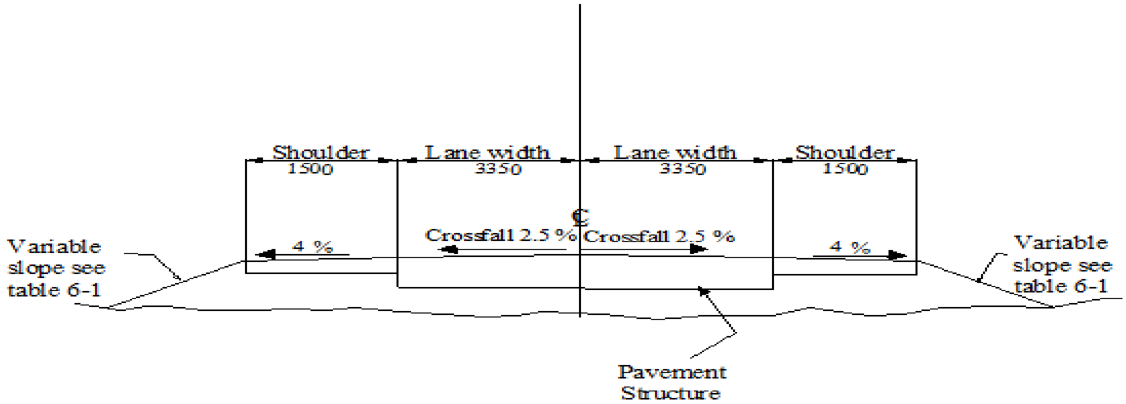


Figure 2. 3: Sample Design of Rural Road (ERA Manual 2002)

2.2.2 AASHTO Design Consideration

The roads making up the functional systems differ for urban and rural areas. The hierarchy of the functional systems consists of principal (for main movement), minor arterials (distributors), collectors, and local roads and streets; however, in urban areas there are relatively more arterials with further functional subdivisions of the arterial category whereas in rural areas there are relatively more collectors with further functional subdivisions of the collector category [16].

i) Urban Section

The four functional highway systems for urbanized areas are urban principal arterials (streets), minor arterials (streets), collectors (streets), and local streets. The differences in the nature and intensity of development in rural and urban areas warrant corresponding difference in urban system characteristics relative to the correspondingly named rural systems.

Table2. 6 : Urban Functional System

System	Range	
	Travel volume (%)	Length (%)
Principal arterial system	40-65	5-10
Principal arterial plus minor arterial street system	65-80	15-25
Collector road	5-10	5-10
Local road system	10-30	65-80

ii) Rural Section

Rural roads consist of facilities outside of urban areas. The names provided for the recognizable systems are principal arterials (roads), minor arterials (roads), major and minor collectors (roads), and local roads [17].

Table2. 7: Typical Distribution of Rural Functional System

Systems	Percentage of Total Rural Road Length
Principal arterial system	2-4%
Principal arterial plus minor arterial system	6-12%, with most states falling in 7-10% range
Collector road	20-25%
Local road system	65-75%

2.3 Effects Of Characteristics Of Road Geometrical Design Elements On Traffic Safety

Some of the primary geometric design elements that can affect on highway safety are Carriageway, grade, horizontal curvature, shoulder, median [18].

- Carriageway characteristics: At the end of many studies it is proven that the width of the road carriageway has an obvious effect on accidents. As it can be seen in Figure 1.a, as carriageway width increases, traffic accidents decrease. This relationship is more important in developing countries than in developed countries. Also in many studies, other characteristics like the number of carriageways of a road, the number of intersections on it and its number lanes are related with road safety. These studies have shown that the safest road is a divided, multi-lane road with interchanges; and the level of safety decreases on three-lane roads.

- Grade: Although different results were obtained in different studies, it is known that as vertical grade increases, accident rate increases, too. This relationship is given in Figure 1.b.On the other hand, at points where high-slope sections end in low-radius horizontal curves, the numbers of accidents are high.

- Shoulder characteristics: Studies show that there is a relationship between shoulder width and traffic accidents. As width is increased, the number of accidents are decreased (Figure 1c).It is found that when the shoulder surfaces are not paved and there is a shoulder drop-off road safety gets lower.

- Characteristics of horizontal curves: The premier factor in accidents happening inside horizontal curves is radius. As radius is decreased, the number of accidents happening inside horizontal curves are increased. Similarly, as horizontal curve level of curvature is increased number of accidents increase.

-Median characteristics: Presence of a median on a highway contributes positively to road safety. The effect of the median width on safety increase is seen in. Moreover, studies prove that medians designed at a lower altitude than the pavement are better for safety than medians designed at a higher altitude.

Road Surface Conditions: Traffic, weather conditions and ground conditions expose road surface to wear and tear. Ruts, cracks and unevenness in the road surface reduce driving comfort and cab be a traffic hazard. They may make it more difficult to keep a motor vehicle on a steady course. Besides large holes in the road surface can damage vehicles and lead to the driver losing control of his vehicle. Evenness and friction are two important characteristics that influence road safety. Evenness is a measure of the regularity of a road surface. All types of road surfaces (rigid, flexible, gravel, etc.) deteriorate at a rate which varies according to the combined action of several factors: axial load of vehicles; traffic volumes; weather conditions; quality of materials; construction techniques [19].

2.4 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 [20]. 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 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 [20].

In this research work, an attempt is made to apply single linear regression models to characterize the influence of road geometric 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 refers 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 accident rate. The general equations of linear regression models are presented in the following forms [20].

$Y = \beta 0 + \beta 1\ X + \varepsilon$

Where, the slope ($\beta 1$) and intercept ($\beta 0$) of the single linear regression model are called regression coefficients. 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 R^2 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 adequacy of a regression model, some of which are 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, whereby a negative value of R indicates inversely relationship and positive value implies direct relationship. Confidence of the result indicates in terms of significant value (P). The correlation was considered significant if (P) is zero or 5 % different from zero [21].

2.5 Black Spot Definition, Analyses &Treatment

2.5.1 Black Spot Definition & Analyses

Black spot as locations that are generally classified after an assessment of the level of risk and the likelihood of a crash occurring at a location. Black spot safety work can be described as the task of improving road safety through alterations of the geometrical and environmental characteristics of the problematic sites in the existing road network. In towns and cities, there is a tendency for traffic accidents to cluster at specific places, often at intersections. A concentration of accidents at a specific spot may partly be due to inappropriate road design or inappropriate traffic control at that place. In such cases, the clustering of accidents can be avoided or reduced by improving road design or traffic control [22].

The criteria and analysis of accident black spot on a National Highway in Norway is defined as any place with a maximum length of 100 meters, where at least four injury accidents have been reported to the police during a four year period [23]. Thus, a black spot in the UK may well have only five injury accidents in three years, while a city in Bangladesh may have black spot defined as having more than 10 injury accidents in a year [24].In most developed countries, black spots are defined as the locations where there are 12 accidents in 3 years per 0.3 kilometers [18]. In Czech Republic, the black spot criterion is that junctions or 250 m-long road sections that are considered as black spots on condition that at least 3 road accidents with injuries occurred within 1 year or at least 3 road accidents with injuries of the same type occurred within 3 years or at least 5 road accidents of the same type occurred within 1 year [23]. Study on single carriage way trunk road [18] revealed that the criterion used to delineate road sections for accident analysis are age of opening, carriageway width, kerbs, hard strips, and speed of the road section. The points out black spots on national highways in Norway have heavy traffic but do not have particularly high accident rates when compared with places which are not classified as accident black spots [18].

Ranking of black-spots were done with various alternatives [25] show three alternative methods or ranking black spots. These are number of accident with personal injury or serious personal injury, accident rates (accident per million vehicle kilo meter) and potential for accident reduction. In Belgium, potential accident reduction ranking method is employed taking into account the weight of each severity at each site where in three years three or more accidents have occurred. Then, a site is considered to be dangerous when its priority value (P), calculated using the following formula, equals 15 or more [22]:

$$P = \frac{(1* W+2*X + 3*Y +5*Z)}{D},$$

Where

P = Priority value,

X = Total number of light injuries

Y = Total number of serious injury, Z = Total number of deadly injuries

2.5.2 Black Spot Treatment

1) Rumble Strip

It is a safety device that alerts and let the drivers to make a change on the driving operation. It consists of some repeated pattern on pavement surface, that creates vibration on vehicles when tires role over on it. Rumble strip is used to tip or alert drivers in changing geometric of the road or driver approaches to any unusual dangerous road sections or spots. The application of rumble strips on rural areas has been associated with 20 to 60 per cent of accident reductions [18].

2) Traffic Signs and Road Marking

Traffic signs provide a safe environment to road users by guiding drivers to directions for route finding; controlling the use of road with mandatory signs; warning drivers of any substandard or unusual features with warning signs, aiding road users to identify the situation ahead and anticipate hazards; providing consistency within the road signing system, with similar situations receiving the same treatment; providing night-time and day-time visibility informing services rendered to users and emergencies.

3) Road Lights

Road lights are intended to provide enough lighting for drivers to travel with comfort and safety during night periods or under low visibility conditions. This solution is commonly applied where there is the possibility of conflicts between vehicles and pedestrians or cyclists. In rural roads, the implementation of lighting on unlit roads may lead to a 64 per cent reduction in fatal accidents and 20 to 50 per cent of total accident reduction [18].

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Description Of Study Area

The study was carried out in Jimma town which is one of the ancient and largest towns in the country located at the southwestern part of the country. Located in the Jimma Zone of Oromia State, the town lies at latitude and longitude of 7°40'N 36°50'E & 7.667°N 36.833°E. The selected study stretch's are 5.5 & 6 km and both stretch's are busy with more number of vehicle's & over the years traffic density has gone up. According to the 1999 census the population of Jimma town was estimated to be 120960and according to the 2009 census the population of the town becomes 293360.The selected study area mostly covers the roads which were previously constructed for rural highway and nowadays used as urban road as a result of expanding urbanization.

