# JIMMA UNIVERSITY

School of Graduate Studies

Jimma Institute of Technology

School of Civil and Environmental Engineering
Department of Civil Engineering

Highway Engineering Stream

IDENTIFICATION AND ANALYSIS OF HAZARDOUS LOCATIONS AND ITS REMEDIAL ACTIONS AT MAJOR INTERSECTIONS I N ADDIS ABABA
(A CASE STUDY FOR LUKUWANDA - MEGENAGNA ROAD)

*The thesis Submitted to School of Graduate Studies of Jimma University Institute of Technology in partial fulfillment of the requirement for the Degree of Masters of Science in Civil Engineering (Highway Engineering Stream)*

By; - Bushirelkerim Oumer Abegaz

November 2016
Jimma, Ethiopia

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By: - Bushirelkerim Oumer Abegaz

The Thesis Submitted to;-

Main Advisor; - Prof. Dr. - Ing. Alemayehu Gebissa

Co-Advisor; - Eng. Murad Mohammed (MSc)

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JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

HIGHWAY ENGINEERING CHAIR

# IDENTIFICATION AND ANALYSIS OF HAZARDOUS LOCATIONS AND ITS REMEDIAL ACTIONS AT MAJOR INTERSECTIONS I N ADDIS ABABA (A CASE STUDY FOR EAST-WEST CORRIDOR)

By: Bushirelkerim Oumer

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# DECLARATION

*It is certified that, this research work titled "Identification and Analysis of Hazardous Locations and its Remedial Actions at Major Intersections in Addis Ababa (A Case For Lukuwanda-Megenagna Road)" is his (Bushirelkerim Oumer) own work. The work has not been presented elsewhere for assessment and award of any degree or diploma. Where material has been used from other sources it has been properly acknowledged / referred.*

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*Bushirelkerim Oumer*

*Jimma, November 2016*

# ABSTRACT

Hazardous Road Location is an ever chronic problem in the transportation system soon after the invention and mass production of automobiles. Some of the negative effects of hazardous road are; considerable loss of travel time, higher fuel consumption, more vehicle emission and associated environmental and health impact increased accident risk, stress and frustration on commuters and greater transportation cost.

In this MSc thesis the main objective of the study was to identify and analyze the hazardous roads in Addis Ababa along Lukuanda - Megenagna through Piaza road and to indicate its remedial actions.. Because of that there was limited road capacity, on street parking, un-integrated urban planning, and lack of mass transit, accident, poor vehicle condition, very long delay and road side illegal trade throughout the study area.

The analysis and identification of HRL consists in the implementation of three types of methods:

(i) Based on technical weight of prioritization: Road locations are laid under high, medium and low hazard prone level.

(ii) Based on the point density: Which is based on the total number of traffic accident.

(iii)Methods based on GIS analysis: The most vulnerable segments have been identified on the basis of the highest number of accidents occurred during the analysis period.

The remedial measures indicated in this thesis are related to the type and positioning of the road furniture and these have been grouped into three categories: traffic control devices, road and street design, and traffic calming. Since design details are not presented, the road owner should seek engineering expertise when selecting countermeasures. Several engineering countermeasures like traffic control devices, road and street design and traffic calming on lower-speed roadways have been also identified that can be used to influence to give way for pedestrians, driver speed choice and that address speeding problems.

Key words; - Hazardous location, Prioritization, Density Function, Hazard prone level

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# ACRONYMS

| | |
|---|---|
| CMF's | Crash Modification Factors |
| CMS | Congestion Management System |
| ERTA | Ethiopian Road Transport Authority |
| FARS | Fatality Analysis Reporting System |
| FFS | Free Flow Speed |
| GDP | Growth Domestic Product |
| HCM 2000 | Highway Capacity Manual 2000 |
| HRL | Hazardous Road Location |
| LOS | Level of Service |
| NHTSA | National Highway Traffic Safety Administration |
| NWS | National Weather Service |
| OFCM | Office of the Federal Coordinator for Meteorological Services and Supporting Research |
| PIA | Personal Injury Accident |
| RSDP | Road Sector Development Program |
| RTA | Road Traffic Accident |
| RTAs | Road Traffic Accidents |
| RTIRN | Road Traffic Injury Research Network |
| SPSS | Statistical Package for the Social Sciences |
| TOC | Traffic Operation Center |
| TRB | Transportation Research Board |
| IJAET | International Journal Advanced Engineering Technology |

# CHAPTER ONE

# 1. INTRODUCTION

## 1.1. Background Study

For rapid economic, industrial and cultural growth of any country, a good system of transportation is very essential. One of the transportation systems that are economical for developing countries like Ethiopia is road. A well designed road network plays an important role in transporting people and other industrial products to any direction within short time. Roads, to satisfy their intended purpose, must be constructed to be safe, easy, and economical environmentally friendly and must full fill the needs of inhabitant. Being safe, the number of accidents that can occur will be minimized. In order to meet such intended purpose, countries and cities obligated to spend considerable portion of their GDP on transportation sector. According to the ECMP (2007) European countries expend more than 7% of their GDP on transportation and out of which only traffic congestion costs more than 1% of the GDP. In Ethiopia, different reports estimate transportation expenditure to be about $US 1.3 billion, 10% of the country's GDP; however, the actual cost incurred due to hazardous road is not yet known (Government of Ethiopia, Addis Ababa, 2012).

Addis Ababa, which is the capital city of Ethiopia and the seat of many international organizations with more than 100 embassies, has now become one of the fastest growing relatively modern cities in the sub Saharan Africa. According to the 2007 census the population of Addis Ababa was estimated to be 2.8 Million with an average growth rate of 2.1% (FDRE Population Census Commission, 2008). Following the current economic development in the country, Addis Ababa has become the economic hub (center) of the nation due to its geographical as well as political significance. Accordingly, many financial and commercial institutions and about 85 % of the manufacturing industries of the country are located inside and at the periphery of Addis Ababa. Such rapid socio-economic development in the city creates a huge demand for transportation and the passenger-Km travel is increasing (CES in association with SABA Engineering, 2005).

## 1.2 Statement of the Problems

The Urban Transport Study Report of Addis Ababa estimates that the travel demands of Addis Ababa will be doubled in 2020 and the daily trip will become 7.7 Million trips per day from 3.6 Million in

2004 (CES in association with SABA Engineering,2005). Accordingly, evidences show that the associated transportation problems in the city; namely, hazardous road due to environmental factors, traffic congestion and traffic accident rates are becoming worse and worse.

In this MSc thesis one of the main objective of the study was to identify and analyze the hazardous roads in Addis Ababa along Lukuanda-Megenagna through Piaza road as; limited road capacity, road parking, un integrated urban planning, and lack of mass transit, accident, poor vehicle condition, very long delay and road side illegal trade and indicate its remedial actions. Therefore, the common feature in the causes of hazardous road in developing countries shows that the root causes emanate, spread out from the environmental factors, lack of proper planning and improper use of limited road network.

Maitra (1999) summarizes some of the negative effects of hazardous road as; considerable loss of travel time, higher fuel consumption, more vehicle emission and associated environmental and health impact increased accident risk, stress and frustration on commuters and greater transportation cost.

Therefore, proper quantification and measuring the extent or level of hazard is an important step for understanding the performance of the existing road network and for evaluation of proposed hazardous road mitigation measures. Hence, this research will focus on this information gap and will assess and quantify the level of the hazardous road on the selected study corridor of Addis Ababa based on extent or level of hazard approach; and it will assess the effects of hazardous road on the traffic accident situation of the city.

## 1.3 Research Questions

Therefore, quantitative researches based on the engineering parameters of hazardous road should be conducted to answer at least the following hypothetical questions.

1. How to identify and analyze the level of hazard?
2. What is the software that can be used to identify the hazardous locations?
3. What mitigation actions exist and what might be developed?

## 1.4 Objectives

### 1.4.1 General Objectives

The general objective of this study was to identify and analyze the hazardous road locations in Addis Ababa Lukuwanda -Megenagna road and to indicate the necessary remedial actions.

### 1.4.2 Specific Objectives

- To identify and analyze the level of hazard in terms of intensity and extent based on the parameters identified in the literature.
- To identify a GIS based hazardous road location identification system for Lukuwanda to Megenagna road of Addis Ababa.
- To propose mitigation actions for hazardous road of Lukuwanda to Megenagna road section.

## 1.5 Expected Output

After conducting the research the following findings are expected.

1. Distribution of accidents in each set of study units has been identified.
2. The effect of hazardous road on the traffic accident situation of the city has been assessed.
3. Hazardous road locations have been identified statistically.
4. Safety performance function in each set of the study units has been identified.
5. **GIS** based hazardous road location identification system has been provided.
6. Finally, provide efficient design of remedial measurements.

## 1.6 Scope

Accordingly, the scope of this study was limited to the major road of Addis Ababa **(Lukanda-Menahariya-Piaza-Megenagna)** and other road sections and intersections were not included in this study.

Furthermore, the analysis has been segment study rather than area wide or regional study. Hence, it focused mainly on the road segments corridor and the relative effect of consecutive part was not discussed.

## 1.7 Significance of the study

As this study is aimed on the identification of hazardous road locations, it will have a significance of pointing the hazard locations to sustain the safety of road users. Related to this it is important in analyzing the effect of traffic accidents in finding of fatality and injury rates. This is helpful in estimating the degree of severity of crashes.

In general, this study is important to minimize the road safety problems in the study area and also to develop policy related to road safety audit. In addition, it can be used as an input for the road safety audit program set by AACRA.

## 1.8 Limitation

There were limitations on the thesis, mainly on time restriction to collect actual data like traffic density, traffic flow (volume) data required for the research work. Data from the Addis Ababa Traffic Police Office was in the form of Hard copy, and it makes very difficult to collect accident rate for each segments in consideration. Therefore only seven-year data, Appendix II, Table B-1, 2001/2-2007/8 EC, has been used for segment hazard analysis and risk comparisons.

Budget Constraints forces the researcher to use manual counts for the vehicle density, which may have human error and could not possible to capture the vehicle speed with in the selected range of time.

And also there was limitation on getting accurate data of accident location, vehicle speed and possible reasons of traffic accidents. Therefore, to implement the research one has to verify all the collected data and refine the assumptions taken.

# CHAPTER TWO

# 2. LITRATURE REVIEW

## 2.1 INTRODUCTION

Many researchers and professionals in the field of transportation agree that hazardous road is an ever critical problem and global phenomenon of major cities throughout the world. This section reviews recent research in the analysis of many of these hazards, but it should not be considered comprehensive. Transportation systems are designed to move people, goods, and services efficiently, economically, and safely from one point on the earth's surface to another. Despite this broad goal, there are many environmental hazards that commonly disrupt or damage these systems at a variety of spatial and temporal scales. Whereas road-curve geometry and other engineered hazards can be addressed through design (Persaud, Retting, and Lyon 2000), hazards such as extreme weather, landslides, and earthquakes are much more difficult to predict, manage, and mitigate. These adverse events can dramatically reduce network serviceability, increase costs, and decrease safety.


Fig.2.1 Environmental Hazard (Shola, Addis Ababa)

As the movement of people, goods, and services increases at all scales due to population growth, technological innovation, and globalization (Janelle and Beuthe 1997), the systematic study of these events becomes increasingly important. Research in the area of transportation hazards aids governments in allocating scarce resources to the four phases of emergency management: mitigation, preparedness, response, and recovery. New fields of study are emerging to address this need, as in the case of Highway Meteorology, which focuses on the adverse effects of extreme weather on transportation systems (Perry and Symons 1991). For instance, the growing importance of this particular field in the United States can be seen in the recent publication of Weather Information for Surface Transportation National Needs Assessment Report (OFCM) 2002, some transportation agencies organize special teams to manage and mitigate the effects of one or more of these hazards.

## 2.2. Defining Hazardous Road Location

The investigation of factors which lead to accidents' clusters is an important topic in the road safety activity (Moons *et al*., 2009). According to Elsenaar and Abouraad (2005) a high concentration of accidents at the same location is a strong indicator of a road related problem that should be investigated.

While there is no internationally accepted definition of HRL (Geurts and Wets, 2003; Geurts *et al*., 2005a; Brimicombe 2004 cit. in Anderson, 2007; Cheng and Washington, 2008; Anderson, 2009) several different methods have been applied to identify these locations (Retting *et al*., 2001; Hauer *et al*., 2002a; Flahaut *et al*., 2003; Brijs *et al.*, 2007; Elvik, 2008b; Pirdavani *et al.*, 2010).

## 2.3 Hazards to Transportation System

There are many environmental hazards that may damage or disrupt transportation systems, and we review only the more common ones here. For example, Figure 1.0 depicts familiar road hazards grouped by their principal effect along with some of their causal relationships. These road hazards can: (1) compromise the quality of the surface, (2) block or damage infrastructure, (3) compromise user visibility, (4) compromise steering, (5) create a temporary obstacle, or (6) some combination of the prior five.

Recurrence intervals for an event span from daily to centuries, while the associated consequence range from inconvenient to catastrophic, an event causing great damage or suffering. In some cases one event may cause another torrential rain can trigger a landslide that blocks a road. Some occur unexpectedly, while others arrive with significant warning, but all are amenable to some level of prediction and mitigation.

Transportation systems also create hazards. Accelerated movement comes with risks, and the corresponding accidents that occur disrupt lives and transportation systems daily. Vehicles collide, trains derail, boats capsize, and airplanes crash often enough to keep emergency managers and news reporters busy. The transportation of hazardous materials (HazMat) is a controversial example in this regard because it places substantial involuntary risks on proximal people and the environment. Lesser known transportation hazards include elevated irrigation canals, gas pipelines and electrical transmission lines. Intermodal risks are present in much transportation systems, as in wake turbulence behind large aircraft (Gerz, Holzapfel, and Darracq 2002; Harris et al. 2002), but intermodal risks are also a significant factor and train might collide with a truck at an at grade crossing (Austin and Carson 2002; Panchaanathan and Faghri 1995), or a river barge might bump a bridge, leading to the derailment of a train.

Transportation systems that are disrupted by a hazardous event also play a critical role in emergency management. Transportation lifelines are generally considered the most important in an emergency because of their vital role in the restoration of all other lifelines. Emergency managers must route personnel to an accident site, restore lifelines, relocate threatened populations, and provide relief, all of which rely on transportation. Research in this area is increasing, and there are many methods and tools to aid in addressing problems in this domain.

Therefore, quantitative researches based on the engineering parameters of hazardous road should be conducted to answer at least the following hypothetical questions. These include review following these questions:

1. What is the hazard?
2. What has been done to address the hazard in research and practice?
3. How well can we predict the hazard in space and time?
4. What are the consequences of the hazard and how are they defined and measured?
5. What mitigation actions exist and what might be developed?

Hazardous road is a negative output of transportation system which has many detrimental effects on the performance of the road network, the traffic flow, the society, the national economy and the environment. Maitra (1999) summarizes some of the negative effects of hazardous road as;

considerable loss of travel time, higher fuel consumption, more vehicle emission and associated environmental and health impact increased accident risk, stress and frustration on commuters and greater transportation cost. Since then different research efforts to develop methods and parameters for measuring hazardous road have been proposed by different researchers and manuals. Further to the above; many more researches have been conducted by different researchers and professionals to develop measuring parameters and models (Maitra, P.K. Sikdar, & S.L.Dhingra, 1999; Lomax,Turner, and Shunk, 1997; W.D.Cottrell, 2001).

However, many scholars agree that unlike the other traffic flow characteristics, still there is no consistent, standard definition and a single performance measure for hazardous road location. An abnormally high recorded number of accidents could to a large extent be the result of random variation and does not necessarily mean that a site has a high expected number of accidents, warnings, road closures, and low level wind shear alert systems. An airport wind-warning system generally consists of a set of anemometers that are analyzed by computer. A warning is issued when levels differ by some threshold. Automated wind-warning systems for individual roads may appear soon because of advances in weather instrumentation. The finest level that wind warnings are commonly issued is at a county scale. Improved weather forecasting is generally viewed as the principal means for reducing the hazard (Perry and Symons 1994).

Hurricanes and tornadoes represent special cases of extreme winds. Due to satellite, radar, and other in situ sensor networks, their prediction has greatly increased in recent years. Much of the transportation research in this area focuses on evacuation. Wolshon (2001) reviews the problems and prospects for contraflow freeway operations to reduce the vulnerability of coastal communities by reversing lanes to increase freeway capacities in directions favorable for evacuation. This problem is simple conceptually but represents a significant challenge for both traffic engineers and emergency managers. Proper quantification and measuring the extent or level of hazard is an important step for understanding the performance of the existing road network and for evaluation of proposed hazardous road mitigation measures.

## 2.4. Cause of Hazardous Road Location

Different researches and reports identified many interrelated factors that cause hazardous road location in developed and developing countries where the road network and road users behavior are different.

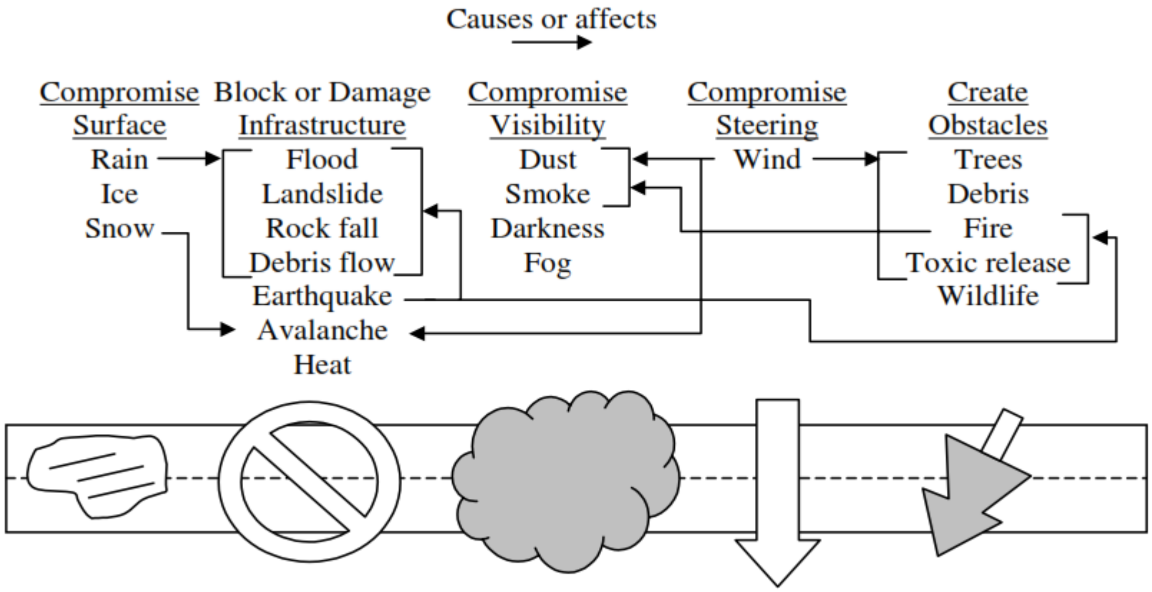



Figure 2.2: Example road hazards grouped by their principle effect, including some of their causal relationship (Handbook-of-Transportation-Engineering)

From the figure, it is clear that rain, wind, and earthquakes have causal links with many other hazards. Rain and earthquakes can both induce a flood, landslide, rock fall or debris flow. Earthquakes can also start a fire or result in a toxic release. Extreme wind can kick up dust, start a fire, drive smoke from a fire, blow trees and debris into the roadway, or redeposit snow, leading to an avalanche. This is only a sample of the many hazards and relationships that might exist.

## 2.5. Identification of Hazardous Road Locations

The investigation of factors which lead to accidents' clusters is an important topic in the road safety activity (Moons *et al*., 2009). According to Elsenaar and Abouraad (2005) a high concentration of accidents at the same location is a strong indicator of a road related problem that should be investigated. While there is no internationally accepted definition of HRL (Geurts and Wets, 2003; Geurts *et al*., 2005a; Brimicombe 2004 cit. in Anderson, 2007; Cheng and Washington, 2008; Anderson, 2009) several different methods have been applied to identify these locations (Retting *et al*., 2001; Hauer *et al*., 2002a; Flahaut *et al*., 2003; Brijs *et al*., 2007; Elvik, 2008b; Pirdavani *et al*., 2010). Elvik (2007), based on an OECD report, proposed a distinction between the different definitions of HRL into *numerical*, *statistical* and *model-based* definitions. Generally, most of the identification through *numerical definitions* can be applied with information only about the road network and the road accidents, in particular their location. In general, those definitions identify the places where the recorded accident number or rate (e.g. accidents per traffic flow) during a period, is higher than a threshold.

Examples of *numerical definitions* are presented in Table 2.1. The remaining types of definitions require complementing information, such as traffic data, which is often not available, especially in countries where road safety programs have not been recurrently applied (Sörensen, 2007). For this reason, *statistical* and *model-based* definitions are out of the scope of this work.

To apply these definitions and/or methods, the use of spatial analysis software in the HRL identification is recommended (Elsenaar and Abouraad, 2005). From the literature and among the several options available (TRL, 2011; TES, 2011; Jarvis and Kamal, 2009; BioMedware, 2010), the possible option is:

**ArcGIS™** - A widely used multipurpose proprietary geographic information system (GIS) with a comprehensive range of spatial analysis tools and useful data processing functionalities. Examples of the implementation of this software for HRL identification are described by Anderson (2007) and Xie and Yan (2008);

Table 2.1 some of the operational HRL definitions found in literature

| Definition | ANSR | Belgium | Flanders | Hungary | Germany | Norway |
|---|---|---|---|---|---|---|
| Period of records | 1 year | Over a year | 3 years | 3 years | 3 years | 5 years |
| Location (road extension) | 100 m | 50 m | 50 m | 50 m | 50 m | 50 m |
| Severity index (SI) | SI=100F+10SerI+3SliI | - | SI=5F+3SerI+SliI | - | - | - |
| Criterion 1: No. of accidents | ≥ 5 | ≥ 3 serious | ≥ 3 | ≥ 4 | ≥ 5 with casualties or ≥ 3 serious | ≥ 4 |
| Criterion 2: Severity index | ∑ SI > 20 | - | ∑ SI ≥ 15 | - | - | - |
| Source | ANSR, 2011 | Flahaut *et al.*, 2003 | Elvik, 2007; Geurts *e al.*, 2006 | Elvik, 2007 | Elvik, 2007; 2008b | Elvik, 2007; 2008b |
| Legend: | F – fatal injury | SerI – seriously injured | | SliI – Slightly injured | | |

## 2.6. GIS application in transportation

Most of the documents reviewed consider the use of GIS in transportation under either for general data maintenance or for simple data analysis. Several studies describe how GIS help the integration of many transportation elements. Meyer and Sarasua (1996) envisioned a common and coordinated database system that will serve all aspects of transportation management such as congestion, pavement, bridges, safety, inter-modal activities, and public transportation. Martin (1993) did a similar study, in which he proves that incorporating GIS in a pavement management program improves the reporting and analysis of data through the production of maps and graphic displays.