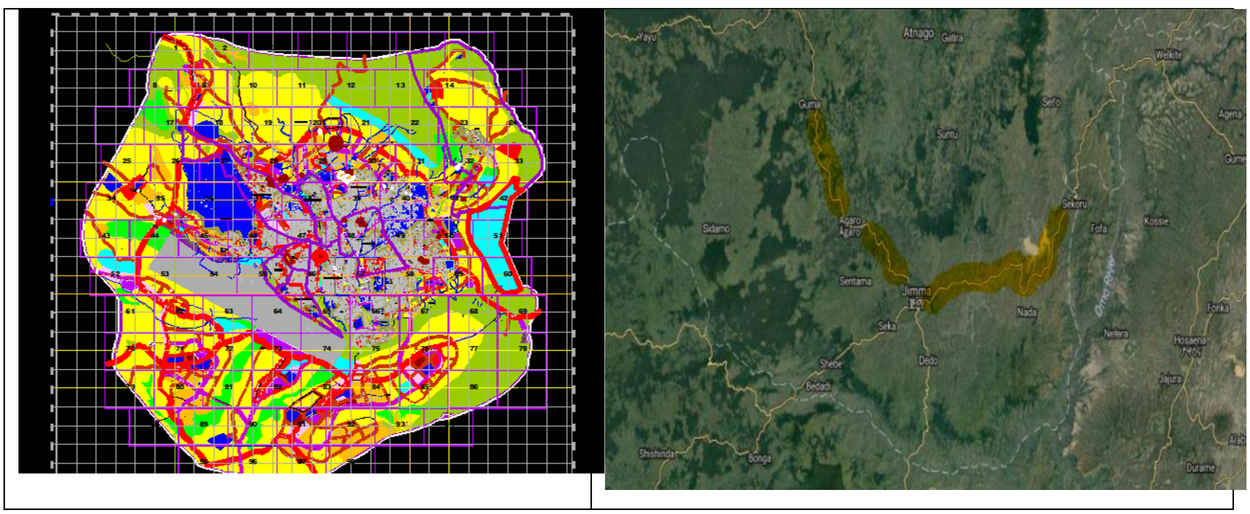


Figure 3. 1: Location Of The Study Area (Source Municipality Of Jimma Town & Google Earth (2017)

3.2 Data Collection Techniques

Since Non-probability sampling represents a group of sampling techniques and has free distribution that help researchers to select a unit sample from a population, purposive sampling method was adopted for this study. For evaluation of the influence of rural road characteristics, a four year accident data was collected from police commission reports together with geometric and traffic data obtained from Jimma town and Addis Abeba ERA West district offices.

3.3 Study Design

The existing road, geometric design, population density and traffic accident data have been used to find the effect of rural road characteristics by statistical correlations between road geometric characteristics, total accident & population density. The road data is from the Ethiopian Road Authority (ERA) while accidents were collected from traffic police commission offices recorded in a database system.

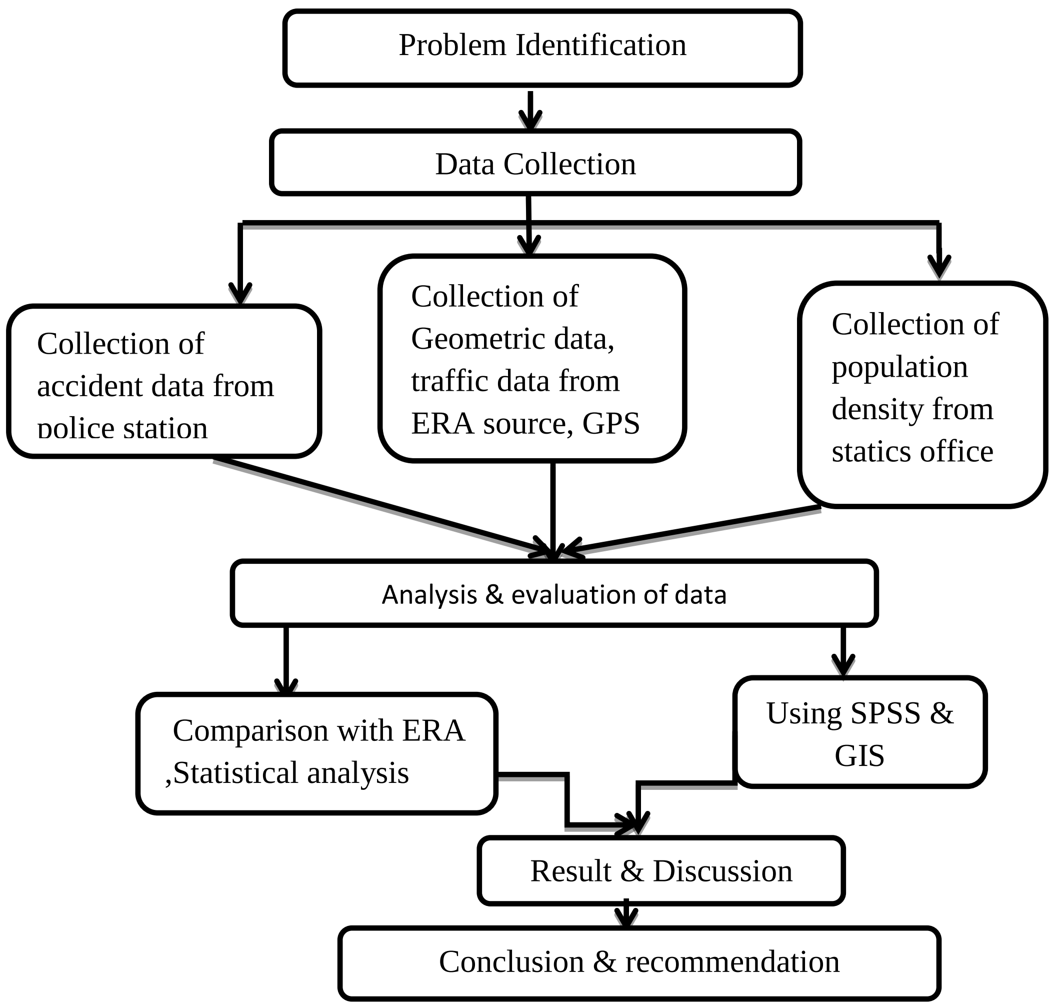


Figure 3. 2: Flow chart showing general outline of the study

3.4 Population

The total number of populations considered in this research was the population existing within the range of the study area, research work and objective of the research. It covers a total length of asphalt road, road data, traffic accident report from police station, ERA district.

3.5 Study Procedure

The research was achieved by a combination of literature review, and analysis of road geometric rural-urban roads and traffic accident data obtained from ERA and police commission offices. The procedure utilized throughout the conduct of this research study are as follows:

- Review of related literatures including articles, books, and research papers, standard specifications (ERA and AASHTO) etc.
- Conducting visual site visit to get more information on effect of rural road characteristics on safety.
- Collection of traffic and geometric data of the selected stretches for the case-study
- Conducting collection of coordinate using GPS & roadway width and related field measurements.
- Obtaining geometric design values from as built- road at selected accident prone sections
- Collection of accident data from traffic police reports of Jimma town
- Collection of population data from statics office of Jimma town
- Conducting statistical correlation and linear regression analysis between the road geometric components and total accident, & black spot identification.
- Comparing the results with preexisting literatures, standard specifications and manuals.
- Drawing conclusions and recommendations based on the results and findings inferred during the whole analysis and discussion parts.
- Put appropriate remedial measures to be taken on the indicated problems.

3.6 Study Variables:

There are two types of variables that are taken into consideration:

3.6.1 Dependent Variables:-

Effects of rural road characteristics

3.6.2 Independent Variables:-

Traffic data,

Carriageway width deficiencies

Shoulder width,

Drainage system

Population density

No. of Residential buildings & Commercial buildings

3.7 Data Types And Sources:

Quantitative as well as qualitative data types have been employed. The data needed for this work was collected from both primary and secondary sources. It specifically comprised of yearly road traffic accidents and corresponding as-built road geometric design values for the path from Jimma to Addis Ababa covering the periods from 2006 to 2009, and it includes the path from Jimma to Agaro which have no as-built and most of its road way becomes urbanized and contains high accident occurrence. For the collection of these primary data, this research made use of tape meter. The data was collected as soft copies, hard copies and maps. Additional data was also used for the verification of the collected primary data sources from Google earth through internet and some were modified and presented in the form of tables and figures for practical analysis purpose. The road stretches selected for this study are mentioned in Table 3.1

Table 3. 1 : Description of the considered stretches (selected roads for case study)

Stretch	Description	Length (Km)	Police station
1	Gas station to Boye hayek (sub part of Jimma to AdisAbeba road)	5.5	Jimma Town
2	Fromi Hotel to adisu kera (Jimma to Agaro road)	6	Jimma Town

3.7.1. Primary Data Collection

Primary research data was collected through site visits, and direct measurements of geometric components at accident locations.

3.7.2. Secondary Data Collection

Secondary data was collected through reviewing the existing relevant documents, reports, literatures whereas master plan of the town obtained from munciplity of Jimma town , road accidents were obtained from the daily RTA police accident files of Jimma town traffic office, and also as-built road geometric design data and traffic data from Ethiopia road authority office.

3.8 Sampling Size And Technique

The data collected from site observation, primary data and secondary data, four main categories of data were used: traffic accident data, geometrical data, traffic data (AADT) and population density. Qualitative and quantitative data were collected from both primary and secondary data.

3.9 Method Of Data Processing And Analysis

This study seeks to find answers to the problems through comparison of as-built design of the selected stretches with the ERA manual and assisting the black spot areas that affect the safety. Statistical correlation analysis was adopted to determine whether the dependent variable was significantly related to the independent variables using the relative importance of these factors. Exploratory data analyses were conducted using Microsoft Excel to investigate interactions and checking of assumptions underlying the use of regression analysis techniques, specifically using scatter and linear plots of the data. This was followed by inferential analysis and subsequently interpretation of results as well as drawing valid conclusions.

Accident data extracted from the case study sites were used to validate the statistical regression analysis. It is important to state that for all analysis P-value < 0.05was considered to be statistically significant. The stretches that have been selected for his study are sufficiently short (5.5 & 6 km). Under such circumstances, the chances of occurrence of multiple black-spots is pretty low and even if they do, the number of accidents in stretch/length, i.e. an averaging cannot be too difficult to consider, since the road parameters for a short stretch do not vary adequately over the length of the stretch to render such averaging useless. So, it is assumed that the total number of accidents in a stretch is directly proportional to the length of the stretch. Hence, is considered by us as the dependent variable which is a function of the number of accidents.

3.9.1 Accident Data

The accident data which has been collected for this research includes accidents that occurred on the selected road segment from Jimma town police station over the four-years study period and police commission offices have provided accident reports as paper copies from 2006-2009 E.C.