GIS has been proven to work well in addressing transportation problems related to safety. Affum and Taylor (1996) described the development of a safety Evaluation Method for a Local Area Traffic Management (SELATM), which is a GIS based program for analyzing accident patterns over time and the evaluation of the safety benefits. GIS can also be implemented in determining roadway and surface conditions. This was proven by Gharaibeh et. Al. (1994) when they proposed to use GIS to obtain statistical and spatial analyses of roadway characteristics such as safety, congestion level and pavement conditions.

There also have been studied that aimed at showing how GIS can be applied in accident management systems. Faghri and Raman (1995) developed a GIS-based traffic accident information system for Kent County, Delaware. Their system included knowledge about the occurrence of crashes, such as conditions of incident site, and frequency of incidents at any given location (mile-point) on a roadway. Since the early stages of GIS, it was noticed that a vision of information technology outside the traditional transportation data analysis and even outside GIS was needed to implement this technology (Lewis, 1990).

## 2.7. Sites and Hazard Identification Using GIS

Based on the seven years accident data, accidents were plotted along the road to give a rough location of accidents. The mapping process was made using GIS software. In order to plot accidents and identify the black spots, step-by-step procedures were used to obtain the desired results.

## 2.8. Road Environment

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

### 2.8.1. Road Alignment

An important factor, which affects the occurrence of road traffic accidents in terms of frequency and severity, is road alignment. Inconsistent horizontal alignments of roads, sharp curves and grades are known for their substantial and adverse safety impacts (Berhanu, 2000)

**i) Horizontal Alignments**

A recent study shows that accidents on horizontal curves are causes for concern in all countries. A study in Denmark has found that about 20 per cent of all personal injury accidents and 13 per cent of all fatal accidents occur on curves in rural areas; and in France, over 20 per cent of fatal accidents occur on dangerous curves in rural areas. Accidents on bends are major problems in many developing countries, although the proportion of such accidents is dependent on both topography and demography of each country (TRL, UK RG45 6AU).

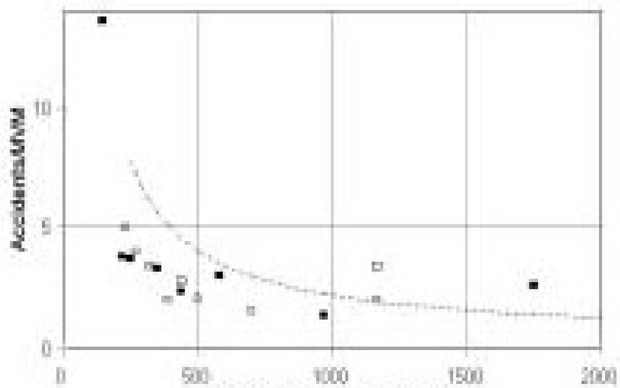
Table 2.2 Casualties at Bends in Developing Countries

| Country | Proportion of Casualties in Rural Areas | Casualties at Bends | |
|---|---|---|---|
| | | Rural | Urban |
| Botswana | 71.1% | 19.6% | 8.6% |
| Zimbabwe | 47.3% | 25.0% | 5.0% |
| Papua New Guinea | 71.5% | 46.9% | 16.1% |

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

Choueiri(2000), reviews a number of studies, which generally has shown that sharp curves result in much higher crash rates than more gentle curves; sections with curvature of between 5 and 10 degrees have at least twice the crash rate of sections with curvature of 1 and 5 degrees, and sections with curvature of between 10 and 15 degrees have crash rates four times as great. In terms of curve radius, 200 m seems to be the point below which crash rate greatly increases. The evidence suggests that curve flattening is highly effective in reducing crashes.

When the accident rate is plotted against the radius it appears as if increasing the radius from 200 m to 300 m has a much larger beneficial effect on the accident rate than an increase from 900 m to 1000 m as shown in Figure-2.3. This has been at times misinterpreted to mean that in the relationship there is some natural bend or ‘knee’ around R=500 m and therefore increasing the radius beyond, say, 500 m is unimportant (1998)




Radius of curve in meter

Figure 2.3 Five Early Studies Radius of Curvature (Source: Getu Segni, 2007)

Lamm observed that curvatures greater than 350 degrees/mile (approximately 220 degrees per kilometer) produced relatively high crash rates and were used in very few cases in modern German design practice. The crash rate which corresponds to this degree of curvature is 2.0 per million vehicle kilo meters, and Lamm suggests that this represents an acceptable level of safety (2003).

**ii) Vertical Curve**

There are three main effects of vertical road alignments, which are closely associated with the occurrences of traffic accidents. These are excessive speeds and out-of-control vehicles on down grades, differential speed between vehicles created on both down and upgrades, and low range of visibility that often occurs in the immediate vicinity of steep grades at the crest of vertical curves. Ross Silcock Partnership (1994), indicates that it may be difficult for driver to appreciate the sight distance available on crust curve and he may overtake when it is insufficient for him to do so safely. This can be extremely expensive to provide safe overtaking sight distances on crust curves. However, a complete ban on overtaking would be difficult to enforce because of the presence of very slow moving vehicles, the lack of driver discipline in selecting places, poor maintenance of road marking and signs. Successive short vertical curves on straight section of road may produce misleading forward visibility.

Berehanu(2000), summarizes the effects of vertical curve in such a way that steep grades have higher accident rates than mild ones. He extends that grades of less than 6 percent have little effect, but grades steeper than this are associated with higher accident rates. Down grades are greater problems, particularly for truck safety than upgrades. A combination of horizontal curves under 450m and grades over 4 percent are not recommended. Poor condition of the horizontal and vertical alignments of a road can result in visual effects, which contribute to accidents and are detrimental to the appearance of the road Ross Silcock Partnership (1994),

### 2.8.2. Sight Distance

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

Choueiri(2000) reviews studies which suggest that inadequate sight distance may be a factor in 20 to 25 per cent of rural accidents resulting from overtaking maneuvers. The actual percentage of crashes in which sight distance has a role would clearly be related to the extent of overtaking maneuvers, which in turn is related to traffic flow. Most studies appear to indicate that crash rates are higher with low sight distances, but they change little when the sight distance is 150-200 m or greater.

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

The TRB Study (1987), in the USA for which accident data were collected for carefully matched sites with and without sight-distance restrictions due to vertical curvature, found accident frequencies to be 52 per cent greater than overall at sites with sight restrictions than at control sites.

### 2.8.3. Road Cross-Sectional Elements

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

**i) Lane and shoulder width**

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

**ii) Road side features and side slopes**

The Transport Research Board Report TRB(1987), reviews that past research on the safety of the roadside environment has produced important improvements to roadside hardware; including, for example, the development of barriers that better contain and more safety redirect errant vehicles, sign and luminaries supports that break away on impact, causing little damage to the striking vehicle and its occupants. In addition, design standards occasionally provide for clear recovery areas- boarders beginning at the edge of the travel lanes with travel lanes, traversable slopes and free of hazardous obstacles. Improved designs for drainage structures such as culvert headwalls reduce hazards posed by unforgiving obstacles.

Entry of an errant vehicle on to the roadside border does not in itself mean that an accident is inevitable. Although some dangers always exist, the chances of recovery are excellent if the border is reasonably smooth, flat, and clear of fixed objects and other non-traversable hazards. The chances of successful recovery diminish as the ground slope within the border. Safety researchers generally agree that at speeds of approximately 55mph, safe clear zones should have side slopes no steeper than about 6:1 and should extend outward at least 30ft from the edge of the travel lanes. When the border is flat, unintended encroachments on tangent alignments seldom extend beyond the 30-ft range (TRB, 1987).

### 2.8.4. Intersections

On two-lane rural highways, intersections are ranked together with horizontal curves and bridges as the most likely locations for accident concentration. According to the National Safety Council estimates in USA, 56 per cent of all urban accidents and 32 per cent of all rural accidents occur at intersection TRB (1987). Although the average accident occurring at intersection is not as severe as the one occurring on the open road, there is nonetheless, a concentration of severe accidents at intersection. Of all the fatal accidents in the United State, 29 per cent of those that occur on urban highways and 16 per cent of those that occur on rural highways are intersection related. It is logical to concentrate on such types of high accident record areas. For safety and traffic management reasons, selection of intersection design depends on the AADT of the major and minor road. Roundabouts have the leas Accident rates as observed in developed countries and best countermeasures from safety of intersection point of view (Jonnessen, S. and Sakshaug, K, 2006).

### 2.8.5. Narrow bridges

Bridges are often located on sag vertical curves where approach traffic is on down grades and a factor responsible for increasing speed which contributes to the losing control of vehicles. Bridges are also more dangerous when located on bend road sections. Berehanu (2000), notes that bridges are over represented in accidents relative to the total length of the road system. Traffic accidents are also severe at bridges. An extensive review of literature on the safety effects of bridges by Mak in Berehanu(2000),points out features including bridge width, curved bridge, approach roadway alignment and adverse surface condition as the most prevalent factors of bridge accidents. Based on the findings of the cited studies, Mak in Berehanu suggests that at least the bridge shoulder should be 1.8 m wider than the approach traveled way width on rural two-lane highways (i.e. 0.9m shoulder width on each side should be carried across the bridge) Berehanu(2000). Besides, frequency and severity of traffic accident at bridges can be reduced through the provision of adequate visual information to enable the driver control and navigate safely on bridges.

## 2.9. Road User Information and Campaign

Elvik (2005), points out that road user ought to acquire the knowledge needed to travel safely by means of formal training and their own experiences. Nonetheless, insufficient knowledge of traffic regulations, traffic signs, vehicles and other elements may be some of the factors contributing to unsafe behavior and road accidents. Road user information and campaigns are intended to reduce accidents by promoting safer behavior in traffic, by giving road users improved knowledge and more favorable attitudes towards such behavior Elvik (2005). Another objective is increased understanding of restrictive measures which are introduced to increase safety, such as speed limits.

Elvik evaluated a number of studies on the effects of information campaigns on the number of accidents Elvik (2005). He reviews that most campaigns targeted at road accidents in general have not led to statistically significant changes in the number of accidents. However, campaigns made to specific target group such as use of seat belt, drink-driving campaign and the like have led to a decrease in number of accidents in particular types during the campaign periods.

## 2.10. Access Management

Access management is a new response to the problems of congestion, capacity loss, and accidents along roadways. Koepke and Lavinson (1992), call for significant improvements in access control, spacing, and design to preserve the functional integrity and operational viability of the road system. Access management is the process that provides access to land development while simultaneously preserving the flow of traffic on surrounding roadways. Three issues kept in the forefront of access management are: safety, capacity, and speed. Fewer direct accesses, greater separation of driveways, better driveway design and location are the basic elements of access management.

In urban and suburban areas, each access point (or driveway) added would increase the annual accident rate by 0.11 to 0.18 per million vehicle miles on undivided highways and by 0.09 to 0.13 per million vehicle miles on highways with TWLTLs or non-traversable medians (Gluck J., H.S. Levinson, and V. Stover; 1999). In rural areas, each point (or driveway) added would increase the annual accident rate by 0.07 per million vehicle miles on undivided highways and 0.02 per million vehicle miles on highways with TWLTLs or non-traversable medians (Gluck J., H.S. Levinson, and

V. Stover; 1999).

## 2.11. Cost of Hazardous Road

Hazards that affect the road surface represent the most costly maintenance function for many cities, countries, and state transportation departments. Many transport engineers and economists have been interested in costing the effects of hazardous road for long period and different studies have been done to estimate the cost of hazardous road. As all planning and hazardous mitigation measures decisions require a quantified cost benefit analysis, costing the effects of hazardous road is a critical task in transportation management process.

Hazardous road costs nations for their transportation activities, negatively impact their national economy, impair the quality of life by costing traveler's time and money, degrading the environment and causing accident (HDR, 2008).

According to HDR (2008) report the principal economic and social costs of hazardous roads are:

1. The costs of reduced economic output and accompanying job losses
2. The costs of travel delay or lost time
3. Vehicle operating costs (fuel, ideal time)
4. Environmental costs and higher frequency of accident risks

Estimating the social and environmental cost is much difficult and different from area to area; but, some literatures try to estimate person hourly cost as a function of considering all trips to work place. The issue of hazardous road has become critical in Ethiopia, a country with low rate of motorization. The number of people killed and injured as a result of traffic accidents has been steadily increasing and the country is experiencing a tremendous loss of life and property each year as one of the leading countries of the world with worst accident record. Recent studies (TRL and Ross Silcock, 2001) reveal that Ethiopia has 170 deaths per 10000 vehicles per annum and road accident is costing the country in the order of 350 - 430 million Birr annually. The trend of accident is not in a state of declining; but rather has continued to rise enormously. The continued steep increase in the number of crashes and fatalities indicates that these losses are undoubtedly inhibiting the economic and social development of the country and adding to the poverty and hardships of the community at large.

## 2.12 Approaches to Decrease Urban Road Accidents

The spatial distribution of accidents is not uniform along the road network. According to their spatial distribution, different approaches to decrease their number as well as their severity have been conceived considering the spatial distribution of road accidents. According to the Chartered Institute of Highways and Transportation (1990) there are accordingly, it is necessary to follow the four main types of approaches: (i) Site action – treatment of a specific location at which road accidents are clustered; (ii)Mass action – application of a road safety treatment procedure to various locations which share common accident factors; (iii) Route action – application of road safety measures to a particular type of road or road section (usually considering 0.5 to 1.5 km sections) where accidents are especially accumulated; and (iv) Area action – application of a zoning in areas where the most hazardous zones (e.g. with higher accident rates) are thoroughly analyzed; road measures are subsequently proposed and implemented taking into consideration the entire zone.

This research project focuses on the Site action approach only. It is divided into the following stages: (i) establishment of the study objectives; (ii) identification of HRL (such as road sections or intersections); (iii) ranking and selection of HRL for subsequent analysis; (iv) accident analysis within the selected hazardous road elements in order to understand and identify the contributing factors to road accident occurrence; and (v) propose, implementation and evaluation of adequate corrective road safety measures.

Although this approach was considered to be effective and has produced large reductions in the number of accidents (IHT, 1990; Heydecker and Wu, 2001; Elsenaar and Abouraad, 2005). Indeed, the consideration of 3 to 10-year periods of accident data for a HRL identification has been often suggested (IHT, 1990; DTLR, 2001).

### 2.12.1. Proposed Counter Measures

The most serious consequences of speeding (19.97%) in this area were the fatalities and serious injuries that result from crashes. Over the last ten years, speeding has been consistently identified as a contributing factor in nearly one-third of all roadway fatalities nationwide. Crashes involving speeding occur on all road types but are particularly prevalent on the local rural road system. The local road system refers to locally owned and maintained roads in rural areas. Of the 30,196 fatal crashes occurring on all road types in 2010, 35.4 percent—or 10,689—occurred on local rural roads, with nearly one-third (3,427) of these involving speeding (FARS, 2010).

As the speed increases, the likelihood of a crash resulting in a serious injury or fatality also increases. Addressing this safety issue can be a challenge for local roadway agencies because of their limited resources. Nonetheless, all agencies, regardless of size and resources, can develop a comprehensive and coordinated program to address speeding.

## 2.12.2. Identifying Countermeasures

A coordinated approach to manage speeding and reducing speed-related crashes based on engineering, enforcement, and education countermeasures is desirable. When identifying countermeasures, practitioners should consider strategies that will minimize the severity of failure to give way for pedestrians and speed-related crashes. This will depend on location characteristics and the contributing factors of crashes identified from crash data and field reviews. One method to evaluate potential engineering countermeasures, and their ability to reduce crashes, is using Crash Modification Factors (CMF's). A CMF is a multiplicative factor used to determine the expected change in the number of crashes after implementing a specific countermeasure at a specific site.
This section provides information on engineering, enforcement, and education countermeasures that can be used to address a failure to give way for pedestrians and speeding issue.

### 2.12.2.1. Engineering Countermeasures

Reducing the speed limit alone generally does not result in lower speeds. Several engineering countermeasures have been identified that can be used to influence driver speed choice, and the following sub-sections describe engineering countermeasures that address speeding. They have been grouped into three categories: traffic control devices, road and street design, and traffic calming on lower-speed roadways. Since design details are not presented, the road owner should seek engineering expertise when selecting countermeasures.

### 2.12.2.2 Traffic Control Devices to Reduce Speed

Installing or upgrading signs and pavement markings on an affected roadway can be a cost effective measure to reduce hazards resulted from speeding. Such improvements include advisory speed signs and pavement markings, speed activated signs, and optical speed bars.

**Advisory speeds; -** are installed with curve warning signs (either on the same sign or as a supplemental plaque) to recommend a safe speed for traversing a horizontal curve.


Figure 2.4 Advisory speeds displayed with curve warning sign (Speed Management Guidebook, 2012).

**A pavement speed limit marking** displays the posted speed limit on the pavement. It is used to emphasize the speed limit. A SLOW curve ahead pavement marking warns the driver of a potentially hazardous curve. This pavement marking is meant to supplement advisory signs. Because they are exposed to traffic wear, both types of pavement markings require regular maintenance to ensure their continued visibility.


Figure 2.5 Special pavements marking to encourage speed reduction for impending curve (Source: Handbook of Road Safety Measures, 2004).

**A speed activated sign; -** is an electronic sign that is connected to a device that measures the speed of approaching vehicles. If the vehicle is exceeding the legal speed limit, then the electronic sign is activated to display the legal speed limit. This may also be accompanied by the word “SLOW” or other appropriate message. A similar device is a speed feedback sign. When connected to a speed-measuring device, a **speed feedback sign** displays the speed at which a vehicle is traveling. The speed-activated sign and the speed feedback sign can be effective in speed transition areas (e.g., entering a school zone, marketing area or other area characterized by high volumes of non-motorized traffic). If used too frequently, the effectiveness of these signs is diminished. Speed feedback signs were found to reduce speeds between two and 10 mph(Hallmark, 2007) (CMF = 0.54)(Elvik, 2004).


Figure 2.6 a solar-powered speed feedback sign (Source: Evaluation of Gateway and Low Cost Traffic-Calming Treatments, 2007).

### 2.12.2.3. Road and Street Designs

There are several modifications to the design of a road or street that can induce to give way for pedestrians and speed reductions and have other safety and operational benefits for all road users. These include zebra crossing, pedestrian overpassing, reduced lane widths, road diet, Center Island or median, and roundabout. Several of these countermeasures can be implemented on higher-speed roadways.

**Reducing lane width; -** to as narrow as 10 feet can reduce speeds. This can be accomplished by restriping narrower lanes without reducing pavement width. The remaining space can then be used for non-motorized uses, buffer areas between travel lanes and non-motorized uses, or space for on-street parking. A nationwide study found no increase in crashes or injuries when lanes were narrowed on urban and suburban roadways (Poots, 2007). Speeds may also decrease by one to three mph for each foot that the roadway is narrowed down to 10 feet.

Figure 2.7 the lane width for motor vehicle travel was reduced to provide exclusive space for cyclists (Source: Relationship of Lane Width to Safety for Urban and Suburban Roadways, 2007).

**A road diet** is a conversion of an existing street cross section to create space for other uses (e.g., bicycle lanes, sidewalks, turn lanes, or on-street parking). Figure 5.37 is a before-and-after drawing of a typical road diet. The original road was four lanes with two lanes in each direction.

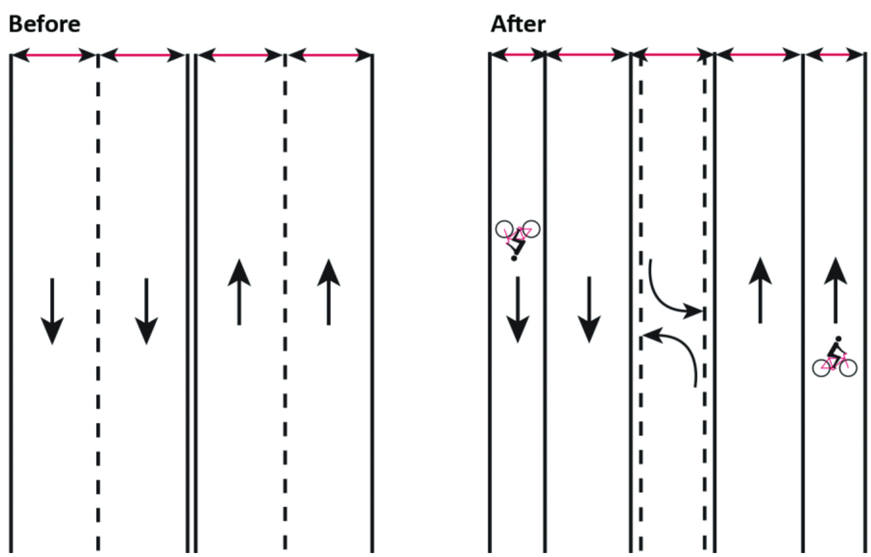



Figure 2.8 Road Diet Comparisons (Source: Evaluation of Lane Reduction, 2004)

The same road width remains after the road diet, but the number of travel lanes for motor vehicles is reduced providing space for bicycle lanes in each direction. Road diets have the potential to reduce speeds due to the perceived narrowing of the roadway, with the extra pavement used for center turn lanes, parking, bicycle lanes, or other uses ( Harkey, D.L., R. Srinivasan, J. Baek, B. Persaud, C.

Lyon, F.M. Council, K. Eccles, N. Lefler, F. Gross, E. Hauer, J. Bonneson, 2008, Persaud, B. N., Retting, R. A., Garder, P. E., and Lord, D., 2001).

### 2.12.2.4. Traffic Calming

Traffic calming is the design or retrofit of a roadway to encourage uniform vehicle speeds, give way for pedestrians and improve conditions for non-motorized users. Traffic calming tends to be applied to roads with operating speeds of 30 mph or less, as these roads are typically developed zones along urban roadways. There are numerous traffic calming countermeasures that can be applied on different types of roads and streets.