Figure 3. 3 :Accident occurred due to shortage of carriageway width (Source Jimma Town Traffic Police office)

Figure 3. 4 :Accident occurred due to imbalance of right of way & residential house (Source Jimma Town Traffic Police office)

Figure 3. 5: Accident on Stretch 1 (Source Jimma Town Traffic Police office)

3.9.2 Geometric Data

To know the deficiencies of rural road with regard to urban requirements the, geometric measurements of the accident location areas have been taken. From the 5.5 km length of the road, 6 sections having frequent accident occurrences were selected from traffic police records with their respective as-built geometric design values, as shown in Appendix B-1.4, Appendix B-1.5, The following geometric components were collected from the given as-built road alignment design values at locations where traffic police have already identified as dangerous sub- sections using traffic accident record.

3.9.3 Vehicle Classification

Vehicle classification is an essential aspect of traffic volume. The types of vehicles are defined according to the breakdown adopted by ERA for traffic counts: cars; pick-ups and 4-wheel drive vehicles such as Land Rovers and Land Cruisers; small buses; medium and large size buses; small trucks; medium trucks; heavy trucks; and trucks and trailers. This breakdown is further simplified, for reporting purposes, and expressed in the five classes of vehicles (with vehicle codes 1 to 5).

Table 3. 2: Vehicle classification by class

Vehicle	Type of Vehicle	Description
1	Small Car	Passenger cars, minibuses (up to 24-passenger seats),Taxis, Pickups, and Land Cruisers, Land Rovers, etc.
2	Bus	Medium and large size Buses above 24 passenger seats
3	Medium Truck	Small and medium sized trucks including tankers up to 7 tons load
4	Heavy Truck	Trucks above 7 tons load
5	Articulated Truck	Trucks with trailer or semi-trailer and Tanker trailers

(Source: Road Asset Management and Contract Implementation Coordinate Directorate).

3.9.4 Traffic Data

Table 3. 3 : Annual Average Daily Traffic Summarized by District for Stretch 1

Year	Car	Land Rover	Small Bus	Large Bus	Small Truck	Medium Tuck	Heavy Truck	Truck & Trailer	Total
2006	33	160	483	101	141	279	219	110	1526
2007	39	181	583	114	177	358	195	91	1738
2008	15	112	253	44	35	301	345	119	1224
2009	29	251	551	54	116	360	325	348	2034

(Source: Average daily traffic summarized by district)

Table 3. 4 : Annual Average Daily Traffic Summarized by District for Stretch 2

Year	Car	Land Rover	Small Bus	Large Bus	Small Truck	Medium Tuck	Heavy Truck	Truck & Trailer	Total
2006	7	58	384	29	90	172	42	24	806
2007	11	173	443	27	12	179	81	29	955
2008	13	205	459	21	3	159	93	43	996
2009	12	185	467	21	13	185	116	26	1025

(Source: Average daily traffic summarized by district)

3.9.5. Field Work Activities

During the field observation, it was necessary to begin by conducting visual inspection and site inventory of the whole stretch of the selected roads of Jimma town road segment in order to get more information about the road structure and its existing condition. All relevant information and data pertaining to the road and its geometric condition, type and number of traffic signs and delineators present, road markings, and other traffic safety works of the area were collected through the initial field visit activities of the present study. Some data were also collected by informal interviewing of road users, ERA managers, urban planning and development, Jimma town traffic police officers and site engineers. According to the information from the people, the road structure could be one of the factors that trigger frequent accident events at different times for the selected case study areas since there is in balance between the roads design and the areas condition .This information from the people helped to put emphasis on the areas with regard to road geometric constituents in comparison with design values of an as built road to understand the effect of rural road characteristics on traffic safety, as it could be one of the major causative factors for traffic accident problems encountered. Furthermore, a visual site visit was made to know the performance of the road, and hazardous road sections were identified depending on the degree of their traffic accidents indicated in the traffic police records and photographs were also taken to show the existing geometric condition.

3.9.6 Traffic Safety Features

Since projects at the planning stage by their nature have little information about the details of design, it is vital that the designer should incorporate important safety elements during the preliminary and detail design stages. Regarding to the subject, none of the existing road sections selected for the case study have complete traffic safety features at the entry as well as exit of adverse geometrical structures which implies that there is a potential safety problem. Some characteristic safety problems, which are not fulfilled to the present road alignment, and their recommended safety measures are indicated below in order to improve the safety of the road and minimize accident occurrences.

i) General Problems Observed During Field Work Activities**:**

- ✓ Narrow width of carriage way

Figure 3. 6 : Field photo with narrow width of carriage way width at stretch 2 (keyeafer)

- ✓ Absence of darainage structure

Figure 3. 7 : Field photo with absence of drainage structure at str 1 & 2.

- ✓ Improper junctions are created with abesence of traffic sign

Figure 3. 8:Field photo with improper junction & missing of traffic sign & streath 2

- ✓ Missing of shoulder , pedestrianwalk way with Congestion

Figure 3. 9 : Field photo with congestion , missing of pedestrianwalk way&shoulder at streath 2

- ✓ Missing of zebra cross
- ✓ Improper taxs station created
- ✓ Missing of road marking
- ✓ Abesence of Parking area with Pavement distress

Figure 3. 10 :Field photo with absence of parking area & pavement distress

Based on the design requirements of urban road the selected stretches miss the above mentioned requirements and those safety problems are observed according to the guidelines set under ERA and AASHTO manuals.

Roadway Width Constriction: there is a width constriction on some parts of the existing road due to edge failure which is the main cause of traffic accident and delay. The traffic coming from one side has to give way for the opposite one with full turning ability, otherwise accident will happen. The situation will get worse while driving at night because of the absence of advance warning signs. AASHTO recommended to widen the existing roadway width on the inside edge to ensure good vehicular maneuvering and smooth transition of vehicles from adverse curved sections to the tangents.

Traffic Safety Marking: Markers are erected so that they appear as a continuous line to the motorist and the chevrons indicating the direction of travel. Pavement markings should be provided along the centerline and edges with no overtaking lines on the roadway alignment. Solid yellow line marking should also be provided for all edges of the pavement to delineate the edge of the road so that it is visible for drivers to decide on.

Lighting: Improve the safety of a highway or street and the ease and comfort of operation thereon. There is evidence that in urban and suburban areas, where there are concentrations of pedestrians and roadside intersectional interferences, fixed-source lighting tends to reduce crashes. Lighting of rural highways may be desirable, but the need for it is much less than on streets and highways in urban areas.

Parking Lanes : Where used in residential areas, a parallel parking lane a minimum of 2.1 m [7 ft] wide should be provided on one or both sides, as appropriate to the conditions of lot size and intensity of development. In commercial and industrial areas, parking lanes should be a minimum of 2.4 m [8ft] wide and are usually provided on both sides. Parking lane width determination in commercial and industrial areas should include consideration for use of the parking lane for moving traffic during peak periods that may occur where industries have high employment concentrations. Where curb and gutter sections are used, the gutter pan width should be considered as part of the parking lane width.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 General Rural Road Characteristics Deficiencies

According to different scientific standards rural road characteristics have several deficiencies compared to urban roads. The design period for rural roads is around 20 years, and in this period a lot of environmental changes occur due to this imbalance between the road user & the roadway.

4.1.1 Design Related Deficiencies of Rural Road Characteristics

Table 4. 1: Comparison with ERA Geometric Design Manual for Road Stretch 1

No	**Road way element**	**ERA Standard Values**		**Observed Values in urban area**
		Rural	**Urban**	
1	Parking area	No	3.5m	No parking area
2	Carriageway width	7	7-14	7-12
3	Shoulder width	0.5m-3m	1.5 - 3.0++	1m-1.5m
4	Pedestrian crossing	Controlled	Controlled	Un Controlled
5	Drainage system	No drainage	Adequate drainage structure	No drainage structure
6	General Pavement condition	Adequate	Adequate	Pavement distresses exist
7	Traffic sign	Adequate	Adequate	No traffic sign
8	Light	Based on terrain	Adequate light	No light
9	Pedestrian walkway	No	2.5m	No pedestrian walkway

The previously constructed rural roads are designed as shown in Figure 4.1 below and based on the urban road design standard, the study road sections lack of sufficient carriageway, drainage system, zebra crossing, pavement markings, and parking area.