**A speed hump** is a raised section of asphalt approximately 10 to 14 feet long and 3 to 4 inches high. Speed humps are typically used on lower speed residential streets in urban areas that are experiencing a high incidence of speeding and/or cut through traffic.

Figure 2.9 a speed hump delineated to notify motor vehicles of its presence (Source: Speed Management Guidebook, 2012).

Speed humps are not to be confused with speed bumps, which are much shorter and usually found in parking lots. Speed humps have been found to reduce injury crashes by 40 to 50 percent and speeds by nine mph (CMF = 0.5-0.6).

Table 2.3: Transportation Hazard Situations and Remedies

| General Transportation Hazard Situation | Remedial Measures |
|---|---|
| ➢ Skidding | ➢ **Restoring surface texture**<br>Resurfacing<br>Improve drainage |
| ➢ Collisions with roadside objects | ➢ **Better delineation**<br>Guardrails or fencing<br>Frangible posts<br>Remove objects |
| ➢ Pedestrian/vehicle conflicts | ➢ **Pedestrian/vehicle segregation**<br>Pedestrian crossing facilities<br>Pedestrian fences or other protection |
| ➢ Loss of control | ➢ **Bigger or better road signs**<br>Road markings<br>Speed controls<br>Safety fencing<br>Super elevation |
| ➢ Nighttime accidents | ➢ **Reflective signs**<br>Delineation<br>Road markings<br>Street lighting |
| ➢ Poor visibility | ➢ **Trim or remove vegetation**<br>Improved sightlines<br>Realignment |
| ➢ Poor driving behavior or lane discipline | ➢ **Road markings**<br>Enforcement<br>Median barriers<br>Overtaking lanes |

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

## 2.13. Summary

Accordingly, methods for predicting accidents have been widely studied in the past. The prediction methods are mostly causative types in which the number of accidents is taken as a function of number of independent variables. Recently there have been studies to identify hazardous locations using fuzzy and neural network classifier approaches. However such methods are highly dependent on traffic flow data like Average Daily Traffic (ADT) and the data collected by the traffic police from the accident sites. But traffic flow data are rarely available in sufficient quantity or accuracy to justify these regression approaches. Moreover the traffic police may not be able to collect all the necessary data required to carry out the analysis using that data.

Considering all the factors mentioned above, it is necessary to develop a methods which can assist in predicting hazardous locations on a given road network. This paper describes a method developed to identify hazard locations on roads using number of accident, prioritization and GIS. A road network is distributed over a given area. Hence it always possesses a 'spatial characteristic' i.e. it always has the geographic locations associated with it. Thus, in order to analysis and identify a road network, an information system capable of processing spatial data is required. A GIS can easily handle, store, analyze, manipulate and retrieve spatial data. Therefore a method for identifying accident-prone location on roads can be easily implemented using a GIS.

## 2.14 Research gap

From the revised literatures from the beginning hazardous locations are creating a greater destruction all over the world. And this problem is increasing in developing countries like Ethiopia which is also a case of the study area. In developed countries road safety improvement is the major activity to decrease the accident due to hazards. Such activities were more or less developed in sub Saharan countries. Improvements must be established to sustain road traffic safety for all users.

# CHAPTER THREE

# 3. METHODOLOGY

## 3.1 Research design

Descriptive and exploratory survey designs have been used in this study. It attempted to collect data from the relevant population (AACRA, Police Stations, Road & transportation office, consulting firms, and contractors) to evaluate the insight of different stakeholders on the issues of traffic accidents, and causes that lead roads to be hazard.

The methodology employed for a research work was the critical aspect for ensuring the proper result which aligns with the objective or the research question rose. Hence, this part of the study discusses the methodology followed and the reason for the selection of the methods in order to address the problem stated earlier in chapter 2.

## 3.2 Description of the Study Area

The study area selected for this research was Addis Ababa city which was the capital city of Ethiopia. Addis Ababa is not only the capital city of Ethiopia but it is also the seat of African Union head quarter and more than 100 embassies. Due to the fact that Addis Ababa is the political and economic center of the nation, it is the highly populated town in the country.

Most of the economic and social developments in the country manifested at this capital city and hence all the benefits and aftermath of such economic and population growth affect Addis Ababa. One of the undesirable effects of such growth in the city is hazardous locations. In order to study hazardous road in Ethiopia, there is no a best place like Addis Ababa due to many factors. Hence, this part of the study focuses on the Addis Ababa city and describes briefly the study area and the selected corridors. It also discusses descriptive parameters and trends which affect the hazardous road.

The city has a total area of about 530.14 Km2 and a population of 2,738, 248 according to 2007 censes. The city is divided in to 10 administrative sub-cities and 99 kebeles.

### 3.2.1 Study junctions and road sections /midblock/

Lukuwanda - Megenagna road of Addis Ababa which was the study corridor for this research as stated above, it contains more than 24 junctions. Some of the main junctions along this corridor are listed in Appendix III, Table 5.

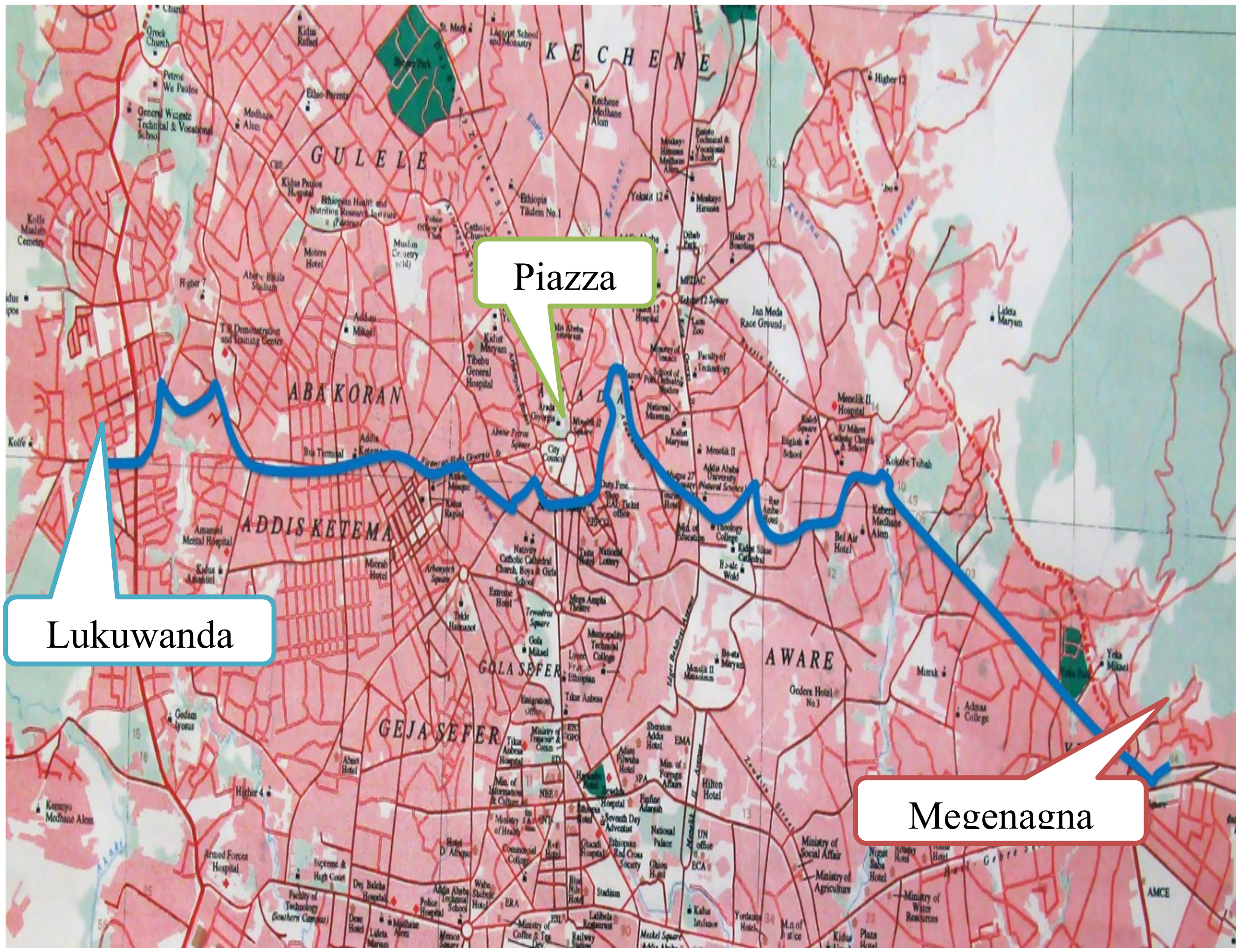



Figure 3.1 Map of the Study Area, Addis Ababa (Source: Google Mapper)

## 3.3 Sampling Frame

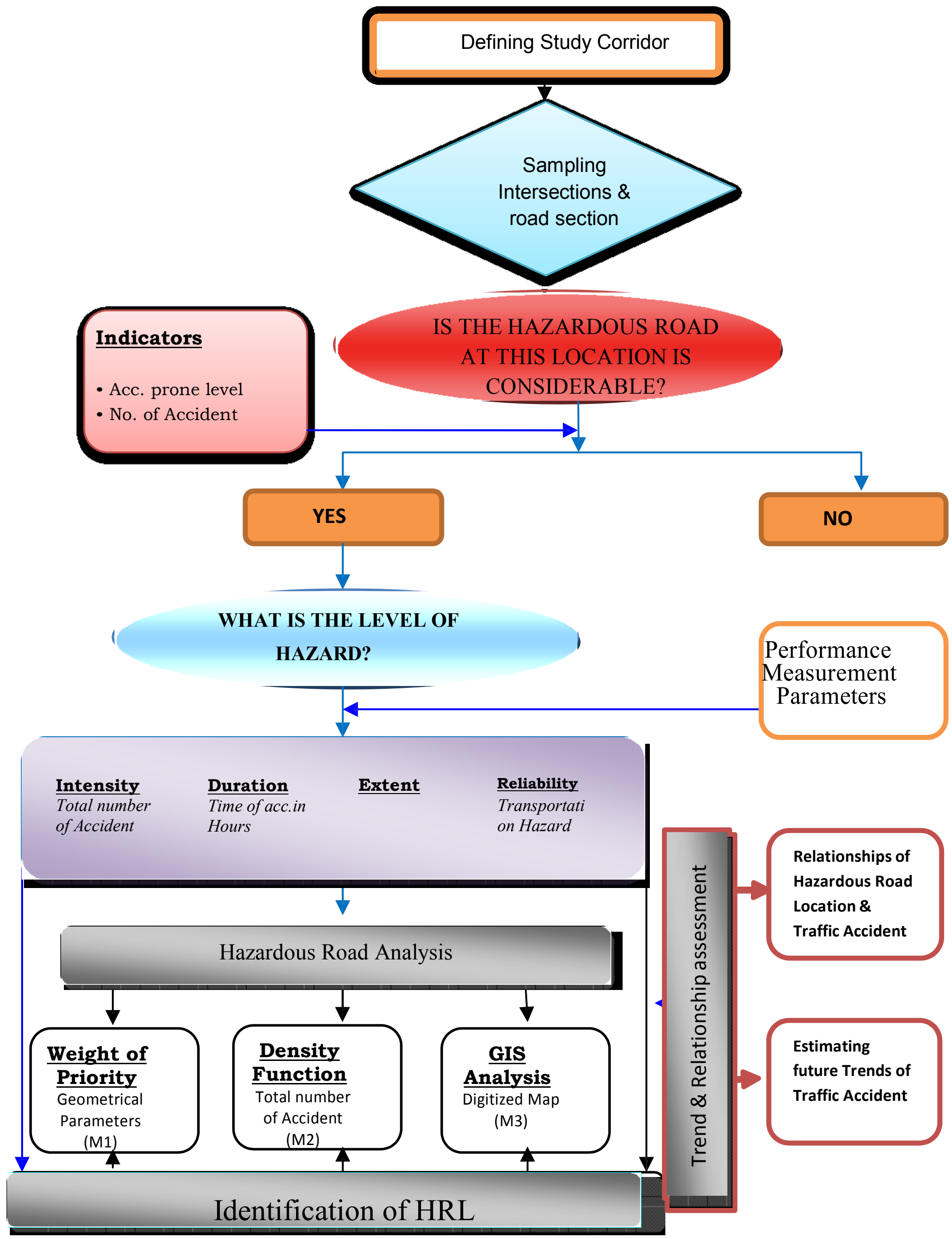



*Figure 3.2: Framework for research approach*

## 3.4. Identification of HRL

In this methodology, the identification of HRL consists in the implementation of three types of methods on the datasets:

i) Methods based on technical weight of prioritization
ii) Methods based on the point density
iii) Methods based on GIS analysis

### 3.4.1. Methods based on GIS Analysis

The method described in this paper also requires a map of the desired road network digitized in a suitable form and certain specified road attributes to carry out prioritization. The analysis then ranks accident black spots on the given road network.

In order to model the mentioned factors and achieve the desired result, a step by step procedure as given below is adopted.

- Scan the map containing the desired road network and input this image to Arc View for digitizing.
- Digitize the road network with due considerations for separation of every link and assign id number to every link.
- Specify the attributes for every road link using the data collected.
- Export the road attribute table generated in dbase format so that it can be imported by Arc view.
- Join the road attribute table to the digitized road map and prioritize the road network by accident occurred on every link.
- HRLs on a given road network are ranked by result obtained.

### 3.4.2. Methods based on Technical Weight of Prioritization

Prioritization involves assigning suitable weights to different factors so as to achieve a desired result. In this model, the various factors, which tend to influence the occurrence of accidents on roads, are assigned weights on a scale of 0-10 in such a manner that the factors which tend to increase the probability of the accidents have lower weights. While carrying out the analysis the method only incorporates the road related factors such as road geometries, which lead to hazard (IJAET, 2010).

The factors considered for evaluating hazardous locations on road are as follows:

- Road width.
- Number of lanes in each direction.
- Approximate number of vehicles per day.
- Drainage facilities.
- Surface condition of the pavement.
- Frequent vehicle type.
- Presence of shoulders, edge obstructions and median barriers.

In order to prioritize roads for occurrence of accidents, the various factors considered and the weights assigned to them are given in following table:

Table 3.1 Factors used in prioritization with possible weights (Source: IJAET, 2010)

| Factors affecting occurrence of accidents | Possible variations | Weights assigned |
|---|---|---|
| Number of lanes in each direction | 1<br>2<br>3<br>4 | 4<br>6<br>8<br>10 |
| Number of vehicles per day | 0-40,000<br>40,001-60,000<br>60,001-80,000<br>80,001-1,00,000<br>1,00,000 above | 2<br>4<br>6<br>8<br>10 |
| Width of the road | Less than 6 m<br>6.1-7.5 m<br>7.6-10.5 m<br>10.6-15 m<br>15 m above | 2<br>4<br>6<br>8<br>10 |
| Drainage facilities provided | Good<br>Satisfactory<br>Poor<br>No drainage | 10<br>7<br>4<br>1 |
| Surface condition of the pavement | Concrete<br>WBM<br>Other bituminous<br>Surface painted<br>Earth roads | 10<br>8<br>6<br>4<br>2 |

| **Factors affecting occurrence of accidents** | **Possible variations** | **Weights assigned** |
|---|---|---|
| Frequent vehicle type on the road | Bus/Truck<br>Car/3 wheeler<br>Two wheeler<br>Bicycles<br>Carts | 2<br>4<br>6<br>8<br>10 |
| Presence of shoulders | Yes<br>No | 10<br>4 |
| Presence of edge obstructions | Yes<br>No | 4<br>10 |
| Provision of median barriers to channelize the traffic | Yes<br>No | 10<br>4 |

The final weight assigned to each road link is obtained by adding all the individual weights and normalizing the value using maximum weight (in this case 90) that can be assigned(IJAET, 2010).

Hence,

Total weight = (∑ Individual Weights) x 100 / 90

Thus road links with high final weight are less prone to accidents than the road link with low final weight. The classification of roads for occurrence of accidents based on final weights was done using the following classification scheme:

Table 3.2 Prioritization scheme (Source: IJAET, 2010)

| **Final weight** | **Accident prone level** |
|---|---|
| 80-100 | Very low |
| 60-80 | Low |
| 45-60 | Medium |
| 0-45 | High |

### 3.4.3. Methods Based on Density Functions

These methods were based on a point density function, which was calculated for all the cells of a segment (after setting a spatial resolution value) covering the entire area under analysis. Cells with point density values higher than a cut-off point density value, are identified as HRL. This density value is chosen by the analyst and can be adopted according to the size of the identified HRL (e.g., it can be determined according with the maximum distance between the HRL boundary from a road network centerline).

## 3.5. Sample size and sampling procedures

Lukuwanda - Megenagna road of Addis Ababa, which was the study corridor for this research and which contains more than 24 junctions. Quantitative data and analysis has been used to determine and measure the level of hazards quantitatively. Observations, surveying, direct field measurements and secondary data has been the main sources of quantitative data.

Incidental or accidental sampling technique was applied to those samples that were taken because they are most frequently available, and also it was very easy method of sampling and it reduces the time, money and energy i.e. it is an economical method.

## 3.6. Data Collection

To attain the stated objectives, previous research studies were reviewed that were found to be relevant to the objectives of this research. The literature review provided a broad background of the existing knowledge of hazardous road and insight into the problems encountered by the researchers at different stage of their works. The knowledge and experience gained during this period helped the writer of this paper in developing reliable, efficient and effective study approach to focus on stated goals.

Within this analytical process, information that characterizes the local environment and traffic as well as accident data play an important role. Indeed, according to PIARC (2007) three levels of data can be considered: Road accident data (e.g. accident identification, time, location, accident type, number of casualties). This data was a key for the analysis and should, when available, be complemented with: Road and traffic data (e.g. road description, location of crosswalks, parking places, road surface, roadside obstacles and traffic flows); and other data (e.g. driver, pedestrian and passenger information: gender, age, alcohol rate).

Before data collection was carried out; training was provided to four enumerators to arm them with knowledge on how to gather reliable data. During this time, three types of data were gathered. These were: accident data, road data, and traffic data.

Furthermore, site visit has been carried out to support intermediate conclusion. The site visit was conducted to note road environment and traffic situation. In some circumstances, site measurements concerning visibility and the likes have been undertaken.

### 3.6.1. Road Accident Recording Systems in Ethiopia

Regional departments of the Traffic Police are responsible for the recording of all traffic accidents under their jurisdictions. The Federal Police Commission is responsible for national accident data compilation and processing. In each Region's Woreda Police Station, accident data are reported manually. The traffic police accident data form contains accident classification, date, time, day of the week, year, age of the driver, sex, education of the driver, ownership of the vehicle, service year of the vehicle, defects of the vehicle, location of accident, road traffic condition, road surface condition, road junction type, weather and illumination condition, collision type, and property damage and parties injured (age, sex, physical fitness and the like).

Monthly reports are submitted to pertinent the Region Police Commissions. A yearly report from the Region Police Commission will then be submitted to the Federal Police Commission to generate national accident statistics. In Ethiopia, much of the information is needed for the traffic police's own activity, primarily, to enforce the law and carry out prosecutions. Some of the accident data are of no direct interest or use to the police, but are vital to the work of other organizations.

### 3.6.2. Traffic Accident Data

Road traffic accident data were collected from Four Addis Ababa Sub-City Administration Traffic Police Stations, namely Arada, Addis, Yeka and Kolfe for the study period of July 2001 to Jun 2008. Official letters are listed in Appendix VII.

The source of road accident data were accident booklets compiled by Traffic Police Officers. To acquire reliable data, a road traffic accident form was designed (See Appendix V).

The form included:-

- Date, day and time of accident,
- Vehicle type and ownership,
- Driver sex, age and education,
- Weather, road, and illumination condition,
- Accident type,
- Degree of severity, and
- Number of victims (driver, passenger, and pedestrian), sex, age, severity; and
- Location of accident,

To back up various analysis and investigations, a road traffic accident data base were established. The data base consists of seven-year accidents which were collected from the police stations. During this period, around 12,086 road accidents were gathered. Furthermore, to determine the location of hazard, each accident location was measured up to the accidents spot by taking Lukuanda as a starting point(0+00Km) and providing station number and dividing the road alignment into 100 m up to Megenagna(13.2Km).

Basically, the definition of road accident is not universal (OECD, 1998). In this study, fetal, injury and damaged accidents were considered, as they are mandatorily reported to the authorities and are recorded in the Ethiopian national database. Road accidents are rare events on public roads involving at least one moving vehicle, registered by the authorities, which leads at least to a personal injury occurrence. Such events can be divided into *fatal*, *serious* or *slight* according to the severity of the most severe casualty. See Appendixes II, Table B2 and B3.

### 3.6.3. Present Accident Situation

Vehicles which were responsible for road accidents have been collected. Table 3.3 shows that fatal accidents are concentrated on trucks with capacity of 11-40 quintals, and on trucks capacity of 41-100 quintals. Similarly, Station wagons and taxi had major shares in traffic accidents during those years.

Table 3.3 Motor Vehicle Involvement in Road Traffic Accidents

| Description | Automobile | Station wagon | Pick up | Truck 11-40qt | Truck 41-100 qt | Truck with trailer | Taxi | bus | others |
|---|---|---|---|---|---|---|---|---|---|
| Fatal | 288 | 430 | 703 | 1199 | 1278 | 362 | 737 | 703 | 628 |
| Serious injury | 700 | 690 | 1091 | 1267 | 993 | 282 | 1451 | 880 | 588 |
| Slight Injury | 185 | 1022 | 1148 | 1099 | 883 | 160 | 2163 | 805 | 649 |
| Property damage | 7662 | 14596 | 3764 | 4258 | 3385 | 1495 | 7148 | 3028 | 982 |
| **Total** | **8835** | **16738** | **6706** | **7823** | **6539** | **2299** | **11499** | **5416** | **2847** |

Source: -Federal Police Commission, Road Traffic Accident Statistics Office, 2005

## 3.7 Data processing and Analysis of Hazardous Locations

Both descriptive and inferential statistics has been used in the data analysis. In the analysis, point density and total weight of priority methods are adopted to establish the extent of hazard and the causes of traffic accident by integrating with GIS.

### 3.7.1. Analysis of HRL and Road Accidents

One of the goals of analyzing hazardous road location and urban road accident was to provide working elements (including diagrams, maps and identification of factors) to the technicians in order to support interventions to reduce the number of such accidents and their severity. Therefore, within the framework of this study, stick diagrams analysis were carried out.

### 3.7.2 Detailed analysis of a hazardous road location

After the identification of HRL, these were ranked in order to prioritize the locations for detailed analysis and subsequently for treatment. Some of the adopted technical criteria to rank the identified HRL were: (i) hazard prone level; (ii) severity of casualty; (iii) the number of road accidents that each HRL contained (accident frequency).

### 3.7.3 Descriptive analysis

A descriptive statistical analysis of injury road accidents has the purpose to characterize the main trends of data, such as the main conditions of occurrence of most road accidents and the main characteristics of the individuals involved on them. This analysis identifies trends that were utilized in the spatial analysis in greater detail.

# CHAPTER FOUR

# 4.0 RESULT AND DISCUSSION

## 4.1 Characteristics of Accidents

Before starting identification of HRLs, it is important to look the characteristics of total accidents database. The accidents database of the Addis Ababa (Lukuanda–AutobusTera–Piazza–Megenagna) Road that was established for this study contains all accidents reported by traffic police at the study sites along the 13.2 kilo meters during the study period of December 2015 to Sep 2016. A seven year (2001/2-2007/8 EC.) accident data with a total number of 12086 accidents were reported. Out of which 2662 Fatal, 4238 Injury and the rest 5186 were property damages. Of the injury accidents, 1721 and 2517 were serious and slight injuries respectively. Appendix II, Table B-2 and B-3 show the details.

### 4.1.1. Accidents in the Study Area

**i) Variation by Time of Accident**

Time variation: Figure 4.1 shows hourly variation of accidents and the peak frequency corresponds with morning and afternoon traffic volume peaks. However, more accidents occurred during 10:00-12:00 pm hour local time which was in the afternoon. Detail analysis is attached in Appendix II, Table B1 and The City accident data in Appendix I, Table A2.

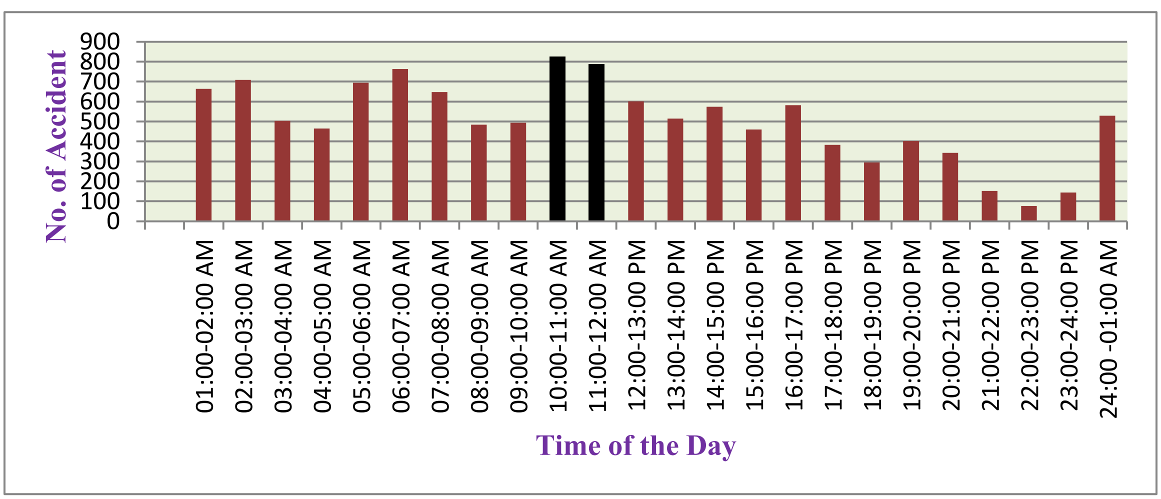



Figure 4.1 Accidents Distribution by Hours of a Day Throughout 13.2km.

**ii) Variation by types of vehicle**

According to Appendix III, Table C-1 from C-1a-C-1f, accident data collected in this study area (throughout 13.2Km) indicated that vehicles most frequently involved in accidents were Taxis (28%). Figure 5.3 shows the types of vehicles involved in the study area.

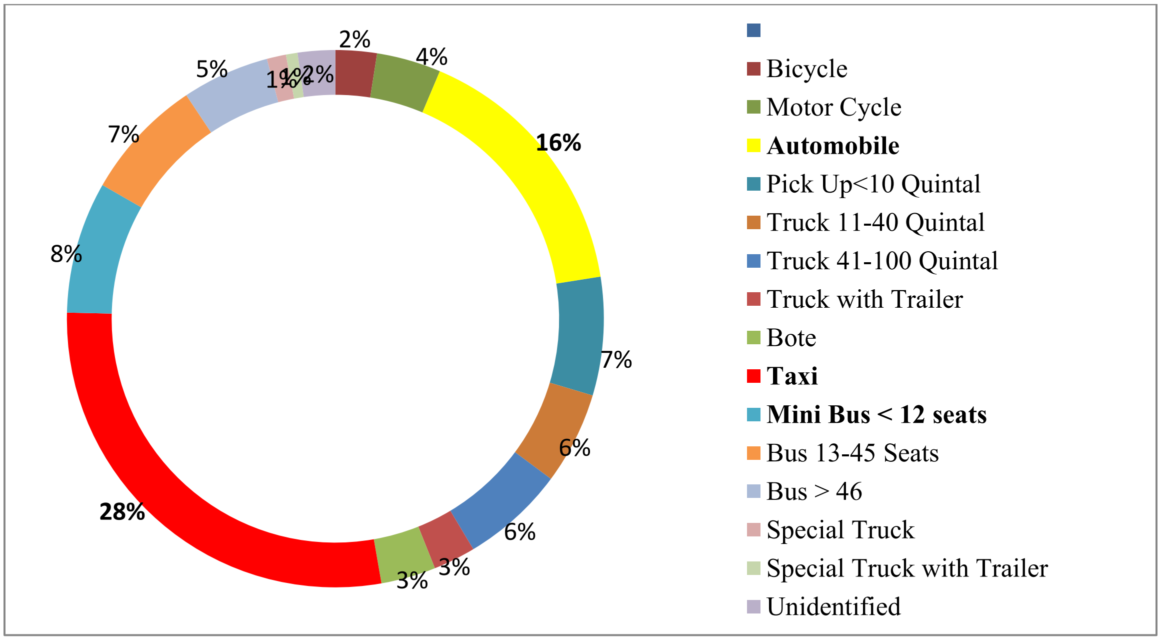



Figure 4.2 Type of vehicle involved in accidents of the study area (throughout 13.2Km) (Source: -A.A Police Commission, Road Traffic Accident Statistics Office, 2001/02-2007/08).

And the second most frequently vehicles involved in accidents were the Automobiles with (16%) as indicated in Figure 4.2.

Particularly, in Appendix III, Table C1a, accident data collected in Asrasimnt (0.3Km) indicated that vehicles most frequently involved in accidents were also Taxis (24.61%). And the second most frequently involved in accidents were the Trucks with 41- 100 quintals (13.09%) as indicated in Figure 4.3. These vehicles are usually operated by professional drivers for extended hours by chewing chat (stimulant leaf). As a result, fatigues together with speed on the down-grade are the main causes for accidents in these types of vehicles.

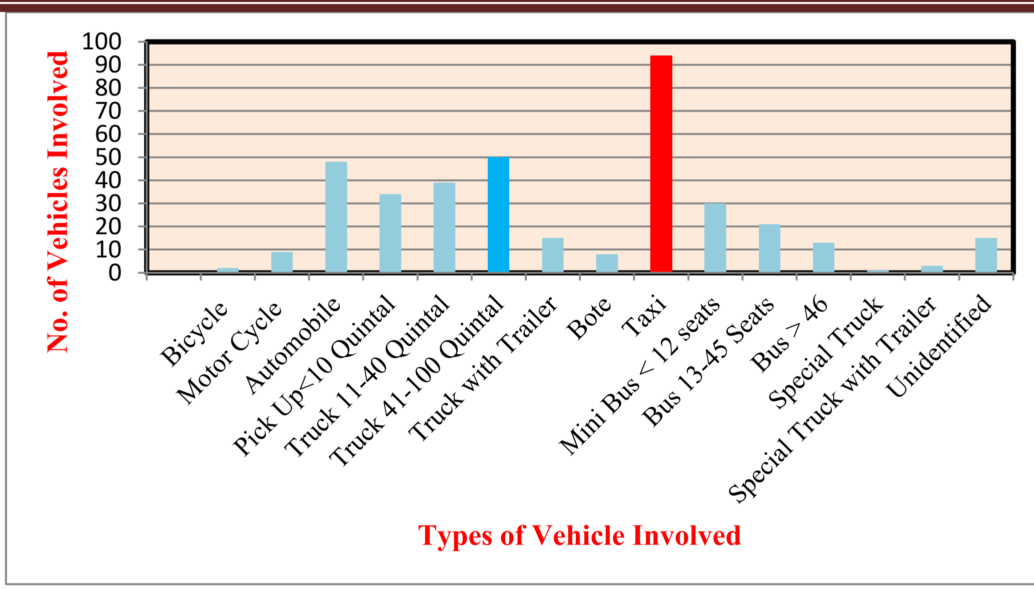



Figure 4.3 Type of vehicle involved in accident at Asrasimnt (0+300), (Source: -A.A Police Commission, Road Traffic Accident Statistics Office, 2001/02-2007/08)

### iii) Causality by Types of Road Users

In terms of collision types as shown in Figure 4.4, the highest percentage of accident was with pedestrians that accounted for about 56% followed by passengers with 30% and then by drivers with 14%. Detail analysis is shown in Appendix III, from Table C2a-C2f.

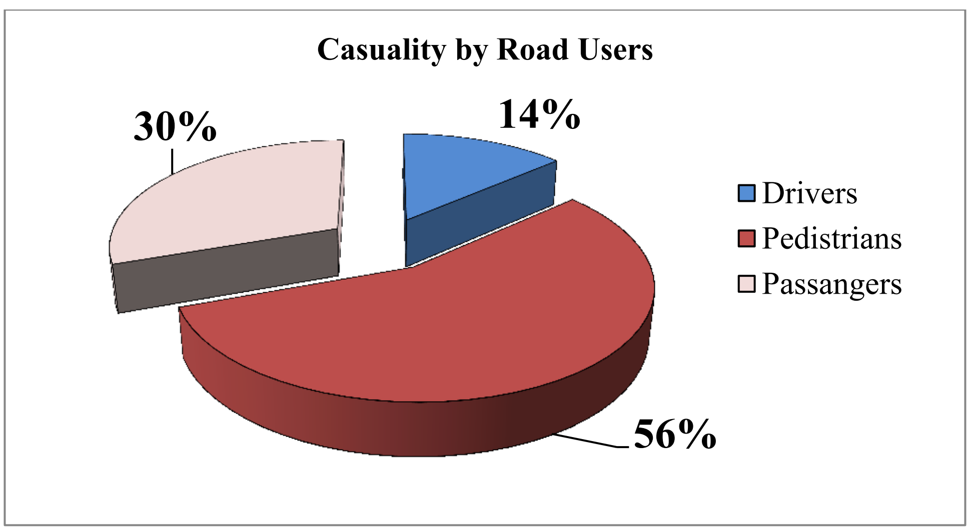



Figure 4.4 Casualties by Road Users throughout 13.2km (Source: -A.A Police Commission, Road Traffic Accident Statistics Office, 2001/02-2007/08).

It is true that urban environment here in Ethiopia does not have proper pedestrian facilities.

Furthermore, road users are not well aware of traffic rules and regulation in the country. In major area of the study road sections especially around market place, carriageways or the edge of carriageways are used as footways. It is common to observe pedestrian and vehicle conflicts.

Table 4.1 Severity of Injuries Casualties by Road Users in Asrasimint (0.3km)

| Accident | Drivers | | Passengers | | Pedestrians | | Total | |
|---|---|---|---|---|---|---|---|---|
| Type | Number | % | Number | % | Number | % | Number | % |
| Fatal | 8 | 20.51 | 32 | 43.24 | 49 | 40.50 | 89 | 100 |
| Serious | 14 | 35.90 | 22 | 29.73 | 44 | 36.36 | 80 | 100 |
| Slight | 17 | 43.59 | 20 | 27.03 | 28 | 23.14 | 65 | 100 |
| Total | 39 | 16.67 | 74 | 31.62 | 121 | 51.71 | 234 | 100 |

#### iv) Variation by Collision Type

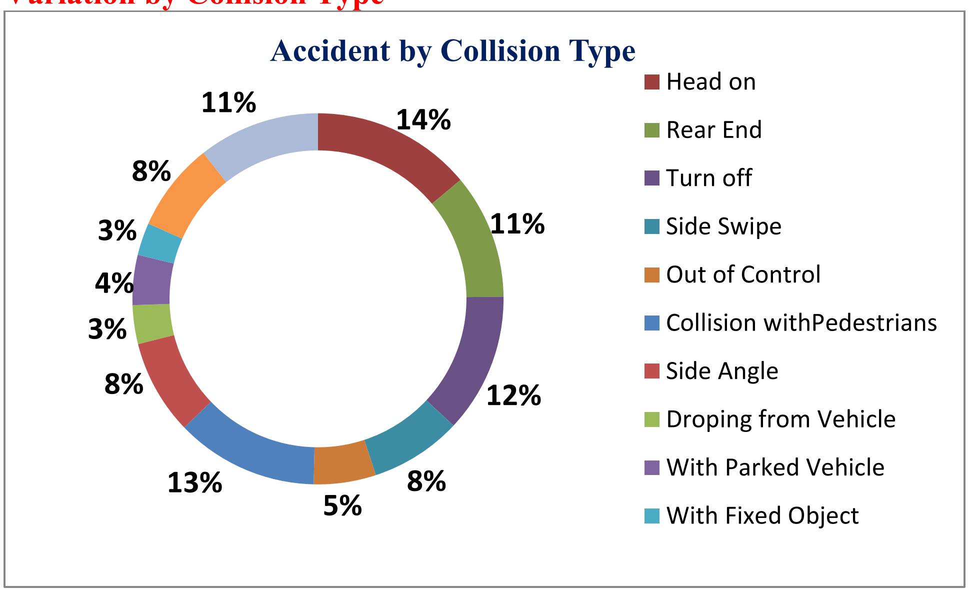



Figure 4.5 Accident by collision type throughout 13.2km (Source: -A.A Police Commission, Road Traffic Accident Statistics Office, 2001/02-2007/08).

As the figure above indicates that head on and turn off collisions with 14% and 12% was the dominating collision types at all the segments of the road respectively. The rear end or nose- tail collision (11%) type was also seen as predominant on the collision diagram. Likewise, side and side angle accidents occurred due to conflict points that exist at the priority junction.

## 4.2 Relationship among Road Traffic Accidents, Road Design Elements and Traffic Factors

It was possible to develop a relationship among road traffic accidents with that of traffic flows and geometric design variables. In this regard, simple categorical analysis was made based on accidents versus road alignments. Furthermore, correlations of accidents with different geometric design elements were also made.

### 4.2.1 Roadway Alignment

Horizontal curves, steep grades, and vertical curves bring additional challenges to drivers, resulting in increased risk of collisions. During the seven years period, the number of accidents on horizontal curves was less than the tangent sections.

**i) Collision by Roadway Alignment**

Figure 4.6 shows a result of collisions according to roadway alignment. Accordingly, 80% of the collisions occurred on level and tangent sections and similarly, 5 percent occurred on horizontal curves or grades. Detail analysis is shown in Appendix III, Table D-1.

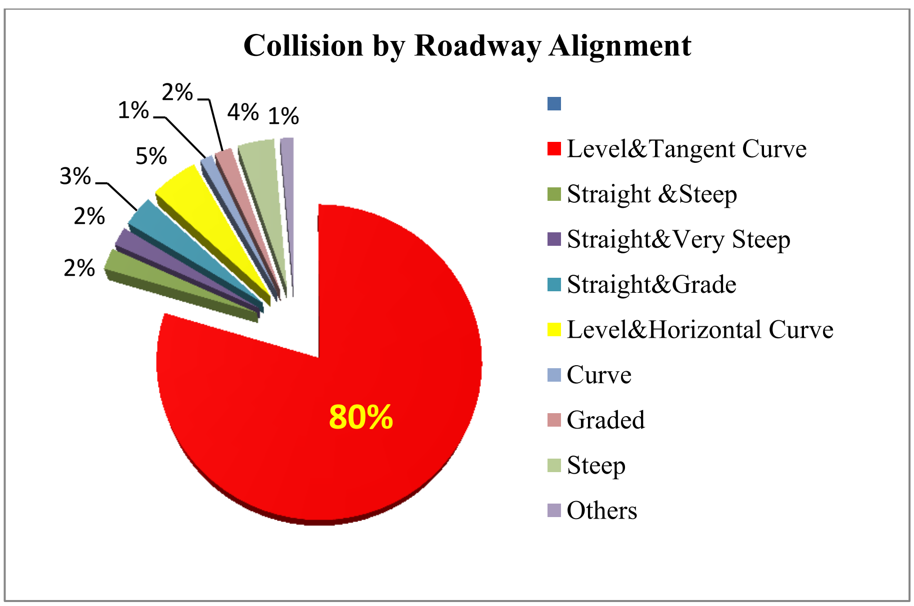



Figure 4.6 Collision by Roadway Alignment

**ii) Collisions by Roadway Junctions**

Accidents on horizontal curves cause a significant amount of pain and suffering to those involved in the accidents because of the nature of the collisions. Figure 4.7 indicates that the greatest number of accident with the rate of 48% is recorded at the Islands and Roundabout parts of the road junction. And also road with two-direction contribute about 28% of traffic accidents. Detail analysis is shown in Appendix III, Table E-1.

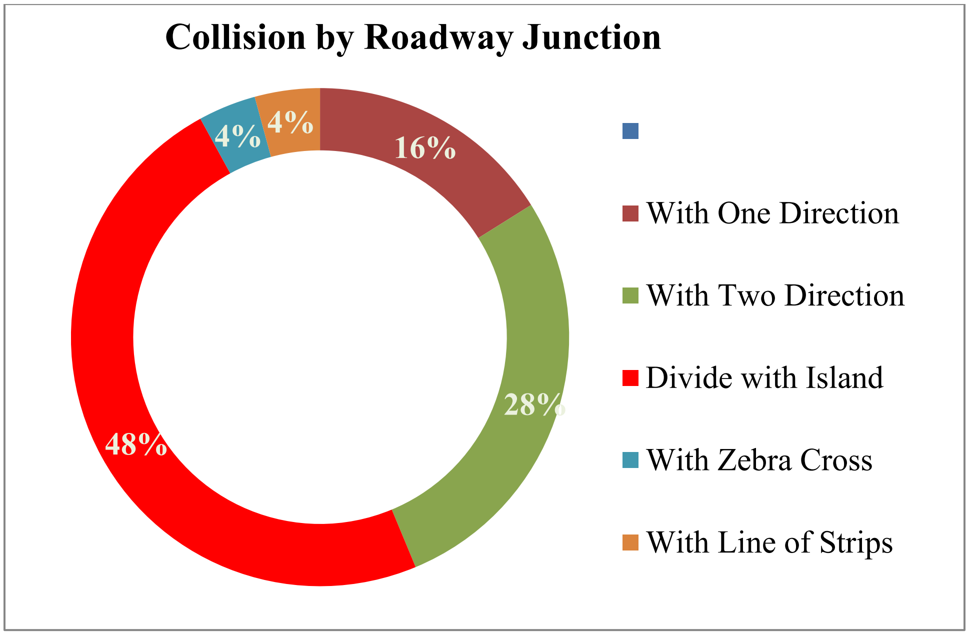



Figure 4.7 Collisions by Roadway Junctions

As exhibited in Figure 4.7 and 4.8, the accident rates steeply increased at road Roundabout and Islands, which is more related with its radius of curvature. Therefore, accidents are inversely related to the radius of curvature.

## 4.3 Ranking and Selection of a HRL

HRL ranking, usually according to technical criteria, has the purpose to prioritize places for further analysis and implementation of measures. Some of the possible ranking criteria for HRL are accident frequency, technical priority, accident rate, proportion of accident types considered susceptible for treatment and severity of casualties.