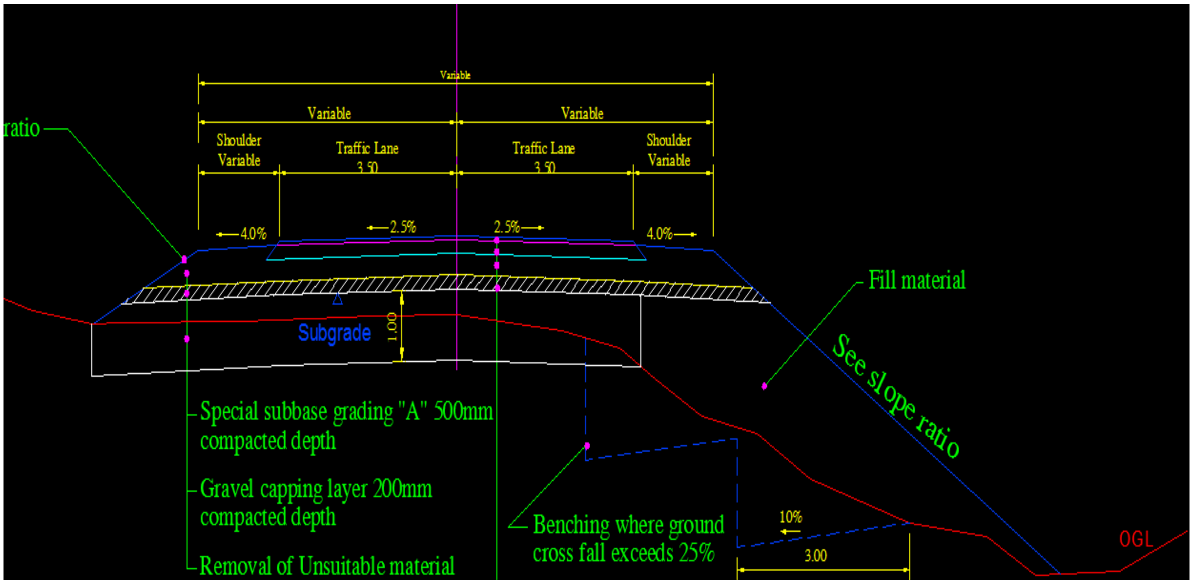


Figure 4. 1 : Sample of rural road taken from asbuilt design of Jmma to AA

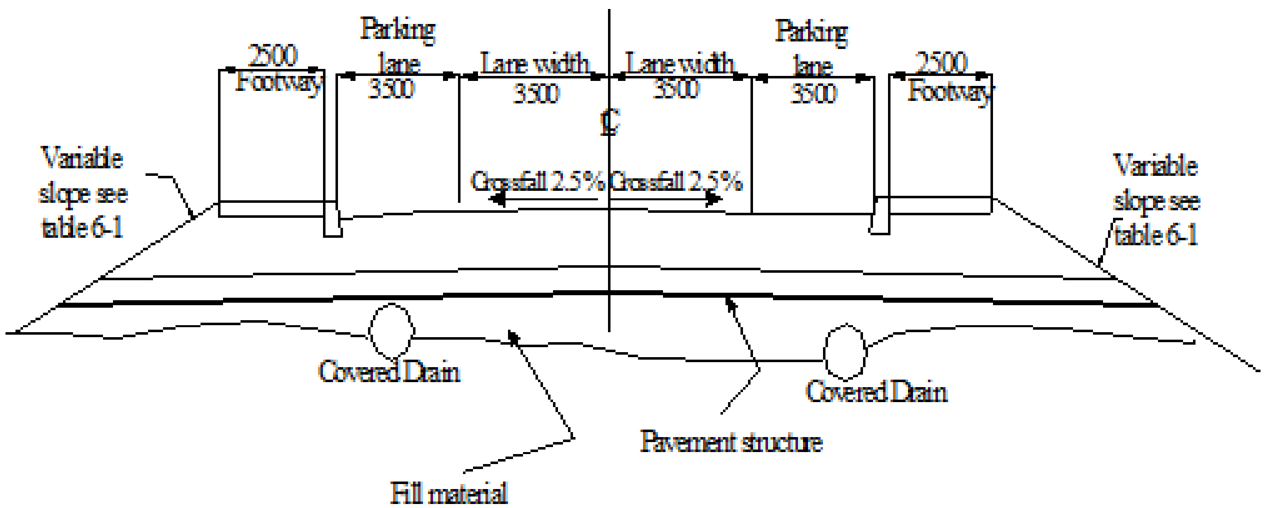


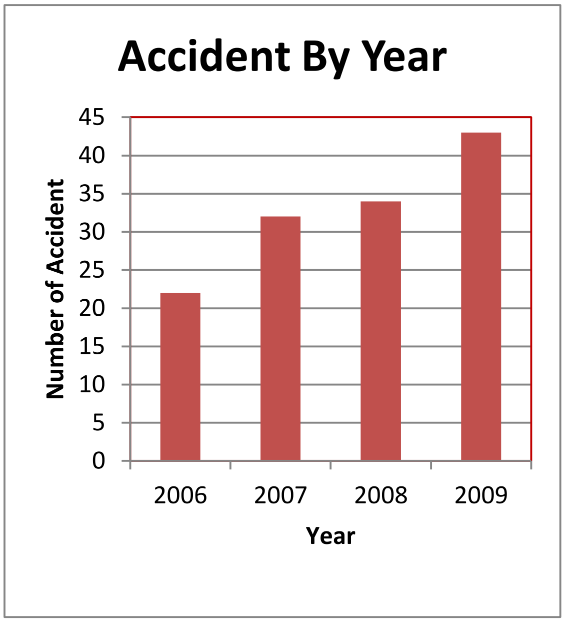
Figure 4. 2 : Sample design of urban road(ERA design manual 2002)

Table 4. 2 : Comparison with ERA Geometric Design Manual For Road Stretch 2

No	**Road way element**	**ERA Standard Values**		**Observed Values in urban area**
		Rural	**Urban**	
1	Parking area	No	3.5m	No parking area
2	Carriageway width	7	7-14	6
3	Shoulder width	0.5m-3m	1.5 - 3.0++	1m-1.5m
4	Pedestrian crossing	Controlled	Controlled	Un Controlled
5	Drainage system	No drainage	Adequate drainage structure	No drainage structure
6	Asphalt Pavement condition	Adequate	Adequate	Pavement distress exist
7	Traffic sign	Adequate	Adequate	No traffic sign
8	Light	Depend on terrain	Adequate light	No light
9	Pedestrian walkway	No	2.5m	No pedestrian walkway

4.2 Effect of Rural Road Characteristics On Traffic Safety

Based on ERA Standard Specifications, the existing rural roads have several deficiencies compared with the urban road. According to Jimma town traffic police accident records, majority of the accident occurred on both road stretches are due to design factor problems. Figure 4.3 below shows the total number of accidents distributed over the past four years of analysis period for road stretches 1 and 2. It is understood that the number of years and traffic volume indicated an influence on the accident situation. The most significant feature of the chart is that the number of road traffic accidents in the subject area, in which the accident increased as the number of years also increased.



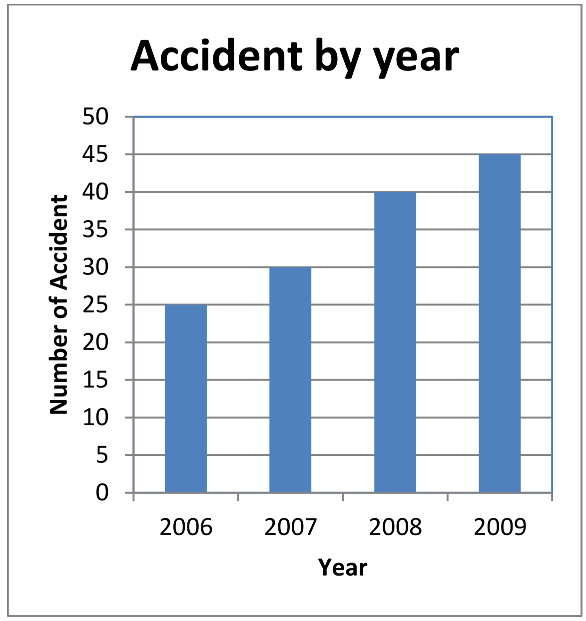


Figure 4. 3: Road Stretches 1 and 2

The traffic safety of the town is affected by the imbalance of the road way design which showed a strong relationship of the accident patterns as seen in Figure 4.3. The condition would persist if the road sections will not be improved based on the identified deficiencies as described in table 4.1 & 4.2.On the other hand, figure 4.4shows the trend of the number of population in the subject area.

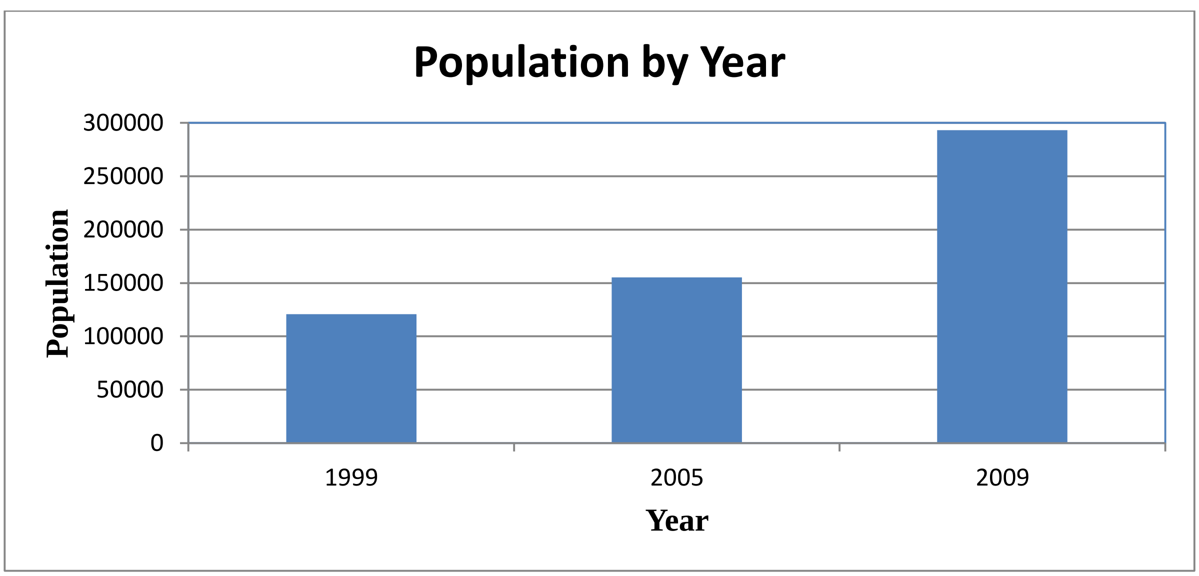


Figure 4. 4 : Total number of population vs year(source statics office of Jimma town)

As the population grew from year to year, it grew along with the number road traffic accidents indicating a positive relationship between these variables.

4.2.1 Road stretch 1 along Gas Station to Boye Hayek Road

Some parts of this road way became populated with residential houses which have no parking space , no pedestrian walkways, zabra crossing. This existing condition of the road tends to contribute probability of accidents, including discomfort of road users. Figure 4.5 shows the yearly variation of accident.

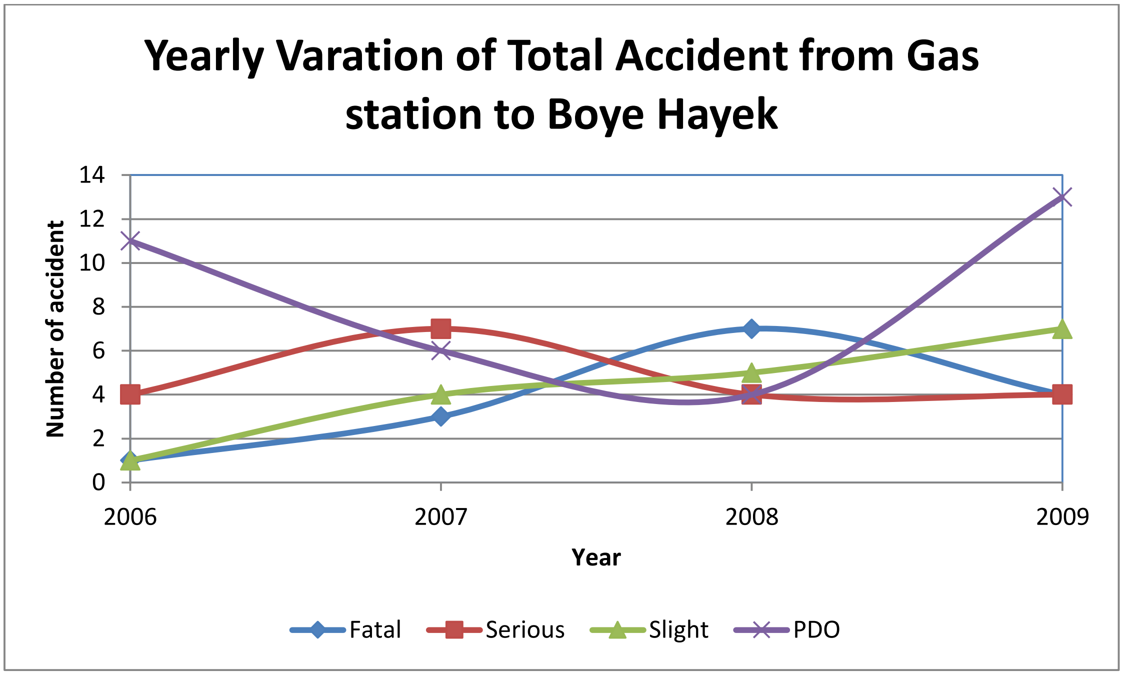


Figure 4. 5 : Yearly variation in degree of severity of accidents in str 1.