### 4.3.1 Ranking by Total Number of Accidents

Table 4.2 Identification of Hazardous Locations based on Total Number of Accidents (2001/2002 to 2007/2008 EC) (Source: -A.A Police Commission, Road Traffic Accident Statistics Office, 2008-2016)

| | Ranking Roads by Total Number of Accidents | | | | | |
|---|---|---|---|---|---|---|
| **Station** | **Km** | **Total Accident** | | **Station** | **Km** | **Total Accident** |
| 0+100 | **0.1** | 37 | | 3+500 | 3.5 | 36 |
| 0+200 | 0.2 | 75 | | 3+600 | 3.6 | 61 |
| 0+300 | **0.3** | **382** | | 3+900 | 3.9 | 85 |
| 0+400 | 0.4 | 98 | | 4+000 | 4 | 79 |
| 0+500 | 0.5 | 62 | | 4+200 | 4.2 | 72 |
| 0+600 | 0.6 | 57 | | 4+300 | 4.3 | 211 |
| 0+700 | 0.7 | 92 | | 4+500 | 4.5 | 67 |
| 0+800 | 0.8 | 58 | | 4+800 | 4.8 | 92 |
| 0+900 | 0.9 | 110 | | 4+900 | 4.9 | 191 |
| 1+000 | 1 | 94 | | 5+200 | 5.2 | 77 |
| 1+100 | 1.1 | 125 | | 5+300 | 5.3 | 108 |
| 1+200 | 1.2 | 44 | | 5+400 | 5.4 | 145 |
| 1+300 | 1.3 | 131 | | 5+600 | 5.6 | 70 |
| 1+400 | 1.4 | 36 | | 5+700 | 5.7 | 102 |
| 1+500 | 1.5 | 94 | | 5+800 | 5.8 | 258 |
| 1+600 | 1.6 | 174 | | 5+900 | 5.9 | 121 |
| 1+700 | 1.7 | 36 | | 6+100 | 6.1 | 123 |
| 1+800 | 1.8 | 68 | | 6+400 | 6.4 | 82 |
| 2+000 | 2 | 161 | | 6+500 | 6.5 | 25 |
| 2+200 | 2.2 | 128 | | 6+600 | 6.6 | 144 |
| 2+400 | 2.4 | 124 | | 6+800 | 6.8 | 23 |
| 2+500 | 2.5 | 10 | | 6+900 | 6.9 | 186 |
| 2+600 | 2.6 | 66 | | 7+000 | 7 | 62 |
| 2+800 | 2.8 | 107 | | 7+100 | 7.1 | 58 |
| 2+900 | **2.9** | **275** | | 7+200 | 7.2 | 26 |
| 3+000 | 3 | 87 | | 7+300 | 7.3 | **283** |
| 3+200 | 3.2 | 80 | | 7+400 | 7.4 | 127 |
| 3+400 | 3.4 | 91 | | 7+600 | 7.6 | 59 |
| 7+700 | 7.7 | 49 | | 10+500 | 10.5 | 62 |
| 7+800 | 7.8 | 100 | | 10+600 | 10.6 | 92 |
| 8+000 | 8 | 105 | | 10+700 | 10.7 | 54 |
| 8+100 | 8.1 | 65 | | 10+800 | 10.8 | 70 |

| ID No. | Km | Total accident | | | Km | Total Accident |
|---|---|---|---|---|---|---|
| 8+200 | 8.2 | 32 | | 10+900 | 10.9 | 181 |
| 8+300 | 8.3 | 63 | | 11+000 | 11 | 114 |
| 8+400 | 8.4 | 52 | | 11+100 | 11.1 | 111 |
| 8+500 | 8.5 | 168 | | 11+200 | 11.2 | 96 |
| 8+600 | 8.6 | 71 | | 11+300 | **11.3** | **226** |
| 8+700 | 8.7 | 215 | | 11+400 | 11.4 | 168 |
| 8+800 | 8.8 | 27 | | 11+500 | 11.5 | 72 |
| 8+900 | 8.9 | 84 | | 11+600 | 11.6 | 172 |
| 9+000 | 9 | 73 | | 11+700 | 11.7 | 35 |
| 9+100 | 9.1 | 171 | | 11+800 | 11.8 | 142 |
| 9+200 | 9.2 | 80 | | 12+000 | 12 | 82 |
| 9+300 | 9.3 | 151 | | 12+100 | 12.1 | 130 |
| 9+400 | 9.4 | 108 | | 12+200 | 12.2 | 136 |
| 9+500 | 9.5 | 61 | | 12+300 | 12.3 | 76 |
| 9+600 | 9.6 | 119 | | 12+400 | 12.4 | 174 |
| 9+700 | 9.7 | 84 | | 12+500 | 12.5 | 137 |
| 9+800 | **9.8** | **261** | | 12+600 | 12.6 | 56 |
| 9+900 | 9.9 | 117 | | 12+700 | 12.7 | 155 |
| 10+000 | 10 | 102 | | 12+800 | 12.8 | 58 |
| 10+100 | 10.1 | 134 | | 12+900 | 12.9 | 192 |
| 10+200 | 10.2 | 68 | | 13+000 | 13 | 154 |
| 10+300 | 10.3 | 208 | | 13+100 | **13.1** | **270** |
| 10+400 | 10.4 | 100 | | 13+200 | 13.2 | 128 |
| | | | | | **Total** | **12086** |

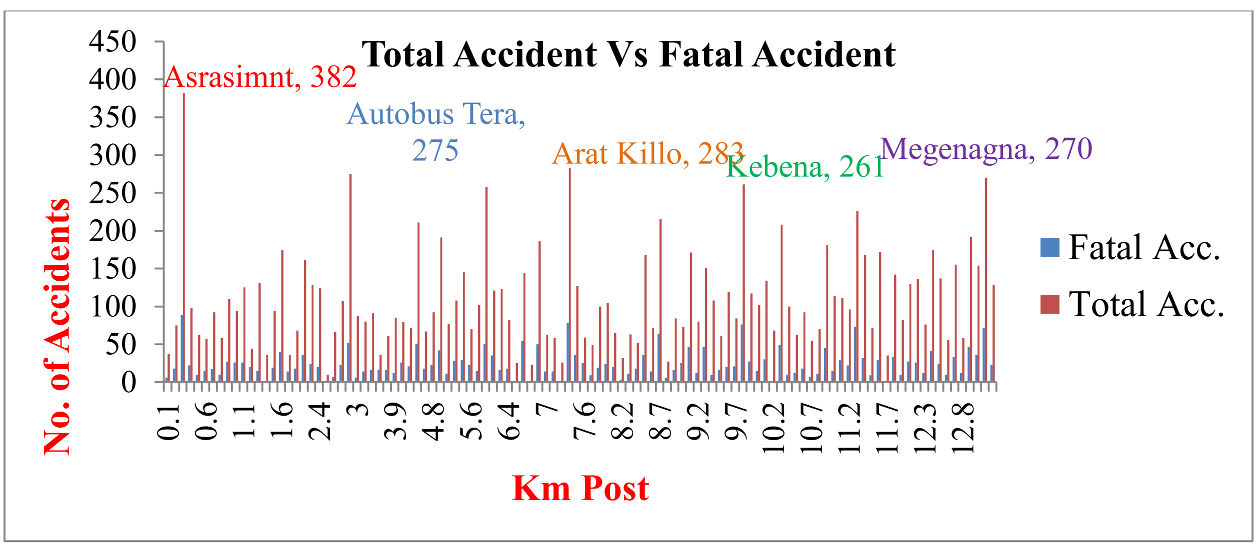



Figure 4.8 Total Accidents vs. Fatal Accidents of the Study Area

### 4.3.2 Ranking by severity of casualties (Fatal Accident)

Table 4.3 Identification of Hazardous Road Locations based on Severity of Accidents (2001/2-2007/8)

| Station | Km | Fatal Acci. | | Station | Km | Fatal Acci. |
|---|---|---|---|---|---|---|
| 0+100 | 0.1 | 6 | | 3+900 | 3.9 | 12 |
| 0+200 | 0.2 | 18 | | 4+000 | 4 | 26 |
| 0+300 | **0.3** | **89** | | 4+200 | 4.2 | 21 |
| 0+400 | 0.4 | 22 | | 4+300 | 4.3 | 51 |
| 0+500 | 0.5 | 10 | | 4+500 | 4.5 | 18 |
| 0+600 | 0.6 | 15 | | 4+800 | 4.8 | 23 |
| 0+700 | 0.7 | 17 | | 4+900 | 4.9 | 42 |
| 0+800 | 0.8 | 10 | | 5+200 | 5.2 | 11 |
| 0+900 | 0.9 | 27 | | 5+300 | 5.3 | 28 |
| 1+000 | 1 | 26 | | 5+400 | 5.4 | 29 |
| 1+100 | 1.1 | 26 | | 5+600 | 5.6 | 23 |
| 1+200 | 1.2 | 20 | | 5+700 | 5.7 | 15 |
| 1+300 | 1.3 | 15 | | 5+800 | 5.8 | 51 |
| 1+400 | 1.4 | 0 | | 5+900 | 5.9 | 35 |
| 1+500 | 1.5 | 19 | | 6+100 | 6.1 | 16 |
| 1+600 | 1.6 | 40 | | 6+400 | 6.4 | 18 |
| 1+700 | 1.7 | 14 | | 6+500 | 6.5 | 0 |
| 1+800 | 1.8 | 18 | | 6+600 | 6.6 | 54 |
| 2+000 | 2 | 36 | | 6+800 | 6.8 | 0 |
| 2+200 | 2.2 | 24 | | 6+900 | 6.9 | 50 |
| 2+400 | 2.4 | 20 | | 7+000 | 7 | 14 |
| 2+500 | 2.5 | 0 | | 7+100 | 7.1 | 14 |
| 2+600 | 2.6 | 7 | | 7+200 | 7.2 | 1 |
| 2+800 | 2.8 | 23 | | 7+300 | **7.3** | **78** |
| 2+900 | **2.9** | **52** | | 7+400 | 7.4 | 36 |
| 3+000 | 3 | 6 | | 7+600 | 7.6 | 25 |
| 3+200 | 3.2 | 14 | | 7+700 | 7.7 | 9 |
| 3+400 | 3.4 | 16 | | 7+800 | 7.8 | 19 |
| 3+500 | 3.5 | 16 | | 8+000 | 8 | 24 |
| 3+600 | 3.6 | 16 | | 8+100 | 8.1 | 20 |

(Source: -A.A Police Commission, Road Traffic Accident Statistics Office, 2008-2016)

| Station | Km | Fatal Acc. | | Station | Km | Fatal Acc. |
|---|---|---|---|---|---|---|
| 8+200 | 8.2 | 3 | | 10+700 | 10.7 | 7 |
| 8+300 | 8.3 | 11 | | 10+800 | 10.8 | 11 |
| 8+400 | 8.4 | 18 | | 10+900 | 10.9 | 45 |
| 8+500 | 8.5 | 36 | | 11+000 | 11 | 15 |
| 8+600 | 8.6 | 14 | | 11+100 | 11.1 | 29 |
| 8+700 | 8.7 | 64 | | 11+200 | 11.2 | 22 |
| 8+800 | 8.8 | 5 | | 11+300 | **11.3** | **73** |
| 8+900 | 8.9 | 16 | | 11+400 | 11.4 | 32 |
| 9+000 | 9 | 25 | | 11+500 | 11.5 | 9 |
| 9+100 | 9.1 | 46 | | 11+600 | 11.6 | 29 |
| 9+200 | 9.2 | 12 | | 11+700 | 11.7 | 0 |
| 9+300 | 9.3 | 46 | | 11+800 | 11.8 | 33 |
| 9+400 | 9.4 | 10 | | 12+000 | 12 | 10 |
| 9+500 | 9.5 | 16 | | 12+100 | 12.1 | 27 |
| 9+600 | 9.6 | 20 | | 12+200 | 12.2 | 26 |
| 9+700 | 9.7 | 21 | | 12+300 | 12.3 | 12 |
| 9+800 | **9.8** | **76** | | 12+400 | 12.4 | 41 |
| 9+900 | 9.9 | 27 | | 12+500 | 12.5 | 24 |
| 10+000 | 10 | 15 | | 12+600 | 12.6 | 10 |
| 10+100 | 10.1 | 30 | | 12+700 | 12.7 | 33 |
| 10+200 | 10.2 | 0 | | 12+800 | 12.8 | 12 |
| 10+300 | 10.3 | 49 | | 12+900 | 12.9 | 46 |
| 10+400 | 10.4 | 10 | | 13+000 | 13 | 36 |
| 10+500 | 10.5 | 12 | | 13+100 | **13.1** | **72** |
| 10+600 | 10.6 | 18 | | 13+200 | 13.2 | 23 |
| | | | | | **Total** | **1288** |

(Source: A.A Police Commission, Road Traffic Accident Statistics Office, 2001/2002 -2007/2008 EC)

### 4.3.3 Ranking by Technical Weight of Priority

The work done in this ranking system is based on survey work. This includes collecting the accident records from Four Addis Ababa Sub-City Administrations police stations and choosing Hazard locations to be worked upon. The places from Lukuwanda (0.00Km) up to Megenagna (13.2Km) through Piazza were selected for investigation of hazards on the basis of experienced accident history.

The values of various factors contributing to accidents were collected from these sites mentioned above (Table 3.1) and total weights were calculated.

Table 4.4 Identification of Hazardous Road Locations based on weight of Priority (2001/2-2007/8)

| Station | Total accident | Total Wt. of Priority | Accident prone level | | Station | Total Accident | Total Wt. of Priority | Accident prone level |
|---|---|---|---|---|---|---|---|---|
| 0+100 | 37 | 52.22 | Medium | | 3+500 | 36 | 63.33 | Low |
| 0+200 | 75 | 52.22 | Medium | | 3+600 | 61 | 63.33 | Low |
| 0+300 | **382** | 44.44 | High | | 3+900 | 85 | 63.33 | Low |
| 0+400 | 98 | 36.67 | High | | 4+000 | 79 | 63.33 | Low |
| 0+500 | 62 | 36.67 | High | | 4+200 | 72 | 63.33 | Low |
| 0+600 | 57 | 36.67 | High | | 4+300 | 211 | 63.33 | Low |
| 0+700 | 92 | 36.67 | High | | 4+500 | 67 | 60.00 | Medium |
| 0+800 | 58 | 36.67 | High | | 4+800 | 92 | 60.00 | Medium |
| 0+900 | 110 | 36.67 | High | | 4+900 | 191 | 60.00 | Medium |
| 1+000 | 94 | 52.22 | Medium | | 5+200 | 77 | 50.00 | Medium |
| 1+100 | 125 | 52.22 | Medium | | 5+300 | 108 | 50.00 | Medium |
| 1+200 | 44 | 52.22 | Medium | | 5+400 | 145 | 50.00 | Medium |
| 1+300 | 131 | 52.22 | Medium | | 5+600 | 70 | 53.33 | Medium |
| 1+400 | 36 | 54.44 | Medium | | 5+700 | 102 | 60.00 | Medium |
| 1+500 | 94 | 54.44 | Medium | | 5+800 | 258 | 66.67 | Low |
| 1+600 | 174 | 54.44 | Medium | | 5+900 | 121 | 60.00 | Medium |
| 1+700 | 36 | 54.44 | Medium | | 6+100 | 123 | 60.00 | Medium |
| 1+800 | 68 | 54.44 | Medium | | 6+400 | 82 | 54.44 | Medium |
| 2+000 | 161 | 54.44 | Medium | | 6+500 | 25 | 54.44 | Medium |
| 2+200 | 128 | 54.44 | Medium | | 6+600 | 144 | 53.33 | Medium |
| 2+400 | 124 | 54.44 | Medium | | 6+800 | 23 | 54.44 | Medium |
| 2+500 | 10 | 61.11 | Low | | 6+900 | 186 | 54.44 | Medium |
| 2+600 | 66 | 61.11 | Low | | 7+000 | 62 | 54.44 | Medium |
| 2+800 | 107 | 61.11 | Low | | 7+100 | 58 | 54.44 | Medium |
| 2+900 | 275 | 58.89 | Medium | | 7+200 | 26 | 54.44 | Medium |
| 3+000 | 87 | 65.56 | Low | | 7+300 | 283 | 66.67 | Low |
| 3+200 | 80 | 63.33 | Low | | 7+400 | 127 | 63.33 | Low |
| 3+400 | 91 | 63.33 | Low | | 7+600 | 59 | 61.11 | Low |
| 7+700 | 49 | 61.11 | Low | | 10+500 | 62 | 54.44 | Medium |
| 7+800 | 100 | 61.11 | Low | | 10+600 | 92 | 52.22 | Medium |
| 8+000 | 105 | 61.11 | Low | | 10+700 | 54 | 62.22 | Low |
| 8+100 | 65 | 61.11 | Low | | 10+800 | 70 | 68.89 | Low |
| 8+200 | 32 | 61.11 | Low | | 10+900 | 181 | 68.89 | Low |
| 8+300 | 63 | 61.11 | Low | | 11+000 | 114 | 68.89 | Low |

| Station | **Total Accident** | **Total Wt. of Priority** | **Accident Prone Level** | | Station | **Total Accident** | **Total Wt. of Priority** | **Accident Prone Level** |
|---|---|---|---|---|---|---|---|---|
| 8+400 | 52 | 61.11 | Low | | 11+100 | 111 | 60.00 | Medium |
| 8+500 | 168 | 54.44 | Medium | | 11+200 | 96 | 60.00 | Medium |
| 8+600 | 71 | 54.44 | Medium | | 11+300 | 226 | 44.44 | High |
| 8+700 | 215 | 54.44 | Medium | | 11+400 | 168 | 60.00 | Medium |
| 8+800 | 27 | 54.44 | Medium | | 11+500 | 72 | 60.00 | Medium |
| 8+900 | 84 | 54.44 | Medium | | 11+600 | 172 | 60.00 | Medium |
| 9+000 | 73 | 54.44 | Medium | | 11+700 | 35 | 60.00 | Medium |
| 9+100 | 171 | 54.44 | Medium | | 11+800 | 142 | 60.00 | Medium |
| 9+200 | 80 | 61.11 | Low | | 12+000 | 82 | 65.56 | Low |
| 9+300 | 151 | 61.11 | Low | | 12+100 | 130 | 65.56 | Low |
| 9+400 | 108 | 67.78 | Low | | 12+200 | 136 | 67.78 | Low |
| 9+500 | 61 | 67.78 | Low | | 12+300 | 76 | 67.78 | Low |
| 9+600 | 119 | 67.78 | Low | | 12+400 | 174 | 67.78 | Low |
| 9+700 | 84 | 67.78 | Low | | 12+500 | 137 | 67.78 | Low |
| 9+800 | 261 | 54.44 | Medium | | 12+600 | 56 | 67.78 | Low |
| 9+900 | 117 | 67.78 | Low | | 12+700 | 155 | 67.78 | Low |
| 10+000 | 102 | 67.78 | Low | | 12+800 | 58 | 67.78 | Low |
| 10+100 | 134 | 67.78 | Low | | 12+900 | 192 | 67.78 | Low |
| 10+200 | 68 | 67.78 | Low | | 13+000 | 154 | 63.33 | Low |
| 10+300 | 208 | 67.78 | Low | | 13+100 | 270 | 56.67 | Medium |
| 10+400 | 100 | 61.11 | Low | | 13+200 | 128 | 61.11 | Low |

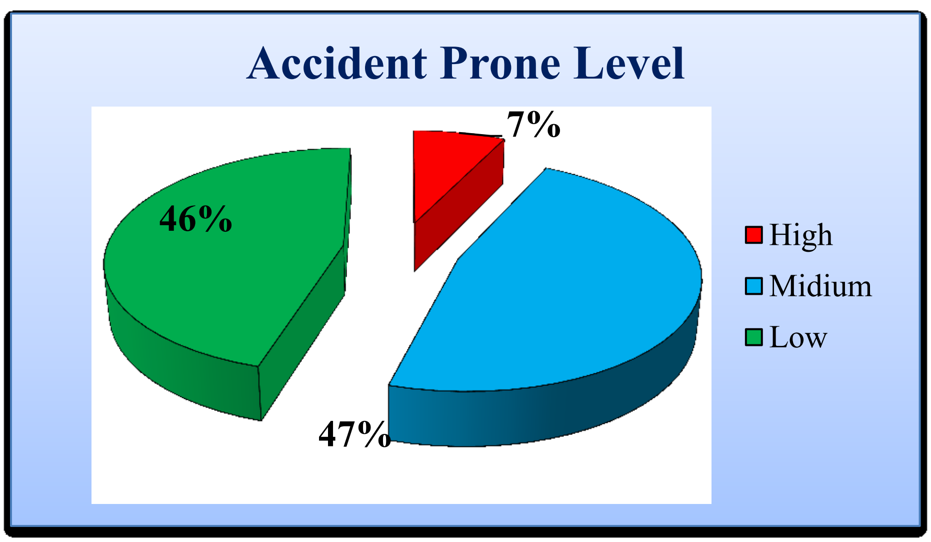



Figure 4.9 Hazard Prone Level

As the figure, it is clearly visible that 7% out of the total road segment has minimum weight (i.e. total weight of technical priority less than 45) which according to the concept of prioritization in this report was the most accident prone location. Detail analysis is calculated in Appendix III, Table C-3.

As in the above records given by Addis Ababa police station, Asrasimint (Location 0.3Km) has reported maximum number of accidents i.e. total of 382 accidents including 293 injuries. So it is clear from the records that Asrasimint (Location 0.3Km) is the most hazard prone location in this study area which verifies that the GIS approach is valid and it can be applied to accident sites successfully.

### 4.3.4 Ranking Based on GIS Analysis

***Software work***

- For selected places road maps were downloaded.
- Latitude and longitude values for selected points were found.
- The map image was input in ARCGIS 10.2.
- Geo-referencing was done with all the segments in one map.
- Map image was digitized with shape file.(Appendix IV)
- In the attribute table, desired columns are entered with their values.

Analysis was done to rank hazard locations.

***RESULTS***

An analysis result was taken in picture format for GIS analysis using ArcMap 10.2 showing the following results:

a) Eastern Direction of the Road

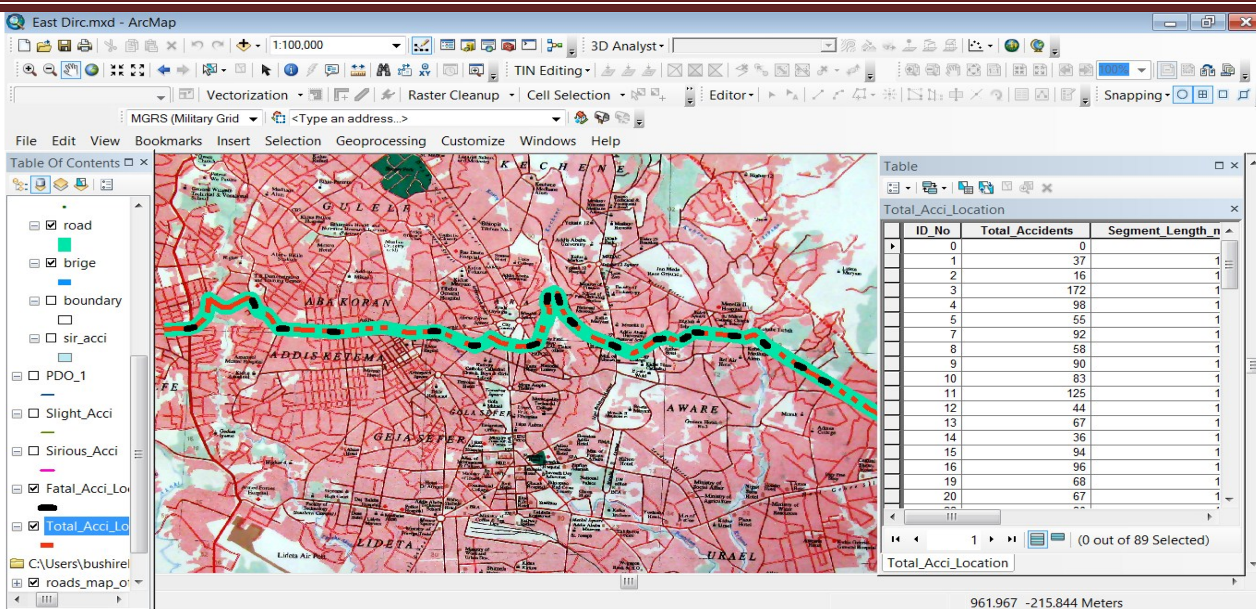



Figure 4.10 GIS Analysis of Accident Location for Eastern Direction of the Road

According to Appendix II, Table B-2, it's found that among the total 13.2 km road length accident occur at 8.3 km of road length. This crashes information has linked with the road network shape file with GIS to locate the hazardous location on road. After this the accident spots are possible to pin-pointed on map. Figure below shows the hazardous road locations on Lukuwanda-Megenagna road in the eastern direction of highway.