Table 4. 3: Details As-built road geometric design outputs & reported accident data

Sampling Location	Satation		Carriageway width(m)	Gradient		Traffic accident
				Min	Max	
Gas station	0+000	2+000	7.25	1.618	0.6223	28
A.A kela	2+000	3+500	9.12	4.096	7.499	15
Tishayer	3+500	4+000	7.5	5.654	6.021	25

Boye	4+000	5+000	7.55	1.127	1.302	25
Boye hayek 2	6+000	7+500	10	1.231	1.35	10

Table 4. 4: Details As-built road geometric design outputs & reported accident data at curve road location

Sampling Location	Satation		Carriageway width(m)	Radius	Gradient		Superelevation		Traffic accident
					Min	Max	Min	Max	
Boye hayek	5+000	6+000	7.53	100	1.441	3.874	2.5	7	20

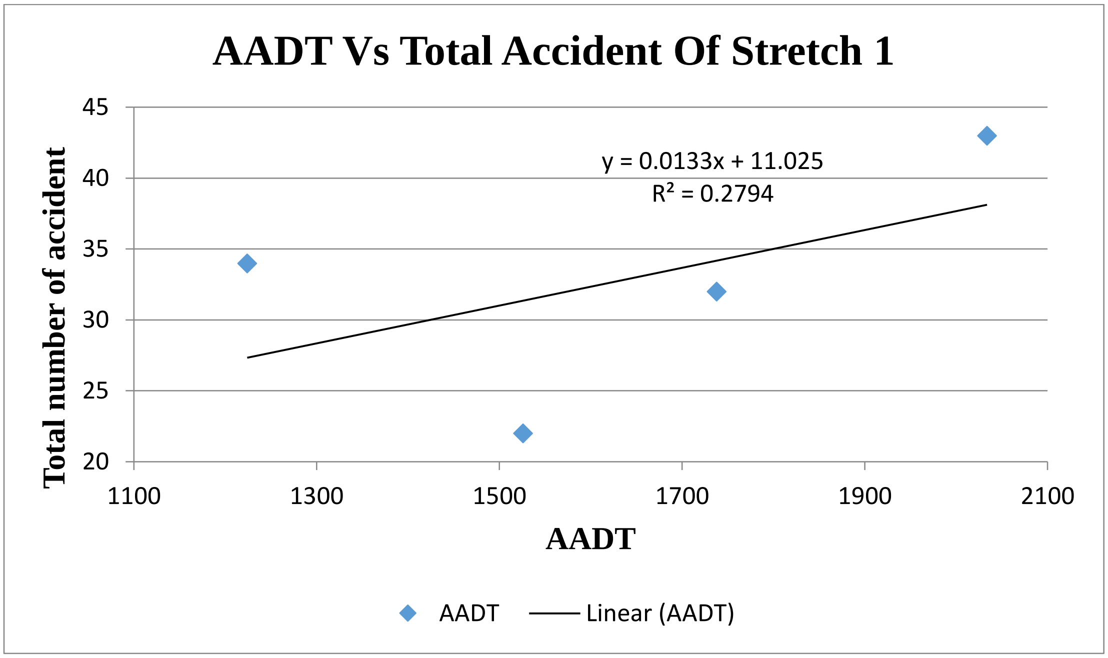


Figure 4. 6: Influence of traffic volume on total accident

As shown in the above total number of accident has a direct relation with the traffic volume. A trend line between the accident rate and traffic volume (AADT) is plotted.

4.2.2 Scatter Plot

Prior to carrying out the regression analysis, a scatter diagram was generated by applying Microsoft Excel Spreadsheet, in order to study the relationships developed between the dependent and independent variables.

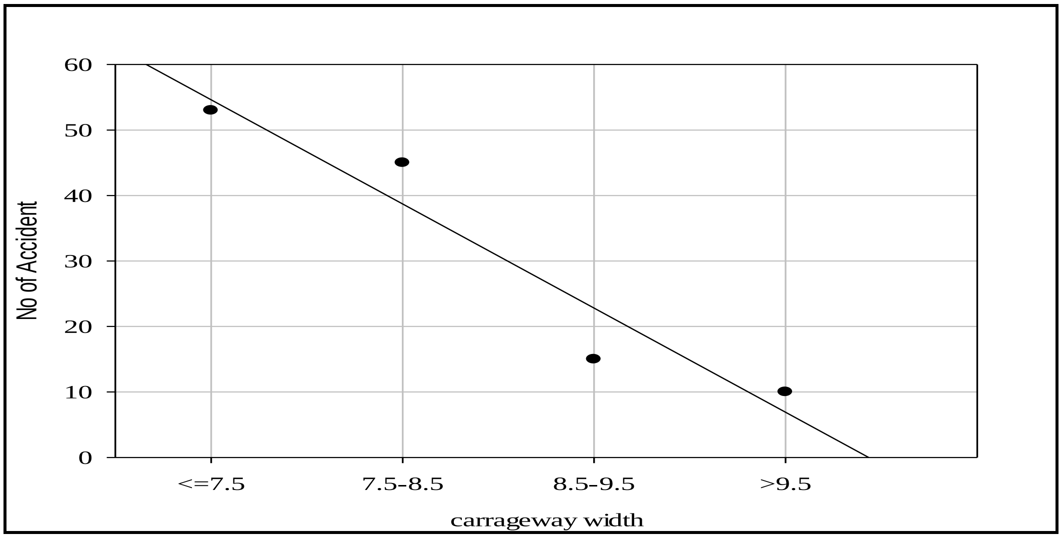


Figure 4. 7: Scatter Diagram of Carriageway Width versus total Number Accident

As shown table 4.3 the carriage way width value, less than 7.5m contributed (57), between 7.5m to 8.5m the number of accident contributed (45), between 8.5m to 9.5m the number of accident contributed (15), the width greater than 9.5m the number of accident contributed (10) and also the figure 4.7 Indicates that the carriageway width and the number of accident directly relationship and the best fit of the carriageway width is greater than 9.5m.

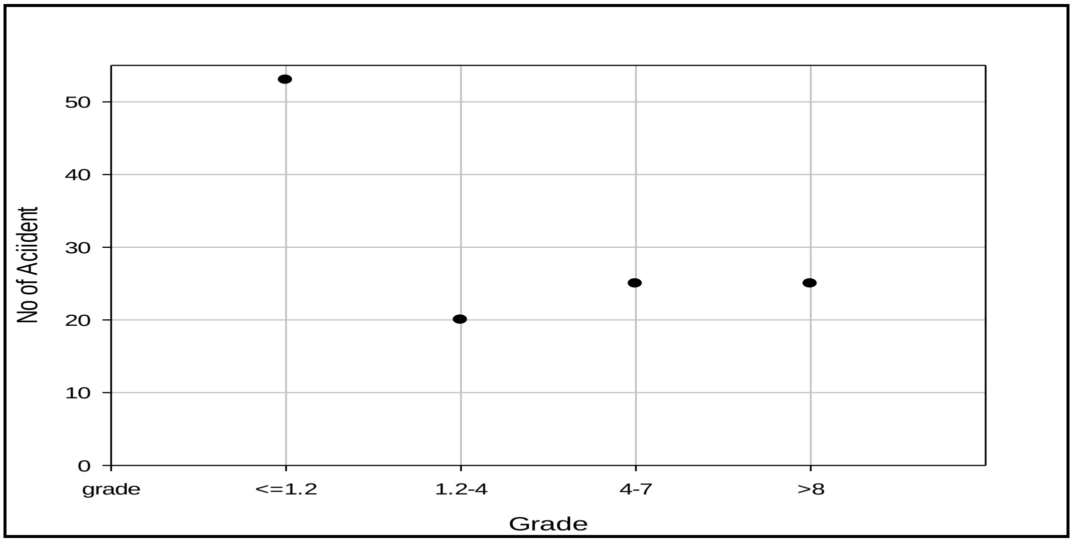


Figure 4. 8: Scatter Diagram of Grade versus number of Accident

As shown table 4.3 the grade value, less than 1.2% the number of accident contributed (55), between 1.2% to 4% the number of accident contributed (20),between 4% to 7% the number of accident contributed (25), and also the figure 4.8. Indicates that the grade value and the number of accident directly relationship.

The above two scatter diagrams provide a visual method of displaying a relationship between variables. Inspection of the scatter diagrams indicate that there is a reasonable indication that the points lie scattered randomly around a straight line, particularly for the carriageway width and grade straight-line fit is suggested.

Relatively the above scatter plot shows a linear response and hence, a linear regression expresses the association between the subject parameters. A linear relationship is usually practiced in solving different engineering problems because of its simplicity.

4.2.3 Regression Analysis

Regression analysis is a statistical method for modeling the relationship between two or more variables using simple and multiple linear equations [20].

Simple linear regression refers to a regression on two variables while multiple linear regressions refers to a regression on more than two variables.

The general equations of a probabilistic single and multiple linear regression models are presented in the following forms [20].

$Y = \beta 0 + \beta 1 X + \varepsilon$

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 also 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 [26].

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-offit"or how closely variables X and Y are related. It does not indicate whether an association between the variables is statistically significant.

Confidence of the result indicates in terms of significant value (P). The correlation was considered significant if (P) is zero or 5 % different from zero [27]. From the (SPSS) statistical output, pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050,there is no significant relationship between the two variables. Effects of driver characteristics haven’t been considered in the analysis due to insufficient information. Specific to this research, (SPSS) software is employed to investigate the significance of individual variables.