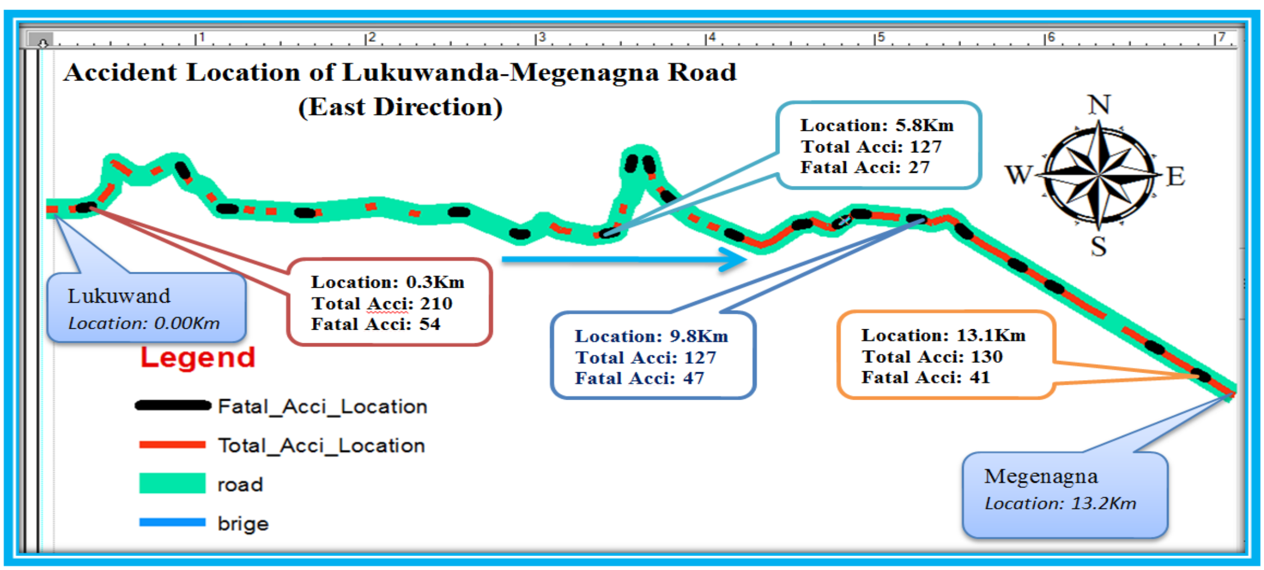



Figure 4.11 Accident Location of Lukuwanda-Megenagna in the East Direction of the Road

As in the figure it is clearly visible that Asrasimint (Location: 0.3km) in the east direction of the road has maximum number of accident i.e.210 which according to the concept of hazard location in this report is the most accident prone point in this study area.

To cross check the results and verify the validity of GIS approach, visits were made to traffic police stations for real time records.

### b) West Direction of the Road

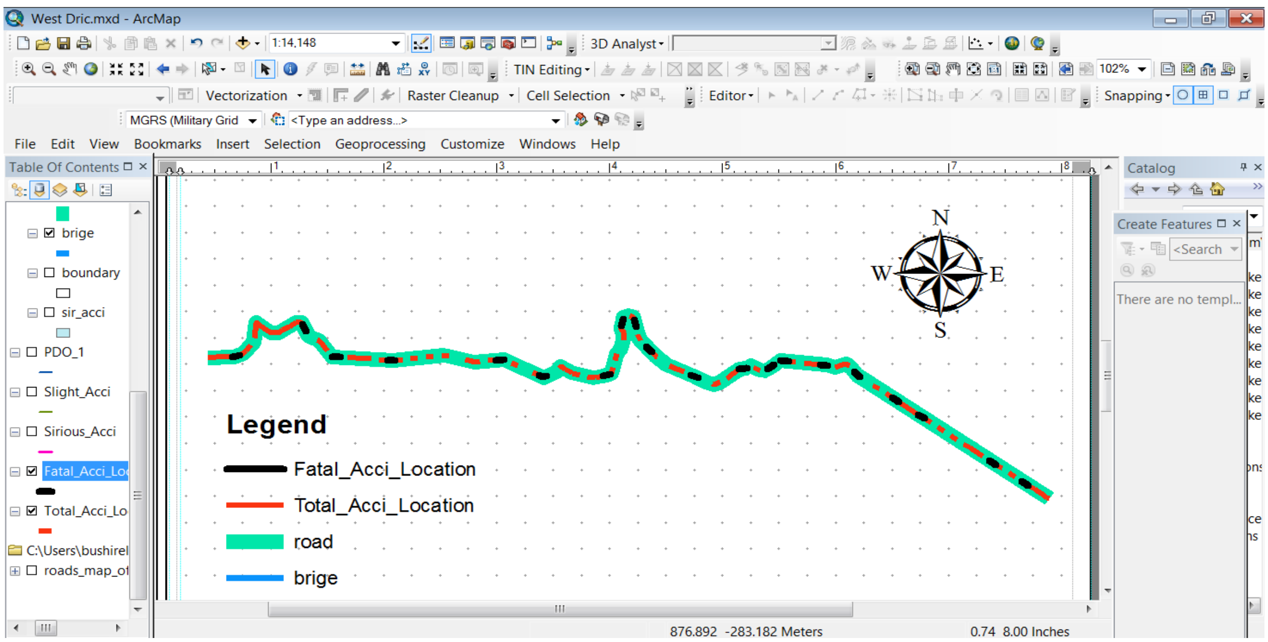



Figure 4.12 GIS Analysis of Accident Location for the West Direction of the Road

Appendix II, Table B-3 shows it’s found that among the total 13.2 km road length accident occur at 8.7 km of road length. This crashes information has linked with the road network shape file with GIS to locate the hazardous location on road. After this the accident spots are possible to pin-pointed on map. Figure below shows the hazardous road locations on Lukuwanda- Megenagna road in the western direction of the road.

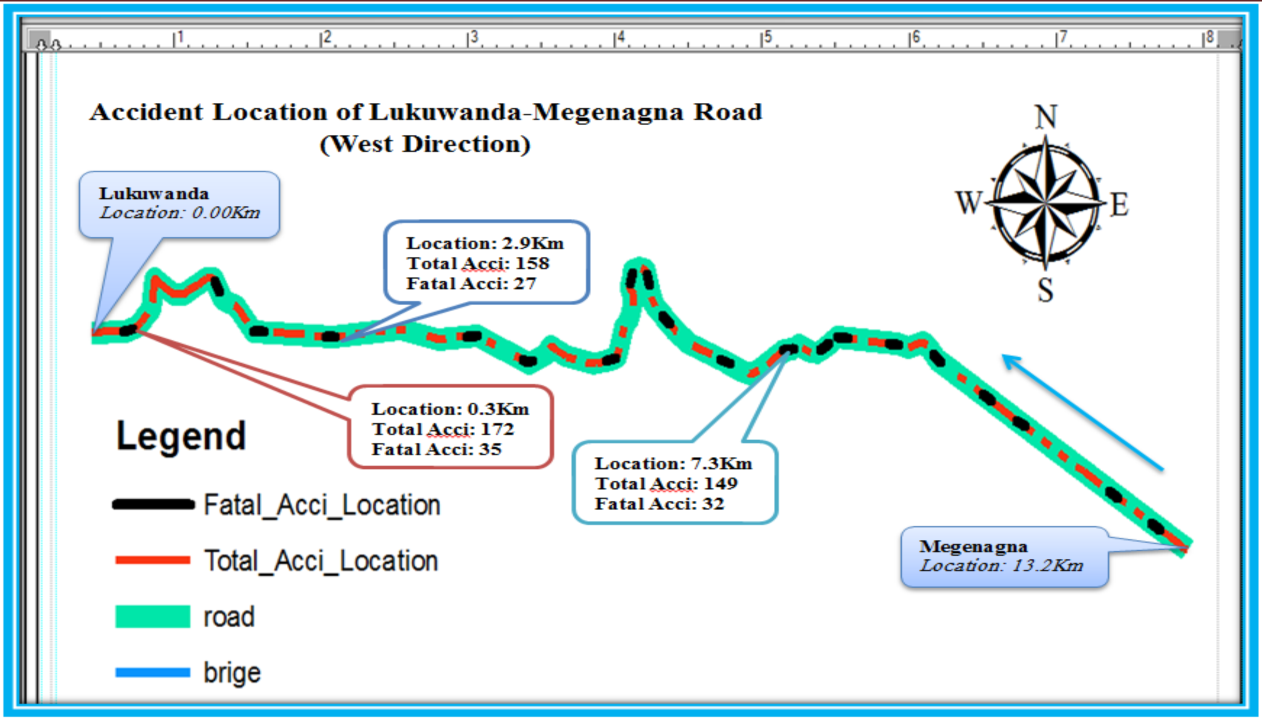



Figure 4.13 Accident Location of Lukuwanda-Megenagna in the West Direction of the Road

As in the above output figure of GIS show that, Asrasimint (Location: 03km) in the west direction of the road has also reported maximum number of accidents i.e. total of 172 accidents including 35 fatal accidents. So it is clear from the result that Asrasimint (Location:03km) is the most hazard location in this study area which verifies that the GIS approach is valid and can also be applied to accident sites successfully.

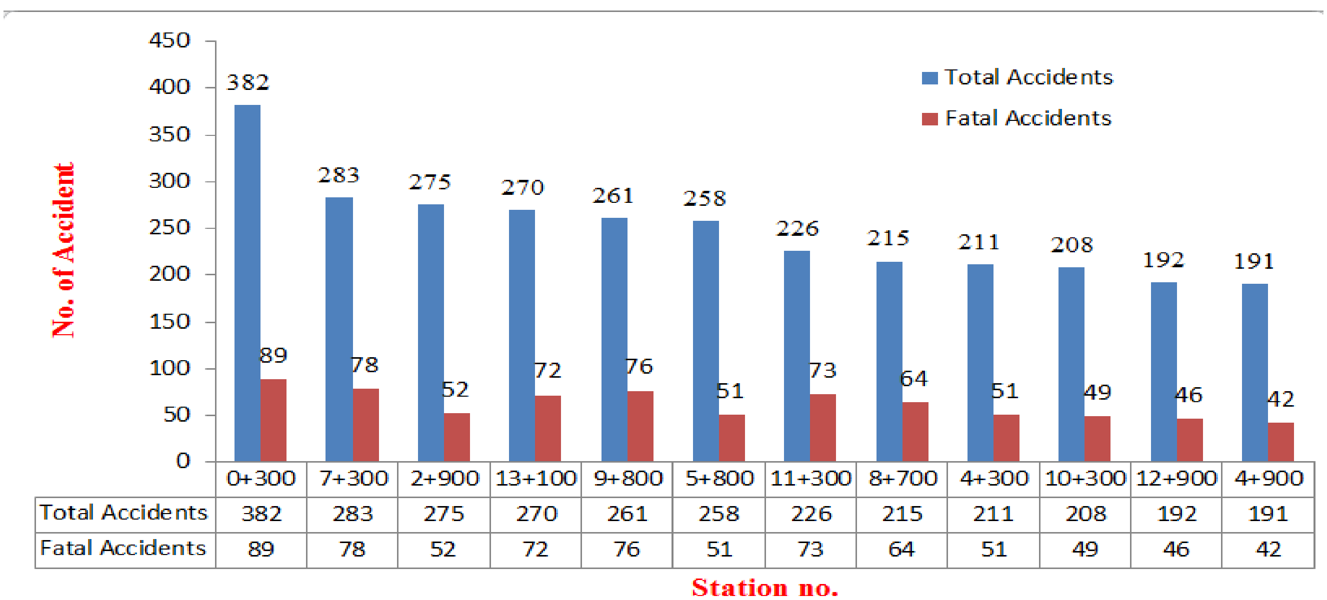



Figure 4.14 Ranking of HRL using GIS tool

## 4.4 Selection of Hazardous Road Location

**i) Selection by Total Number of Accident**

As shown in table 4.5 below crashes location on road with crashes number, here ten locations based on a method of density function were identified as hazardous whose distance from Lukuwanda is 0.3km, 7.3km, 2.9km, 13.1km, 9.8km, 5.8km, 11.3km, 8.7km, 4.3km and 10.3km respectively. Even though, here the first one location(Asrasimint Round about) can be treated as the most hazardous, this is 0.3 km from Lukuwanda with total 382 crashes occur during the year 2001/2002 to 2007/2008 EC when no. of fatal accident is 89. The next five hazardous locations are also selected for detail analysis. Details of accident rate calculations are available in Appendix II, Table B-4.

Table 4.5 The First Ten Hazardous Locations based on Total Number of Accidents

| Station | Km | Total Accident |
|---|---|---|
| 0+300 | **0.3** | **382** |
| 7+300 | 7.3 | 283 |
| 2+900 | 2.9 | 275 |
| 13+100 | 13.1 | 270 |
| 9+800 | 9.8 | 261 |
| 5+800 | 5.8 | 258 |
| 11+300 | 11.3 | 226 |
| 8+700 | 8.7 | 215 |
| 4+300 | 4.3 | 211 |
| 10+300 | 10.3 | 208 |

The scenario extracts from the above result illustrates that roundabouts are playing the main role in hazardous road location. The possible reasons are the inadequate design of roundabouts, over speed and local unsafe activities around the intersections with aggressive driving. To find the exact causeswhich make those segments hazardous, an extensive characteristics analysis is required.

**ii) Selection by Severity of Casualty**

Table 4.6 The First Ten Hazardous Location based on **Severity of Casualty**

| Stations | Km | Fatal Accident |
|---|---|---|
| 0+300 | **0.3** | **89** |
| 7+300 | 7.3 | 78 |
| 9+800 | 9.8 | 76 |
| 11+300 | 11.3 | 73 |
| 13+100 | 13.1 | 72 |

| Stations | Km | Fatal Accident |
|---|---|---|
| 8+700 | 8.7 | 64 |
| 6+600 | 6.6 | 54 |
| 2+900 | 2.9 | 52 |
| 4+300 | 4.3 | 51 |
| 5+800 | 5.8 | 51 |

According to the table 4.6 shows that the first ten hazardous locations with km value 0.3km, 7.3km, 9.8km, 11.3km, 13.1km, 8.7km, 6.6km, 2.9km, 4.3km, and 5.8km respectively. From here the first location also can be treated as most hazardous. This is, 0.3 km from Lukuwanda where total 89 fatal occur during the year 2001/2002 to 2007/2008 EC. Details of accident rate calculations are available in Appendix II Table B-4.

**iii) Selection by Accident Prone Level**

Table 4.7 The First Eight Hazardous Location based on **Accident Prone Level**

| Stations | Km | Total Accidents | Total Wt. of Priority | Accident Prone Level |
|---|---|---|---|---|
| 0+400 | 0.4 | 98 | 36.67 | High |
| 0+500 | 0.5 | 62 | 36.67 | High |
| 0+600 | 0.6 | 57 | 36.67 | High |
| 0+700 | 0.7 | 92 | 36.67 | High |
| 0+800 | 0.8 | 58 | 36.67 | High |
| 0+900 | 0.9 | 110 | 36.67 | High |
| **0+300** | **0.3** | **382** | **44.44** | High |
| 11+300 | 11.3 | 226 | 44.44 | High |

Table 4.7 shows that accident prone level based on different technical weight of priority. According to the analysis road locations are laid under high, medium and low hazard prone level with 7%, 47% and 46% respectively. This 7% high level of accident prone level represents eight hazardous locations with km value 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.3 and 11.3. By cross checking the results, from here two locations can be treated as most hazardous. First one is, 0.3 km from Lukuwanda(0.00km) where total weight of priority 44.44 and 382 crashes occurred during the year 2001/2 to 2007/8 when number of fatal accidents are 89. And the second one is 11.3 km from Lukuwanda(Station 0+000) where total weight of priority 44.44 and 226 crashes occurred and among them 73 are fatal. Detail analysis of accident prone levels are available in Appendix III Table C-3.

## 4.5 Detail Analysis of road accidents

Accident analysis within each HRL has the purpose of understanding what causes are in the origin of road accidents, which might be suitable for treatment. Several inspections or analyses can be carried out in this stage, within a *site action* approach: examples are the site visits or the production and analysis of stick diagrams which identify common patterns among accidents that occurred in the same place, supporting the search for common problems between accidents and often contributing to the elaboration of countermeasures. It is, however, important to state that accident analysis may not lead to the finding of common contributory factors to road accidents in a HRL. This might be due to the intrinsic nature of accidents, most probably from the existing fluctuation of variables taken from events considered as random.

### 4.5.1 Descriptive Statistical Analysis

The 1729 road accidents caused 12086 casualties (most of which were fatal and injuries) of which for the first six highest HRL(Table 4.9) 13.59% were drivers, 30.44% passengers and 55.98% pedestrians.

Table 4.8 Collisions by Road Users for the First Six HRLs

| **Road Users** | Asrasmint | Arat killo | Autobus Tera | Kebena | Megenagna | Piazza | **Total** | % |
|---|---|---|---|---|---|---|---|---|
| Location | 0.3km | 7.3km | 2.9km | 9.8km | | 5.8km | | |
| Driver | 39 | 25 | 18 | 17 | 15 | 19 | 133 | 13.59 |
| Passengers | 74 | 57 | 28 | 55 | 47 | 37 | 298 | 30.44 |
| Pedestrians | 121 | 98 | 69 | 88 | 98 | 74 | 548 | 55.98 |
| **Total** | 234 | 180 | 115 | 160 | 160 | 130 | **979** | |

Among these, pedestrians were the type of casualty that suffered more serious injuries or deaths and were mainly (56% of pedestrians) run over on crosswalks. About 94% of drivers had the driver license appropriate to the vehicle. Details are available in Appendix III, from Table C-2a – Table C-2f.

Table 4.9 Collision type by Severity for Asrasmint(0.3km)(A.A Police Commision 2001/02-2007/08)

| Accident | Drivers | | Passengers | | Pedestrians | | Total | |
|---|---|---|---|---|---|---|---|---|
| Type | Number | % | Number | % | Number | % | Number | % |
| Fatal | 8 | 20.51 | 32 | 43.24 | 49 | 40.50 | 89 | 38.03 |
| Serious | 14 | 35.90 | 22 | 29.73 | 44 | 36.36 | 80 | 34.19 |
| Slight | 17 | 43.59 | 20 | 27.03 | 28 | 23.14 | 65 | 27.78 |
| Total | 39 | 16.67 | 74 | 31.62 | 121 | 51.71 | 234 | 100 |

Most accidents occurred on roads with pavements with good or regular conditions of maintenance, and at clean and dry road surface. According to the considered road hierarchy, most road accidents occurred on main distributor roads (68.14%).

### 4.5.2 Detail Analysis of Collision Variation by Types of Motor Vehicle Involved in the Study Area

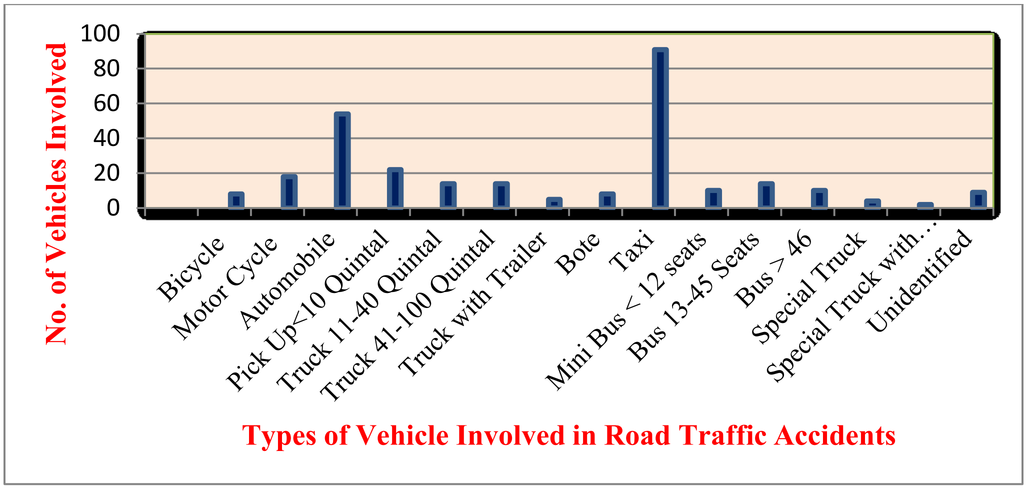



Figure 4.15 Type of vehicle involved in accidents of location 7.3km

Accident data collected in Arat Killo (7.3Km) indicated that vehicles most frequently involved in accidents were Taxis (23.82%). And the second most frequently vehicles involved in accidents were the Auto Mobiles (14.14%) as indicated in Appendix III, C-1b. This area is also faced with high congestion.

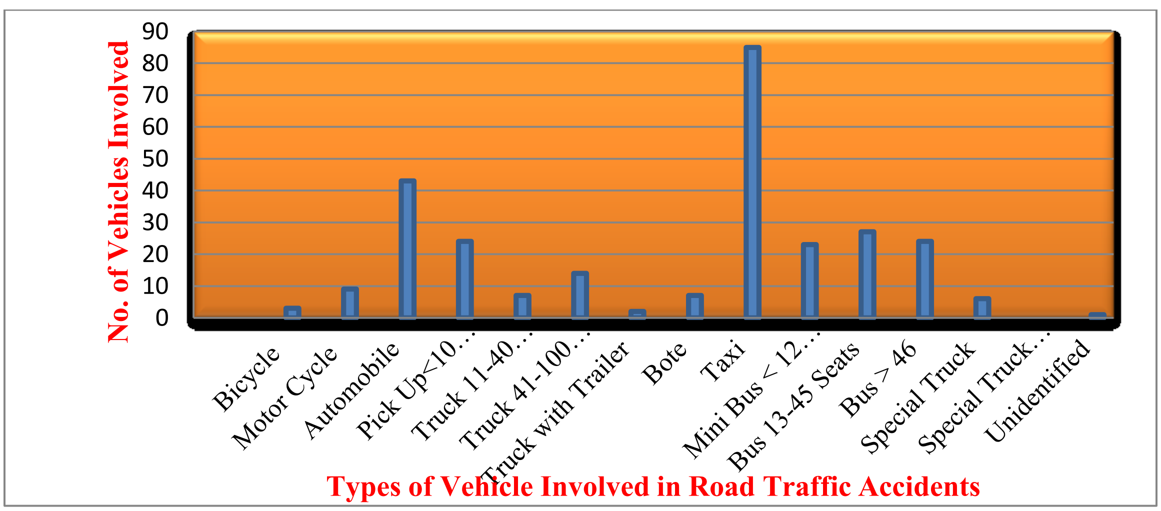



Figure 4.16 Type of vehicle involved in accidents of location 2.9km

Accident data collected in Autobus Tera (2.9Km) indicated that vehicles most frequently involved in accidents were Taxis (22.25%). And the second most frequently vehicles involved in accidents were the Auto Mobil (11.26%) as indicated in Appendix III, C-1c. This area is usually faced with extremely high congestion, lack of road user campaigns, mixed traffic system. As a result, different types of casualty will occur.

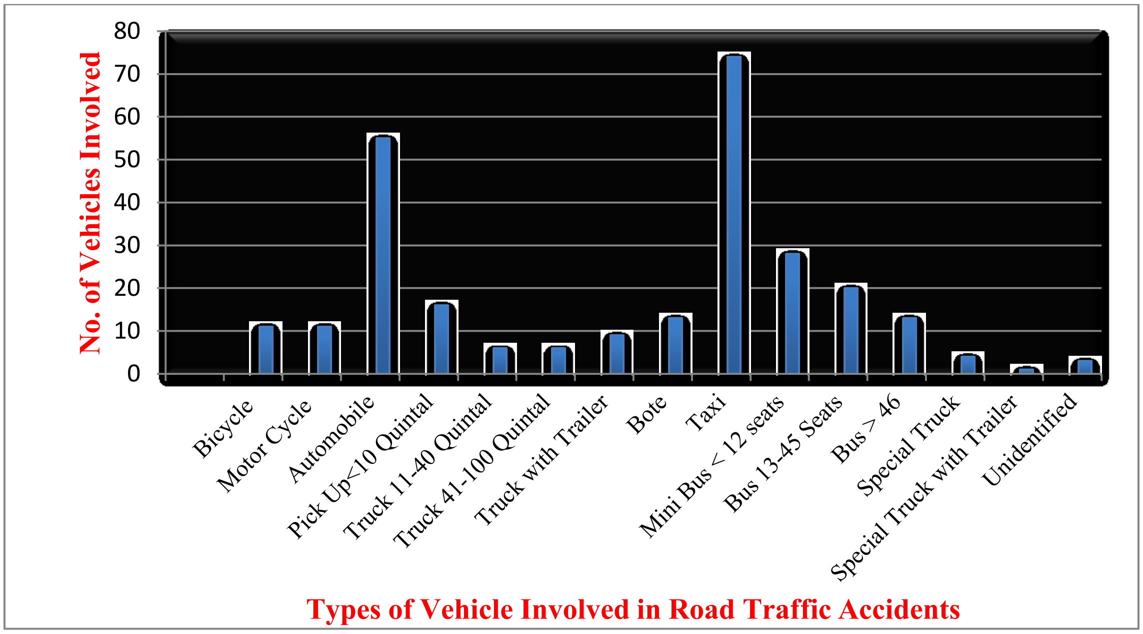



Figure 4.17 Type of vehicle involved in accidents of location 13.1km

Accident data collected in Megenagna (0.3Km) indicated that vehicles most frequently involved in accidents were Taxis (19.37%). And the second most frequently vehicles involved in accidents were the Auto Mobile (14.40%) as indicated in Appendix III, C-1d.

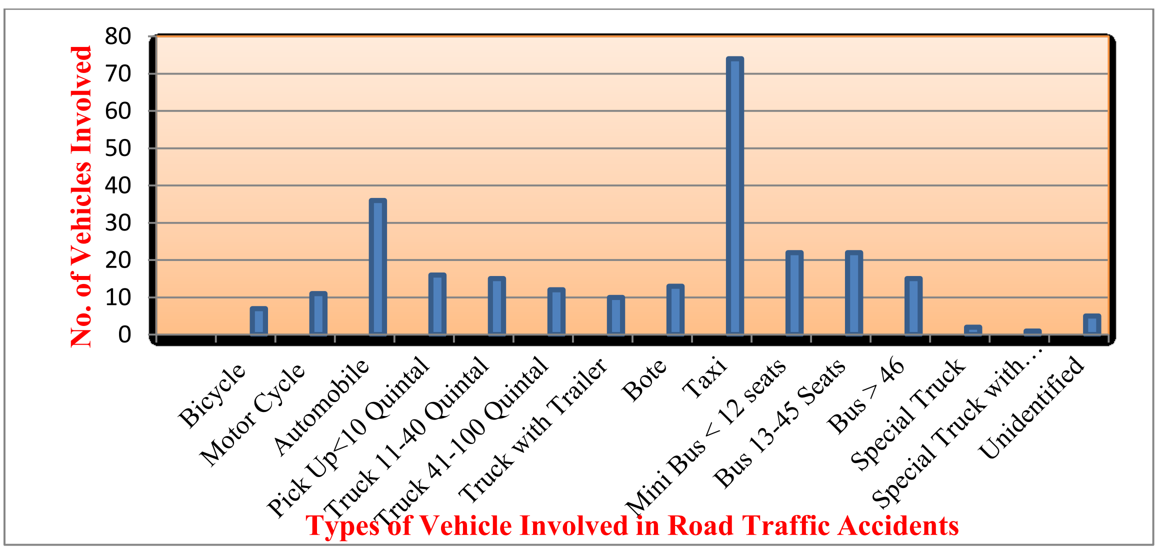



Figure 4.18 Type of vehicle involved in accidents of location 9.8km

Accident data collected in Kebena (9.8Km) indicated that vehicles most frequently involved in accidents were Taxis (19.37%). And the second most frequently vehicles involved in accidents were the Auto Mobiles (9.42%) as indicated in Appendix III, C-1e. This area usually faced with approximately high LOS. As a result, fatigues together with speed were the main causes for accidents in these types of vehicles.

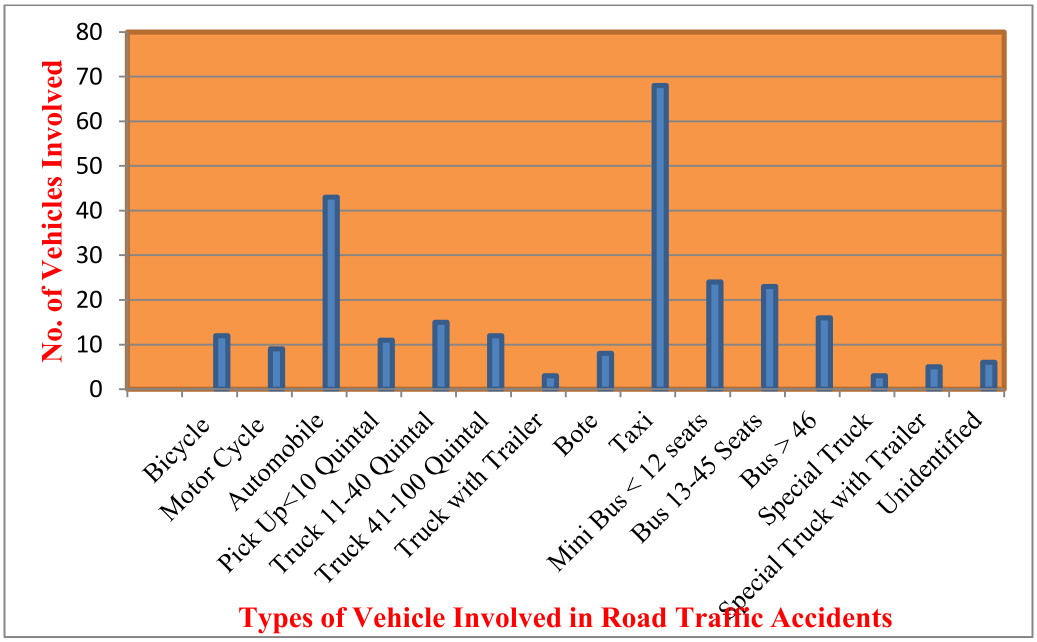



Figure 4.19 Type of vehicle involved in accidents of location 5.8km

Accident data collected in Piazza (5.8Km) indicated that vehicles most frequently involved in accidents were Taxis (17.80%). The reason was that taxis were the most available public transporting system throughout the study area. And the second most frequently vehicles involved in accidents were the Auto Mobiles (11.26%) as indicated in Appendix III, C-1f. This area usually faced with road side marketing, high populated and highly congested. Therefore, it is recommended that the implementation of continuous, sudden and special technical investigation on these vehicle types as well as training and education is required for the society.

### 4.5.3 Collision Variation by Time of a Day

According to Appendix II, Table B-1 indicates that road traffic accidents were concentrated between 2:00 in the morning, 6:00-7:00 and 10:00-12:00 hours local time in the afternoon.

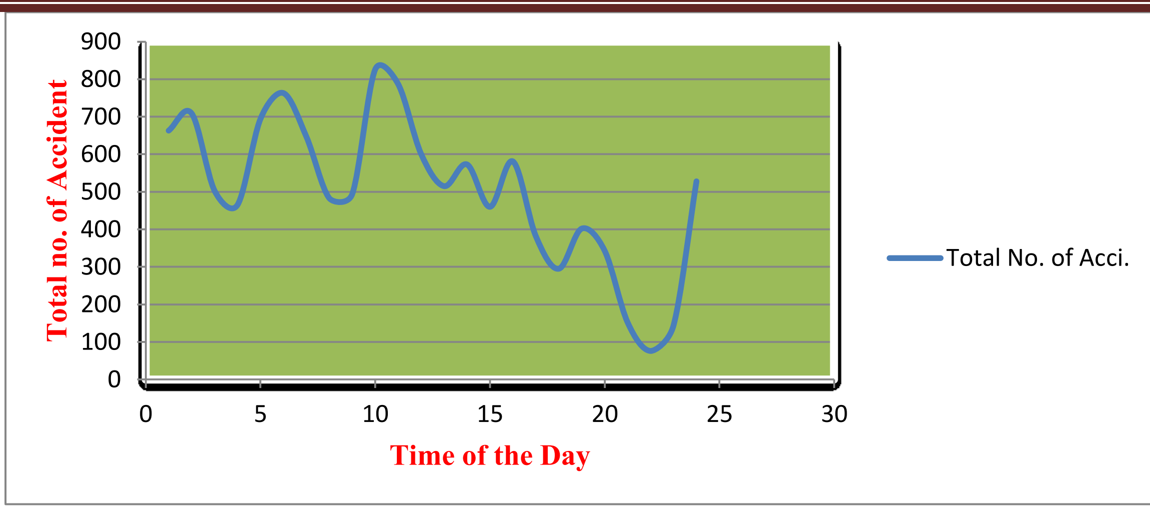



Figure 4.20 Cumulative Collision Variation by time of the day

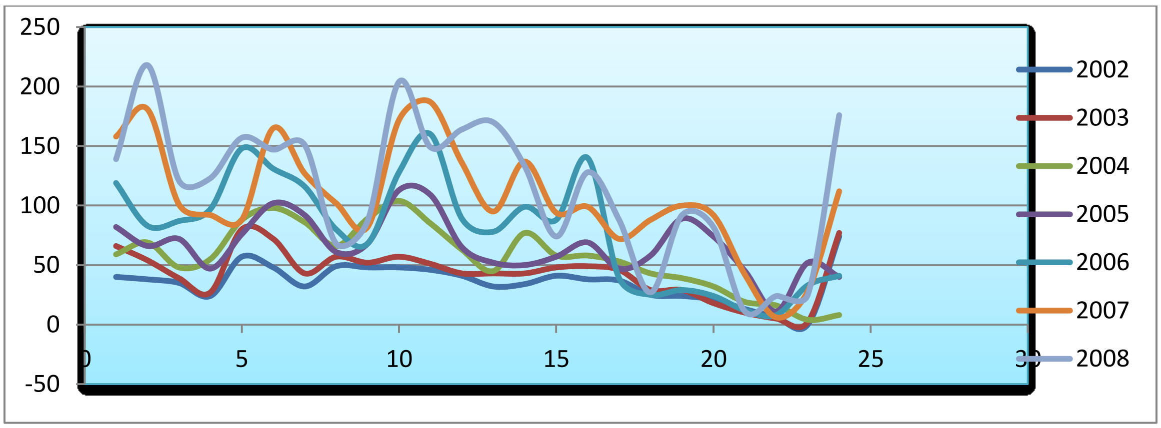



Figure 4.21 Collision Variation by local time of the day for each study year

(Source: -A.A Police Commission, Road Traffic Accident Statistics Office, 2001/02-2007/08)

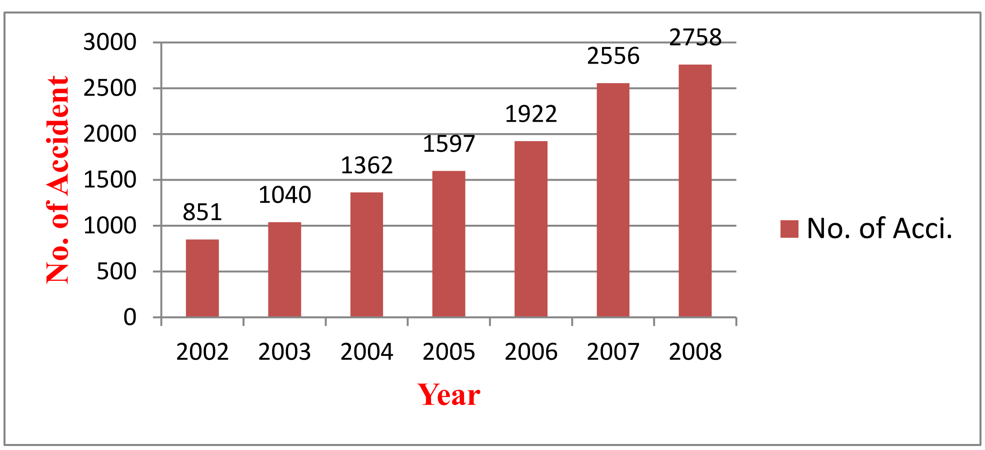



Figure 4.22 Yearly Variation of Accident for 2001/02 - 2007/2008E.C

### 4.5.5 Detail Analysis of Casualty by Types of Road Users

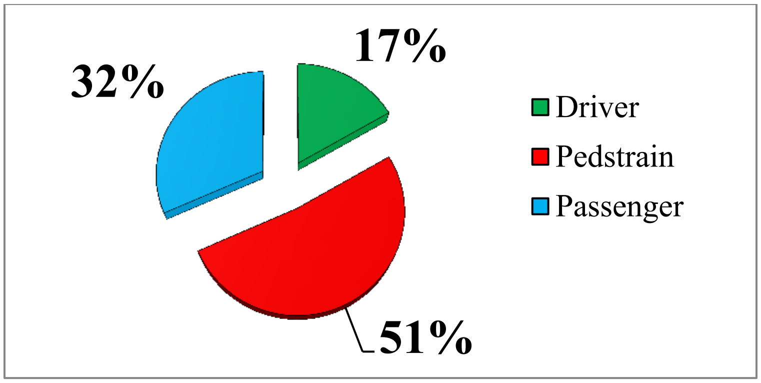



Figure 4.23 Causality by Types of Road Users For Asrasimint(0.3km)

In terms of collision types, the majority of accident severity resulted in pedestrian accidents. As shown in Fig.4.23, the highest percentage of (accident) was with Pedestrians that accounted for about 51% followed by Passengers with 32% and then by drivers with 17%. Detail analysis is calculated in Appendix III, Table C-2a.

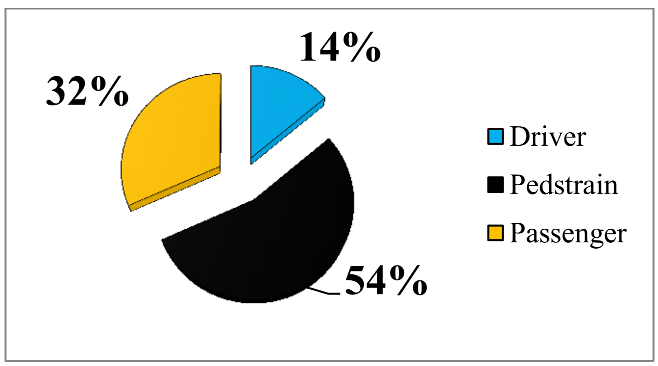



Figure 4.24 Causality by Types of Road Users for Arat Killo(7.3km)

As shown in Fig.4.24, the highest percentage of (accident) was with Pedestrians that accounted for about 54% followed by Passengers with 32% and then by drivers with 14%. Detail analysis was calculated in Appendix III, Table C-2b.

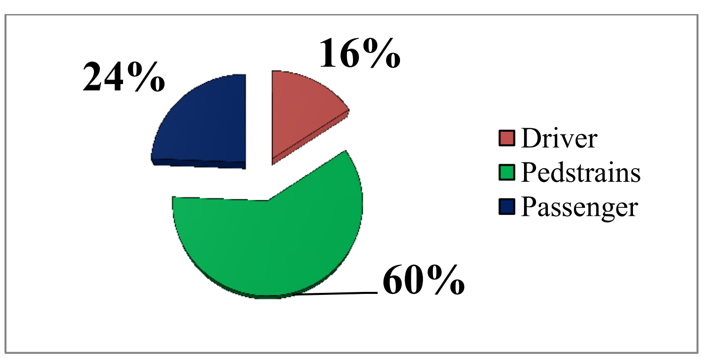



Figure 4.25 Causality by Types of Road Users for Autobus-Tera(2.9km)

As shown in Fig.4.25, the highest percentage of (accident) was with Pedestrians that accounted for about 60% followed by Passengers with 24% and then by drivers with 16%. Detail analysis was calculated in Appendix III, Table C-2c.

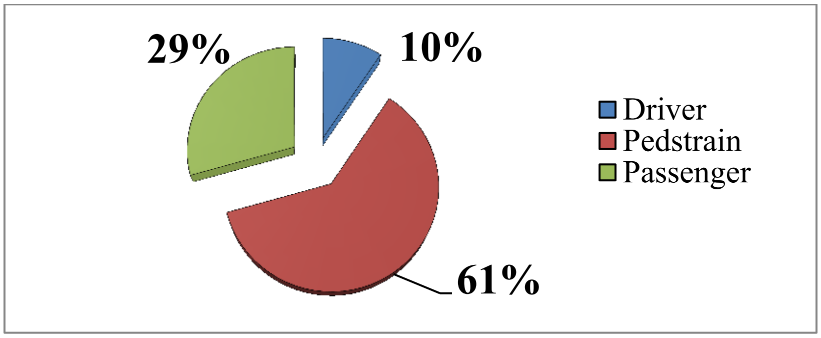



Figure 4.26 Causality by Types of Road Users for Megenagna (13.1km)

As shown in Fig.4.26, the highest percentage of (accident) was with Pedestrians that accounted for about 61% followed by Passengers with 29% and then by drivers with 10%. Detail analysis was calculated in Appendix III, Table C-2d.

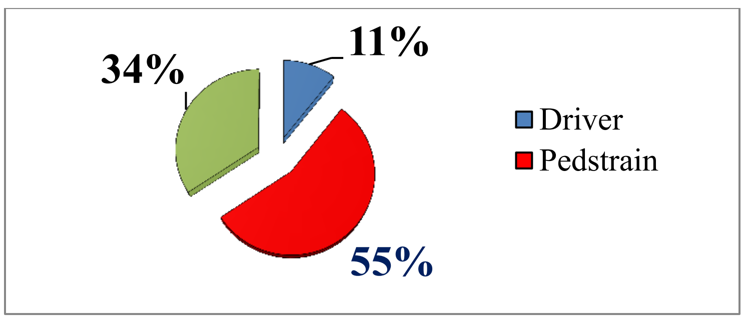



Figure 4.27 Causality by Types of Road Users for Kebena (9.8km)

As shown in Fig.4.27, the highest percentage of (accident) was with Pedestrians that accounted for about 55% followed by Passengers with 34% and then by drivers with 11%. Detail analysis was calculated in Appendix III, Table C-2e.

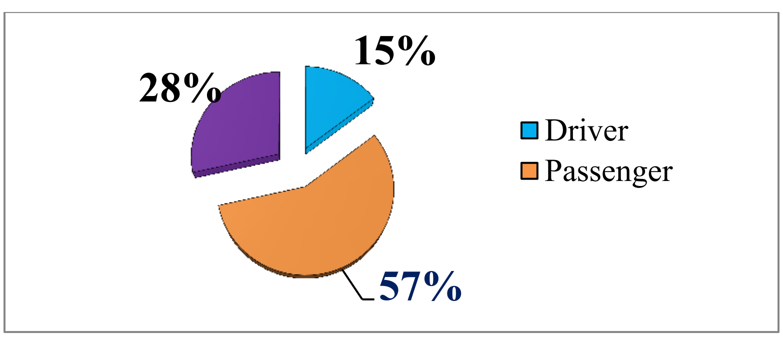



Figure 4.28 Causality by Type of Road User for Piazza (5.8km)

As shown in Fig.4.28, the highest percentage of (accident) was with Pedestrians that accounted for about 57% followed by Passengers with 28% and then by drivers with 15%. Detail analysis was calculated in Appendix III, Table C-2f.