4.2.3.1 Correlation between Number of Accident and Carriageway Width (CW)

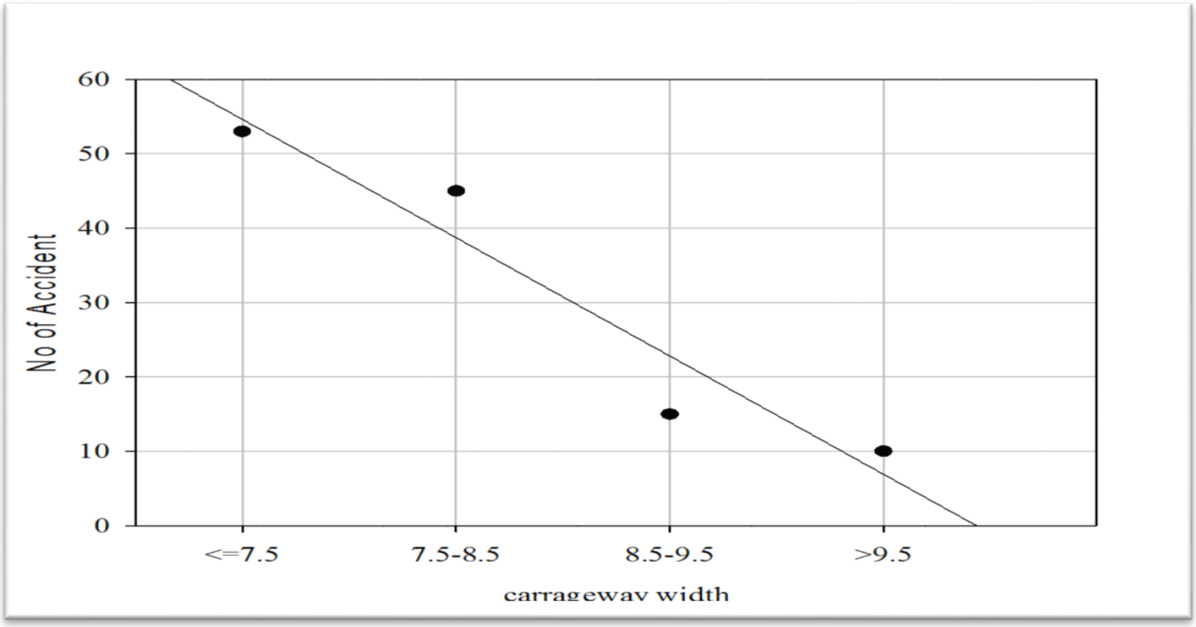


Figure 4. 9: Influence of carriageway on Total Accident

The number of road traffic accident varies with respect to the variation of carriageway width as shown in figure 4.9. No of accident is high in the lowest carriageway width (<7.5 m) and decreases with increasing in carriageway width i.e (>9.5m) the number of accident decreases. The resulting regression analysis after correlating TA with Carriageway Width (CW) is expressed by the following linear equation with its corresponding correlation coefficients:

Linear Regression

TA = 173.850 - (15.900 * CW)

R = 0.958, Rsqr = 0.918,AdjRsqr = 0.877

Standard Error of Estimate = 7.507

	Coefficient	**Std. Error**	**t**	**P**
Constant	173.850	30.446	5.710	0.029
CW	-15.900	3.357	-4.736	0.042

Analysis of Variance:

	DF	**SS**	**MS**	**F**	**P**
Regression	1	1264.050	1264.050	22.432	0.042

Residual	2	112.700	56.350
Total	3	1376.750	458.917

The details of the statistical out-put indicates that the relationship developed between carriageway and Total Accident is significant ($p<0.05$) .

4.2.3.2 Correlation between number of accident and Grade (G)

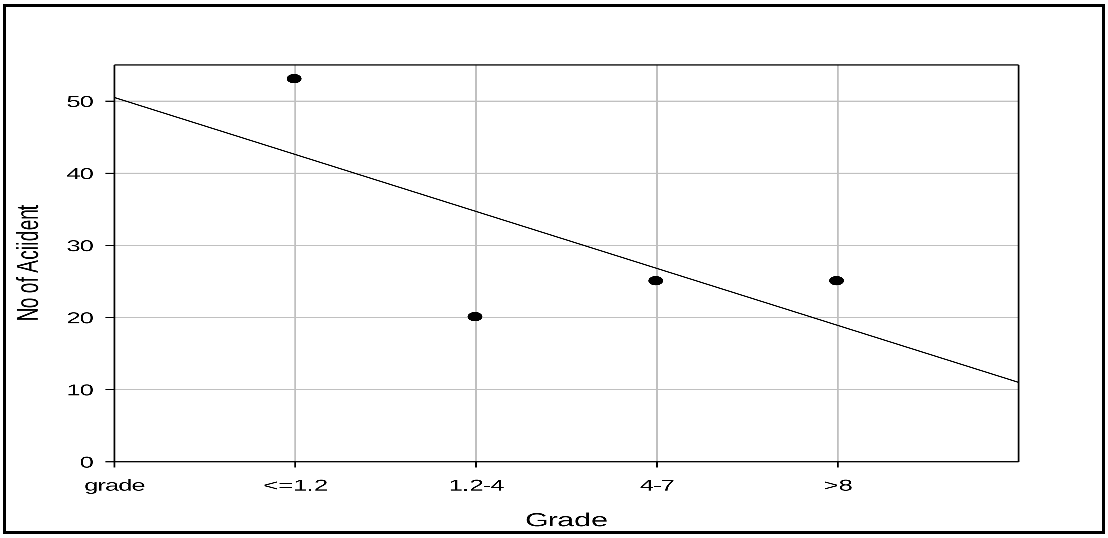


Figure 4. 10: Influence of Grade on Total Accident

The influence of road traffic accident varies with respect to the variation of Vertical curve as shown in fig 4.10. Total number of accident is high in the lowest and in the highest percentage of grade. The resulting regression analysis after correlating TA with G is expressed by the following linear equation with its corresponding correlation coefficients:

Linear Regression

TA = 48.966 - (3.607 * G)

R = 0.739   Rsqr = 0.547   AdjRsqr = 0.320   Standard Error of Estimate = 12.386

	Coefficient	Std. Error	t	P
Constant	48.966	13.266	3.691	0.066
G	-3.607	2.323	-1.553	0.261

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	369.909	369.909	2.411	0.261
Residual	2	306.841	153.421		
Total	3	676.750	225.583		

4.2.4 Road Stretch 2 along Fromi Hotel to Adissu Kera road

The roadway section is far old from its service life, which one of the contributory factor causing traffic accidents due to its dilapidated pavement surface. The increased rate of traffic accident is the direct and obvious result of the out dated road. As a result, the road needs an overall redesigning and reconstruction instead of renewal. Based on the accident data taken from the police station of Jimma town, this section showed high incidence of traffic accident.

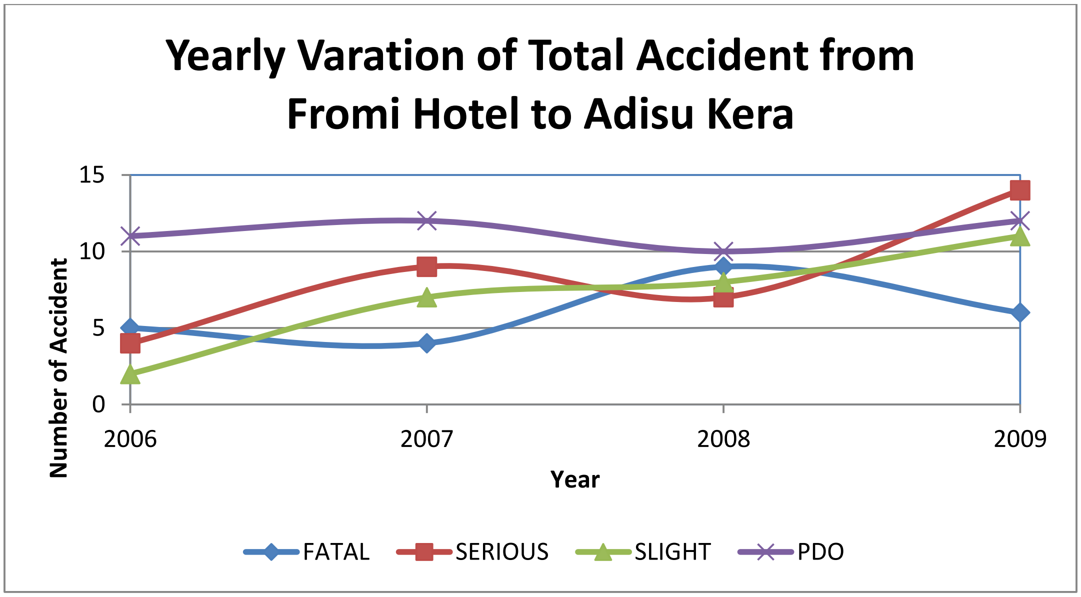


Figure 4. 11: Yearly variation in degree of severity of accidents in Road stretch 1

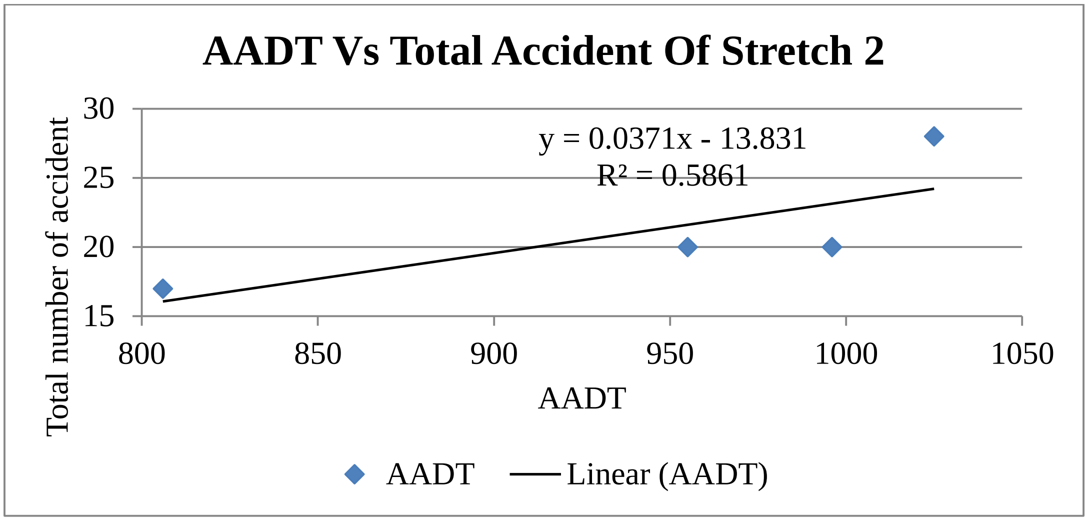


Figure 4. 12: Influence of Traffic volume on Total Accident

4.2.5 Identification of Black Spots

Black spot locations were identified using GIS after collecting coordinate of the accident location using GPS instrument for both stretches.

Table 4. 5: Coordinate of Road stretch 1

No	Northing	Easting	Elevation	Description
1	7.672694	36.85456	1733	Gas Station
2	7.669917	36.85828	1737	AA Kela
3	7.669833	36.86608	1727	Tishayer
4	7.665306	36.87228	1724	Boye
5	7.663444	36.87378	1730	Boye Hayek
6	7.660957	36.87754	1735	Boye Hayek 2

Table 4. 6 : Coordinate of Road stretch 2

No	Northing	Easting	Elevation	Description
1	7.682667	36.83356	1728	Keye Afer
2	7.692278	36.82361	1742	Wareka
3	7.695222	36.81758	1756	Gebrial
4	7.699639	36.81289	1787	Agriculture Office

5	7.701632	36.8077	1763	Agaro Kela
6	7.709083	36.80622	1869	Adisu Kera

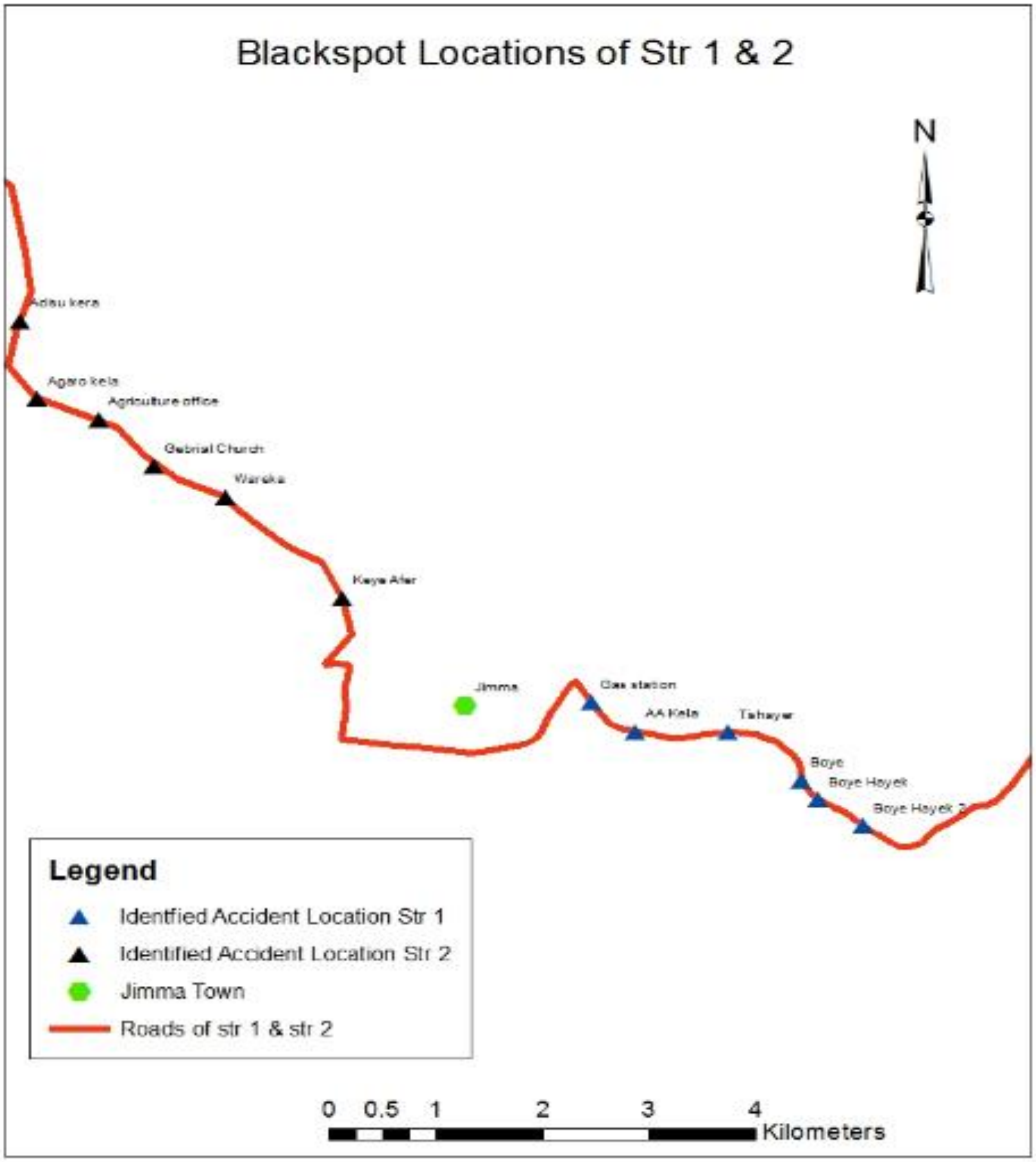


Figure 4. 13: Identified accident locations on both stretches (source: Arc GIS 10.4 result)

4.2.5.1 Method of Prioritization

The prioritization methodology to be used in GIS and how the various accident causing factors like width of road, number of lanes in each direction, drainage condition, surface type, presence of median, ribbon development, etc. are involved, ranking of these parameters according to how they are contributing towards accidents. From the results, suitable countermeasures are provided and the importance of GIS in identification of hazardous locations has been emphasized [28].

i. Calculating Accident Rate

$$A=\frac{A\times 10^{6}}{365\times T\times AADT\times L}$$

Where, A (road section) = accident rates per million vehicle-kilometer on road sections,

A = number of reported accident,

L = length of the road section, in kilometer

T = time frame of the analysis, years (Four years study period).

AADT = average annual daily traffic.

Table 4. 7: Estimation accident rate

accident place	Station		No accident	D	AADT	AR
Gas station	0+000	2+000	28	2	6522	1.470261
A.A kela	2+000	3+500	15	1.5	6522	1.050186
Tishayer	3+500	4+000	25	0.5	6522	5.250932
Boye	4+000	5+000	25	1	6522	2.625466
Boye hayek	5+000	6+000	20	1	6522	2.100373
Boye hayek 2	6+000	7+500	10	1.5	6522	0.700124

Table 4.7 shows the spread of accident rates among the schemes studied was high ranging from a minimum of 0.700124to a maximum of 5.250932. Therefore there is need of ninth percentile because of spread of accident rate is very high. The maximum accident rate could be strongly affected by one scheme with a higher accident rate.

ii .Calculating priority

According to the priority criteria, road sections which have greater than or equal to 20 of priority value considered for immediate treatment. These prioritized based on the following formula:-

$$P = \frac{(1*W+2*X+3*Y+5*Z)}{D},$$

Where :-

W= total number of property damage

X = total number of light injuries

Y = total number of serious injuries

Z = total number of fatal injuries

D= distance of the black spot section in kilo me

Table 4. 8: Estimation priority

No	Station		No of accident	W	2X	3Y	5Z	D	P	Rank
1	0+000	2+000	28	10	8	30	20	2	**34**	**5**
2	2+000	3+500	15	5	10	21	30	1.5	**44**	**4**
3	3+500	4+000	25	10	10	15	25	0.5	**120**	**1**
4	4+000	5+000	25	10	10	18	20	1	**58**	**2**
5	5+000	6+000	20	6	10	12	25	1	**53**	**3**
6	6+000	7+500	10	3	8	6	5	1.5	**22**	**6**

According to the priority criteria developed in other literatures, road sections which have greater than or equal to 20 of priority value considered for immediate treatment. The above table 4.8 shows the selected stretch needs immediate treatment representing the priority value above 20. Station 3+500 to Station 4+000 indicated the highest priority value of 120, which ranked 1st among the six identified sections. Followed by Station 4+000 to Station 5+000 with a priority value of 58.

4.3 General Countermeasures / Suggestion Improvements

After the site visits, as-built review, field measurements and analyses were undertaken, all results obtained have been compared with ERA Standard Specifications. Accordingly, the possible countermeasures are proposed for the identified road design problem as shown in tables 4.9 & 4.10.

Table 4. 9: General situations of stretch 1 and potential countermeasures

No	Observed road way characteristics problems	Potential Countermeasure
1	Narrow Carriageway width	widen the carriage way width according to standard
2	Narrow bridge	Extend the bridge according standard and put bridge sign
3	Missing shoulder	construct shoulder
4	Missing drainage	construct drainage system
5	Asphalt pavement damage	Make appropriate maintenance
6	Miss parking area	Establish parking area
7	Narrow Right of Way	widen the right of way according to standard
8	Missing of Road marking	Make road marking
9	Missing traffic sign	Establish traffic sign at the correct position
10	Uncontrolled Pedestrian crossing	Establish zebra cross
11	Light	construct light poles at necessary positions
12	Missing of Pedestrian walkway	Construct Pedestrian walkway

Table 4. 10: General situations of stretch 2 and potential countermeasures

No	Observed road way characteristics problems	Potential Countermeasure
1	Narrow Carriageway width	widen the carriage way width according to standard
2	Missing shoulder	construct shoulder
3	Missing drainage	construct drainage system
4	Asphalt pavement damage	Periodic and permanent maintenance
5	Miss parking area	Establish parking area
6	Narrow Right of Way	widen the right of way according to standard
7	Missing of Road marking	Make road marking
8	Missing traffic sign	Establish traffic sign at the correct position
9	Uncontrolled Pedestrian crossing	Establish zebra cross
10	Light	construct light poles at necessary positions
11	Missing of Pedestrian walkway	Construct Pedestrian walkway
12	Improper Junction	Junctions should be properly designed

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Rural road characteristics are considered an effective factor to meet the requirements of safety features. There exists a strong positive correlation between road traffic accidents and population, and that specifically, as the population grows, the number of accidents also increases.

Based on the findings of the study, the carriageway width greater than 9.5m indicated lowest number of accidents, while a two lane carriageway without shoulder or a narrow shoulder, ≤ 7.5m, showed the most dangerous road stretch. For a carriageway width <8.5m indicated the highest number of accident. In addition, the Carriageway width and traffic accident revealed a strong statistical relationship with R = 0.958, with standard error of ($p<0.05$), and the resulting linear regression equation with its corresponding correlation coefficient is expressed as TA = 173.850 - (15.900 * CW), with R^2 = 0.918 and Adj. R^2 = 0.877. Grade has a minimal effect on accident, however downgrade road sections have slightly higher accident rates than upgrade sections, based on statistical relationship R = 0.739, standard error of ($p<0.05$) and the resulting linear regression analysis equation with its corresponding correlation coefficient is TA = 48.966 - (3.607 * G), with R^2 = 0.547and Adj. R^2 = 0.32. It means the crashes increased with gradient and downhill have considerably higher crash rates than uphill.

However, the overall crash implications of steep gradients may not be severe since steeper gradients are shorter in the study area. While, the AADT have positive relationships with total number of accident. It means the section with less traffic resulted in less accident rates whenever these variables increased. The major factors directly affecting safety are lane width and shoulder conditions, including traffic sign, and crossings.

Generally, an increase in carriageway width, the number of accident also decreases, increase in gradient, decrease the number of accident. In addition, absence of traffic sign, pavement marking, parking area, pedestrian walkway increases the accident & affects the travel patterns and development of the town. When the population density increase without modification of the surrounding roads, the number of accident increases. When roads are over used beyond their service life, their exposure to traffic accidents exceeds the service it gives to the users. More so, if rural roads do not get periodic maintenance, they will become a dread for the safety of the travelling public. Therefore, once a rural roads become part of the urban area, it must be redesigned in such a way that it would be suitable to the standard requirements of urban users.

5.2. Recommendations

Based on deep understanding of the rural road characteristics, some measures are forwarded to the Administrative and Engineering Office of Jimma Town, and Ethiopian Road Authority (ERA) in order to overcome its negative effect on safety considerations of all road users.

The road stretches along Gas station to Boye Hayek (sub-section of Jimma to Addis Ababa road), and along Fromi Hotel to Adisu kera (Jimma to Agaro road) must be redesigned to meet the minimum urban road design standard as stipulated in the ERA Manual and Standard Specifications. The findings revealed that the existing roads were designed and constructed more than 15 years ago, which falls under rural road criteria. The current road condition was observed to have a lot of deficiencies such as lack of sufficient carriageway, drainage system, zebra or pedestrian crossings, pavement markings, and parking area. It must be clearly understood that the high incidence of the occurrence of accidents as has strong relationship of the limited carriageway width and total number of traffic accidents. Along the study stretch of roads, regular maintenance activities (i.e. both routine and periodic maintenance) must be undertaken.

Traffic rules should be properly enforced, specifically for the prohibition of road side parking which constrict the flow of traffic. Provide appropriate traffic signs and pavement markings, traffic channelization, and pedestrian side walkways.

The roads should have to be re-designed and re-constructed in line with the specified geometric factors with regard to population & facility of the area.

Generally the following modifications should be done :-

- Prohibition of on road side parking
- Furnish appropriate sign and marking
- Providing pedestrian side walk
- Modify carriageway width
- Shoulder Widening
- Pavement Condition Improvement

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APPENDIX A

Appendix A-1: Distribution of RTA based on Geometric Element

Table A 1.1 Distribution of RTA by carriageway width value of stretch 2

Carriageway width	No accident
<=7.5	53
7.5-8.5	45
8.5-9.5	15
>9.5	10

Table A 1.2 Distribution of RTA by Grade value

Grade	No accident
<=1.2	53
1.2-4	20
7	25
>8	25

Appendix A-2 Linear Regression Analysis Results

R	R^2	Adj R^2	Std. Error of the Estimate
0.958	0.918	o.877	7.507

1)Correlation between Total no of Accident (TA) and Carriageway width (CW).

a. Independent Variable: CW

b. Dependent Variable: TA

	Coefficient	**Std. Error**	**t**	**P**
Constant	173.850	30.446	5.710	0.029
CW	-15.900	3.357	-4.736	0.042

Analysis of Variance:

	DF	**SS**	**MS**	**F**	**P**
Regression	1	1264.050	1264.050	22.432	0.042
Residual	2	112.700	56.350		
Total	3	1376.750	458.917		

2) Correlation between Total no of Accident (TA) and Grade (G).

R	R^2	Adj R^2	Std. Error of the Estimate
0.739	0.547	0.32	12.386

a. Independent Variable: G

b. Dependent Variable: TA

	Coefficient	Std. Error	t	P
Constant	48.966	13.266	3.691	0.066
G	-3.607	2.323	-1.553	0.261

Analysis of Variance:

	DF	SS	MS	F	P
Regression	1	369.909	369.909	2.411	0.261
Residual	2	306.841	153.421		
Total	3	676.750	225.583		

APPENDIX B

Appendix B-1: Details of Road Geometric Design Data

Table B-1.1: Details reported accident data at selected locations. Source: Jimma town traffic police office

Stretch 1

No	Roads	Year	Black spot Roads	Fatal	Serious injury	Slight injury	Damaged properties
1	Gas station – Boye hayek 2	2006	Gas station	1	2	-	4
			A.A kela	1	1	1	2
			Tishayer	1	-	-	2
			Boye	1	1	-	1
			Boye hayek	1	-	-	1
			Boye hayek 2	-	-	1	-
2	Gas station – Boye hayek 2	2007	Gas station	-	1	1	3
			A.A kela	1	-	1	1
			Tishayer	1	2	1	2
			Boye	1	3	3	2
			Boye hayek	1	1	1	2
			Boye hayek 2	-	-	-	1
3	Gas station – Boye hayek 2	2008	Gas station	2	2	1	2
			A.A kela	1	1	-	1
			Tishayer	2	1	2	1
			Boye	1	2	2	2
			Boye hayek	2	1	2	1
			Boye hayek 2	-	1	1	1
4	Gas	2009	Gas station	-	4	2	3

	station – Boye hayek 2		A.A kela	1	2	1	-
			Tishayer	2	2	3	3
			Boye	1	1	1	3
			Boye hayek	2	2	1	2
			Boye hayek 2	1	1	2	1

Stretch 2

No	Roads	Year	Black spot Roads	Fatal	Serious injury	Slight injury	Damaged properties
1	Fromi Hotel – adisu kera	2006	Keye afer	1	1	1	4
			Wareka	-	1	-	4
			Gebrial	1	-	1	-
			Agri office	1	-	1	1
			Agaro kala	-	1	-	2
			Adisu kera	-	1	-	1
2	Fromi Hotel – adisu kera	2007	Keye afer	-	2	1	2
			Wareka	2	2	1	1
			Gebrial	-	2	-	1
			Agri office	1	-	1	2
			Agaro kala	1	2	1	2
			Adisu kera	-	1	1	1
3	Fromi Hotel– adisu kera	2008	Keye afer	4	1	2	2
			Wareka	2	1	1	-
			Gebrial	3	1	2	1
			Agri office	1	1	-	1
			Agaro kala	1	-	1	-
			Adisu kera	-	2	1	2
4	Fromi Hotel – adisu kera	2009	Keye afer	1	2	2	4
			Wareka	1	3	2	4
			Gebrial	3	2	2	4
			Agri office	2	1	-	2
			Agaro kala	1	-	1	3
			Adisu kera	1	-	2	2

Table B-1.2: Vehicle Classification by class. (Source: Road Asset Management. and Contract Implementation Coordination Directorate)

Vehicle	Type of Vehicle	Description
1	Small Car	Passenger cars, minibuses (up to 24-passenger seats),Taxis, Pickups, and Land Cruisers, Land Rovers, etc.
2	Bus	Medium and large size Buses above 24 passenger seats
3	Medium Truck	Small and medium sized trucks including tankers up to 7 tons load
4	Heavy Truck	Trucks above 7 tons load
5	Articulated Truck	Trucks with trailer or semi-trailer and Tanker trailers

Table B-1.3: Annual Average Daily Traffic by Road Section and Vehicle Kilometer of Travel Source: compiled from Ethiopian road authority Jimma branch office (2010).

<u>Stretch 1</u>

Year	Car		Land Rover	Small Bus	Large Bus	Small Truck	Medium Tuck	Heavy Truck	Truck & Trailer	Total
2006	33		160	483	101	141	279	219	110	1526
2007	39		181	583	114	177	358	195	91	1738
2008	15		112	253	44	35	301	345	119	1224
2009	29		251	551	54	116	360	325	348	2034

<u>Stretch 2</u>

Year	Car	Land Rover	Small Bus	Large Bus	Small Truck	Medium Tuck	Heavy Truck	Truck & Trailer	Total
2006	7	58	384	29	90	172	42	24	806
2007	11	173	443	27	12	179	81	29	955
2008	13	205	459	21	3	159	93	43	996
2009	12	185	467	21	13	185	116	26	1025

TABLE B-1.4: DETAILS AS-BUILT ROAD GEOMETRIC DESIGN OUTPUTS & REPORTED ACCIDENT DATA

Sampling Location	Satation		Carriageway width(m)	Gradient		Traffic accident
				Min	Max	
Agip gas station	0+000	2+000	7.25	1.618	0.6223	28
A.A kela	2+000	3+500	9.12	4.096	7.499	15
Tishayer	3+500	4+000	7.5	5.654	6.021	25
Boye	4+000	5+000	7.55	1.127	1.302	25
Boye hayek 2	6+000	7+500	10	1.231	1.35	10

TABLE B-1.5 : DETAILS AS-BUILT ROAD GEOMETRIC DESIGN OUTPUTS & REPORTED ACCIDENT DATA AT CURVE ROAD LOCATION

Sampling Location	satation		Carriageway width(m)	Radius	Gradient		Superelevation		Traffic accident
					Min	Max	Min	Max	
Boye hayek	5+000	6+000	7.53	100	1.441	3.874	2.5	7	20

Table B-1.6 : Estimation accident rate

accident place	station		No accident	D	AADT	AR
Gas station	0+000	2+000	28	2	6522	1.470261
A.A kela	2+000	3+500	15	1.5	6522	1.050186
Tishayer	3+500	4+000	25	0.5	6522	5.250932
Boye	4+000	5+000	25	1	6522	2.625466
Boye hayek	5+000	6+000	20	1	6522	2.100373
Boye hayek 2	6+000	7+500	10	1.5	6522	0.700124

Table B-1.7 : Estimation priority

No	Station		No of accident	W	2X	3Y	5Z	D	P	Rank
1	0+000	2+000	28	10	8	30	20	2	**34**	**5**
2	2+000	3+500	15	5	10	21	30	1.5	**44**	**4**
3	3+500	4+000	25	10	10	15	25	0.5	**120**	**1**
4	4+000	5+000	25	10	10	18	20	1	**58**	**2**
5	5+000	6+000	20	6	10	12	25	1	**53**	**3**
6	6+000	7+500	10	3	8	6	5	1.5	**22**	**6**