## 4.6. Possible Reasons for High Number of Road Traffic Accidents

According to the report provided by the Traffic Police Commesion (2001/02-2007/08 EC.) the reasons for the relatively high number of road traffic accident include

i. Lack of driving skills;
ii. Poor knowledge of traffic rules and regulations;
iii. Violation of speed Limit;
iv. Insufficient enforcement;
v. Lack of vehicle maintenance;
vi. Lack of safety conscious design and planning of road network;
vii. Lack of general safety awareness by pedestrians;

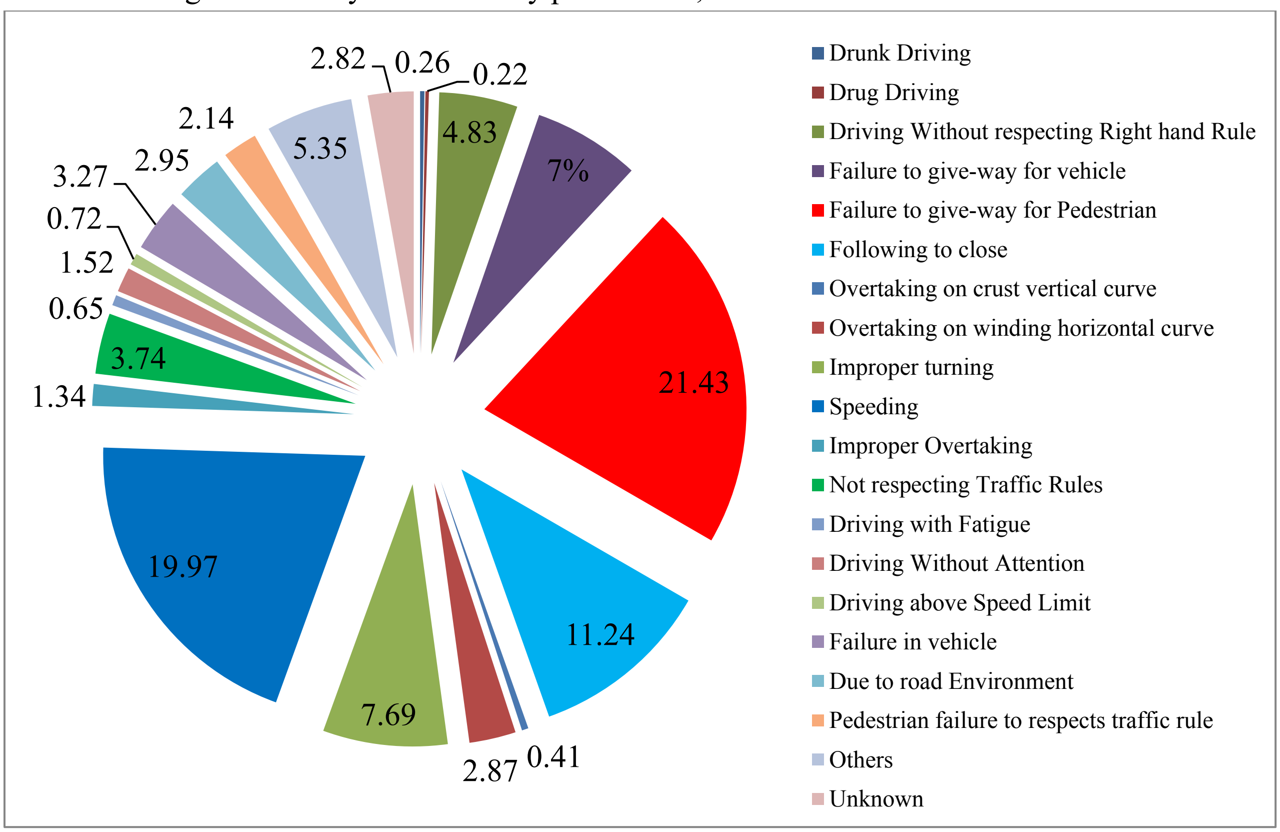



Figure 4.29 reasons for high number of road traffic accident throughout the study area

(Source: -A.A Police Commission, Road Traffic Accident Statistics Office, 2001/02-2007/08)

The apparent causes of accidents were identified by Traffic Police Officers. These causes were not accurate as identified on- the-spot of accident investigations. Usually, the report by the traffic police indicates a single cause of each accident but not multiple causes of the accident. However, the causes of road accidents are normally multi-factors always preceded by a situation in which one or more of road users have failed to cope with the road environment. As a result of lack of appropriate training of the Traffic Police Officers, it is difficult to know the real causes of road traffic accidents in the country.

As shown in Appendix I, Table A-3, the major causes of accidents in the study area were: failure to give-way for pedestrians(21.43%), speeding(19.97%), following too close(11.24%), improper turning(7.69%), failure to give way for vehicle(7%) and due to road environment(5.35%). These six causes contributed to 72.68 % of the total accidents in year from 2001/02 to 2007/08. The rest of the possible reasons accounted for less than 28 percent.

## 4.7. Proposal, Improvements and Remedial Measures

Following the analysis of road accidents registered in each HRL, corrective measures were proposed. Different causes of road accidents require different road safety measure types, including enforcement, education, encouragement and engineering measures.

The main objective in deciding on remedial measures is to consider solutions that ideally will remove the main accident patterns identified. Often the remedial measures relate in detail to the type and positioning of all the road furniture. Further measures that are relevant in this study area include

- Turn prohibition, channelization, or protected turns;
- Traffic signals, roundabouts, or revised intersection designs;
- Refuges, pedestrian crossings, bridges, or underpasses;
- Segregated bicycle tracks or defined bicycle lanes;
- Parking restrictions or controls;
- Speed limits or enforcement; and
- Traffic calming

### A. Asrasimint(Location 0.3km)

The study road incorporates for Asrasmint (0+300) and during the study years, 382 accidents were registered on this road section. The distributions of accident by severity level, 89 accidents were fatal, 145 were injuries and 148 were property damages. In terms of collision type, 51.71%

accidents involved on pedestrian, 31.62% were with passengers and 16.67% accidents were with derivers.

**Site inspection**

The upper approach from Aweliya and down approache to Ayer-Tena of the road had a great elevation difference i.e. there was a steep grade and due to this vehicles were operated at high speed and many drivers violated the speed limit finally controlling of vehicles were difficult during the inspection period. Therefore, improvement of pedestrian facilities and the following were proposed in order to alleviate the problem of the road section.

a) Totally replacement of the Roundabout section of the road with effective and adequate Overpassing section is indicated as the best solution.
b) A speed limit sign (30 km/hr.) should be placed where tangent section begins, before 100-150 meters.
c) Road side parking should be prohibited and provide off-road packing for heavy trucks.
d) Zebra crossings for pedestrian should be marked in 50-70 meters interval.
e) Strict traffic police enforcements should be required during day time because more recorded accidents occurred during this period. Special attention should be given on the off-peak hours in controlling traffic.
f) For problem of lane discipline, improper overtaking and the like, re-painting of the road should be given much attention.

**Before Improvement**

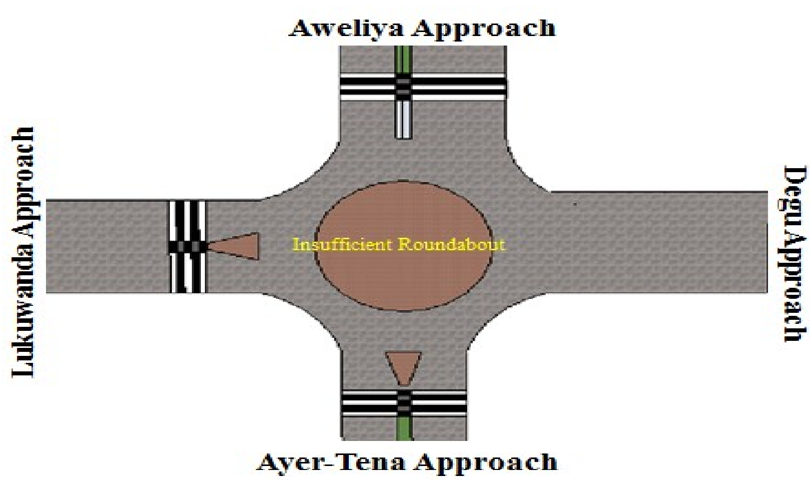



Figure 4.30 Sketch of Asrasimint(0.3km) intersection before improvement

**Recommended Improvement**


Figure 4.31 Sketch of Asrasimint road section after recommended improvement using Software (Google SketchUp Pro 8.)

### B. Autobus-Tera (Location 2.9km)

This section had 275 accidents during the seven years' service time, out of which 52 fatal, 63 injury and the rests are property damaged. About 37% of the accidents were nose-tail type of collision. As depicted on Table 5.8, two vehicles accident had higher percentages (33.52%).

Table 4.10 Vehicles Involved in Traffic Accident (Location 2.9Km)

| **Veh.Types** | **Types of Veh. Involved** | **%** |
|---|---|---|
| Bicycle | 3 | 0.79 |
| Motor Cycle | 9 | 2.36 |
| Automobile | 43 | 11.26 |
| Pick Up<10 Quintal | 24 | 6.28 |
| Truck 11-40 Quintal | 7 | 1.83 |
| Truck 41-100 Quintal | 14 | 3.66 |
| Truck with Trailer | 2 | 0.52 |
| Bote | 7 | 1.83 |
| Taxi | 85 | 22.25 |
| Mini Bus < 12 seats | 23 | 6.02 |

| Veh.Types | Types of Veh. Involved | % |
|---|---|---|
| Bus 13-45 Seats | 27 | 7.07 |
| Bus > 46 | 24 | 6.28 |
| Special Truck | 6 | 1.57 |
| Special Truck with Trailer | 0 | 0.00 |
| Unidentified | 1 | 0.26 |
| Total | 275 | |

The junction has more than fifteen conflict points. The nose- tail collision type was seen as predominant on the collision diagram. Likewise, side and side angle accidents occurred due to conflict points that exist at the priority junction.

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

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

a) Priority junction should be replaced by roundabout. Roundabout has best records in accident reduction by reducing the conflict points as shown in Figure 5.43.
b) The roundabout should be furnished reflective chevron on island with an adquate dimension.
c) Prohibition of parking signs should be placed before 50 meters of each leg and provided off road parking facilities.
d) A speed limit sign should be placed where the junction begins and ends.
e) Zebra crossings for pedestrian should be provided in every 50 meters.
f) Provide pedestrians over-passing structures.

**Before Improvement**

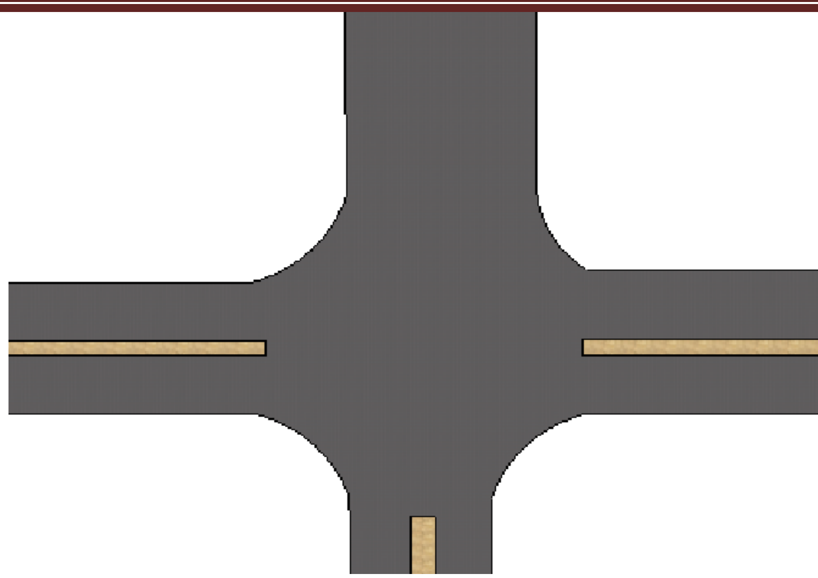


Figure 4.32 Sketch of Autobus -Tera priority junctions before improvement.

**Recommended Improvement**

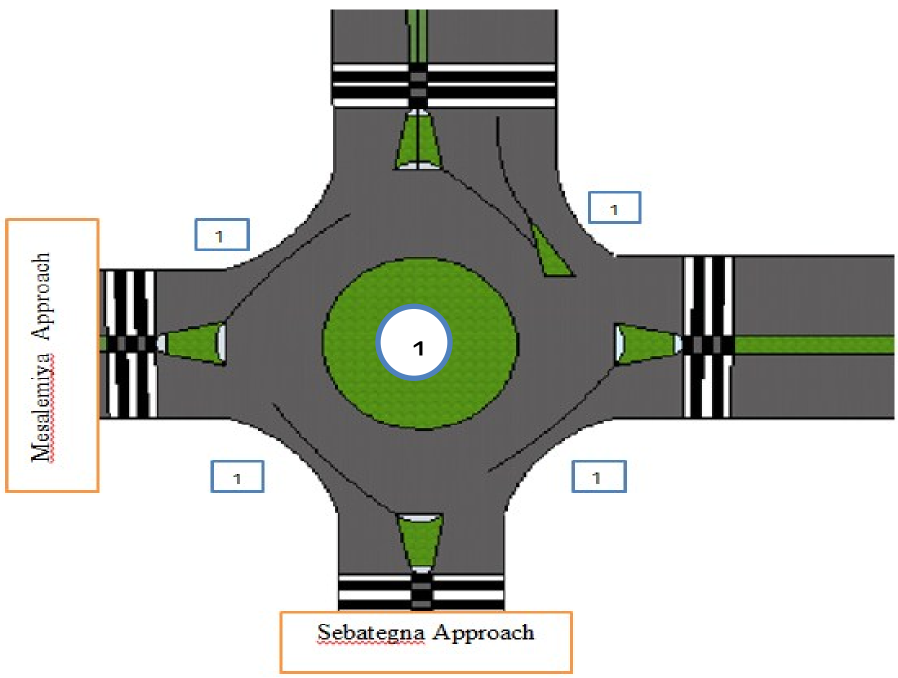



Figure 4.33 Sketch of Autbus -Tera junctions after recommended improvement.

Numbers shown on the sketch indicate that the proposed traffic signs will be furnished during counter measure.

## Summary

It was summarize that in this research, adequate accident data with a wide range of road geometric design element and traffic data were collected to achieve the stated objectives. The field work was time consuming. Since Traffic Police Officers had many tasks and were usually out of their offices, it was difficult to get them.

In general, the situation of roads traffic accident due to HRL at the national level is getting worse every day. The figures and facts presented in the previous Chapters states this clearly. Even though the country has gravely small vehicle ownership about 2.2 vehicles per 10,000 people, the accident record is one of the highest in the world with about 110 fatalities and 310 injuries per 10,000 vehicles in 2004/05. In this study area, in the last Seven years, traffic accident fatalities and injuries have been increased by about 15.78% and 10 percent respectively.

The accidents database of the Addis Ababa (Lukuanda–AutobusTera–Piazza–Megenagna) Road that was established for this study contains all accidents reported by traffic police at the study sites along the 13.2 kilo meters during the study period of December 2015 to Sep 2016. A seven year (2001/2-2007/8 EC.) accident data with a total number of 12086 accidents were reported. Out of which 2662 Fatal, 4238 Injury and the rest 5186 were property damages. Of the injury accidents, 1721 and 2517 were serious and slight injuries respectively.

Accident data collected in this study area (throughout 13.2Km) indicated that vehicles most frequently involved in accidents were Taxis (28%). And the second most frequently vehicles involved in accidents were the Automobiles with (16%). Night time accidents are few due to low traffic volume. The off-peak period for Crashes comes out to be between 10:00 pm – 12:00 pm hrs.

Accident data collected in Asrasimnt (0.3Km) indicated that vehicles most frequently involved in accidents were Taxis (24.61%). And the second most frequently vehicles involved in accidents were the Trucks with 41- 100 quintals (13.09%). This area is usually faced with extremely high congestion.

Finally, the study road incorporates for Asrasmint (0.3km road section) that requires improvement of pedestrian facilities, totally replacement of the Roundabout section of the road with effective and adequate Overpassing section is indicated as the best solution in order to alleviate the problem of the road section.

As mentioned earlier, for Autobus-Tera (2.9km road section) an accident prone spot was four legs priority junction. Therefore, to improve the situation at the priority junction, Priority junction should be replaced by roundabout. Roundabout has best records in accident reduction by reducing the conflict points.

From the study it is summaries that the highest percentage of accident was with pedestrians that accounted for about 56% followed by passengers and drivers with 30% and 14% respectively. Collisions due to roadway alignment indicate that, 80% of the collisions occurred on level and tangent sections and similarly, only 5 percent occurred on horizontal curves or grades. Collisions due to roadway junction depicted that the greatest number of accident with the rate of 48% was recorded at the Islands and Roundabout parts of the road junction. And also road with two-direction contribute about 28% of traffic accidents.

Based on the technical weight of priority, it is also summarized that road locations are laid under high, medium and low hazard prone level with 7%, 47% and 46% respectively. This 7% high level of accident prone level represents eight hazardous locations with km value 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.3 and 11.3. By cross checking the results, from here two locations can be treated as most hazardous. First one is, 0.3 km from Lukuwanda(0.00km) where total weight of priority 44.44 and 382 crashes occurred during the year 2001/2 to 2007/8 when number of fatal accidents are 89. And the second one is 11.3 km from Lukuwanda(0.00km) where total weight of priority 44.44 and 226 crashes occurred and among them 73 are fatal.

Based on total number of accident it is summarize that ten locations are identified as hazardous whose distance from Lukuwanda is 0.3km, 7.3km, 2.9km, 13.1km, 9.8km, 5.8km, 11.3km, 8.7km, 4.3km and 10.3km respectively. The 1729 road accidents caused 12086 casualties (most of which were fatal and injuries) of which for the first six highest HRL(Table 5.9) 13.59% were drivers, 30.44% passengers and 55.98% pedestrians. Therefore, these hazardous locations are also selected for detail analysis. Methods based on GIS analysis, among 109 segments, the first six most vulnerable segments with their station number 0+300, 2+900, 5+800, 9+800, 13+100 and 7+300 have been identified as most hazardous on the basis of their highest number of accidents occurred during the study period.

The major causes of accidents in the study area were: failure to give-way for pedestrians (21.43%), speeding(19.97%), following too close(11.24%), improper turning(7.69%), failure to give way for vehicle(7%) and due to road environment(5.35%). These six causes contributed to 72.68 % of the total accidents in year from 2001/02 to 2007/08. The rest of the possible reasons accounted for less than 28 percent. Particularly, Asrasimint (Location 0.3Km) has reported with maximum number of accidents i.e. total of 382 accidents including 293 injuries. So it was clear from the records that Asrasimint (Location 0.3Km) is the most hazard prone location in this study area and the GIS approach also verifies this is true.

Finally, Road safety has been an increasing concern to community in recent years in Ethiopia. This paper has discussed about the analysis and identification of hazardous roads location using priority, density function and implementation of GIS based on crashes analysis to make an effective way of analysis and represent the accident with the exact location and verification of the method for a major roads of Ethiopia. Based on the period of 2001/02 –2007/08, traffic accident data, six specific sections of this national highway worthy of being treated and identified as the most hazardous. In recent years, Lukuwanda-Autobus Tera-Piazza- Megenagna road have become very busy roads as it passes through the center of the city. On the basis of the results and findings, the necessary remedial measures should be provided to make the operation of this most important and widely used national road Lukuwanda-Megenagna Road safe and efficient.

# CHAPTER FIVE

## 5. CONCLUSIONS AND RECOMMENDATIONS

### 5.1 Conclusions

In literature there is no universally accepted definition of a hazardous location. Locations are generally classified as hazardous after an assessment of the level of risk and the likelihood of a crash occurring at a location. Hazardous location 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. Accordingly, this work may be divided into traffic control devices, road and street design, and traffic calming on lower-speed road ways.

Besides the analysis of the total number of reported accidents at a site, several methods have been investigated including the severity of the accident and the accident contributory factors present in the accident. Risk factors, such as course of the accident, traffic, environmental, human and vehicle conditions have elaborately been adopted in the literature for explaining accident involvement and accident severity and the accident category to profile these high frequency accident locations. In general, risk factors related to traffic and road section characteristics were found to be essential in analyzing accident injury severity. Risk factors such as accident dynamics/speed, failure to give-way for pedestrian, failure to give-way for vehicle, following to close, vehicle type, time variation and road user type were found to be most important in explaining accident severity.

Recently, identification of hazard zones has been considered in the literature, as arising from the awareness of the evident spatial interaction existing between contiguous accident locations. The use of Geographical Information Systems (GIS), density function and technical priority has proven to be very useful when identifying such zones. And also some attempt was made to find out which factors explain the occurrence of accidents, or which countermeasures should be taken to reduce their number. But different research focuses merely on an exploratory spatial data analysis problem: defining the location and the length of hazard zones.

In conclusion, analysis of the accident figures show that hazardous road safety work has to be taken in order to reduce the number of casualty crashes. However, as road and traffic authorities will tend to treat the worst sites first, the benefits from treating remaining sites reduce progressively. This means that ongoing evaluation is necessary to help governments determine, if the benefits from further treatment of hazardous road locations justify the treatment costs.

## 5.2 Recommendations

Based on deep understanding of the main causes of hazardous road that lead to traffic accidents, low cost engineering measures are recommended. In general, the followings are recommended for Addis Ababa Traffic Police Commission (AATPC) to implement.

- Strict traffic police enforcement and speed control
- Road user information and campaign
- Prohibition of on road side parking

Generally, appropriate signs, road markings, fencing, guardrails, junction modifications, and improvements to visibility should be considered as remedial measure. Dangerous and inappropriate operation of heavy vehicles (buses and trucks) such as reckless overtaking, overloading and braking/stopping on roads and road sides are particularly a serious problem in all those segments. So, adequate enforcement should also be considered.

These are also some of recommended potential measures for Addis Ababa City Road Authority (AACRA) as follows:

- Effective and user friendly pedestrian facility such as briar, overpass, underpass, zebra crossing, pedestrian signal etc. should be established in those sections on the basis of its function. Also focus on speed reduction near bus stoppages also near schools, bazaar and residential should be considered.
- Furnish appropriate sign and marking,
- Rumble stripes should be placed on changing traffic and road environment
- Access density and access permit regulation should be given a focus by the Road Authority.
- Particularly, for Asrasmint(0.3km) priority roundabout, placement of effective overpassing was recommended with appropriate road signs and markings.

In case of Asrasimint to Mesalemiya road junctions, channelization of road either using road marking or construction of island and placement of road sign will solve problems on the spot.

The specific locations of many road traffic accidents incidences have not been described in the daily road traffic accident recording format of Addis Ababa City traffic office. It is therefore suggested that trainings should be provided to traffic officers on how to use GPS to specify where the accident has occurred and the data can easily be used to map and take countermeasures in the road traffic accident risk areas. For this fact, the daily road traffic accident recording format should be redesigned in a way that the Easting, Northings and elevation of the accident spot can be recorded.

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# APPENDIX I; - National Accident Statistics

Table A-1:- Addis Ababa City Accident Statistics based on days of the week for year 2001/02-2007/08

Addis Ababa City Accident Statistics Based on Days of the Week for Year 2001/02-2007/08

| Years<br>No. | Days | | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| 1 | Monday | 117 | 1427 | 1836 | 2369 | 2692 | 3245 | 3627 |
| 2 | Tusday | 898 | 1451 | 1702 | 2068 | 2537 | 2657 | 3228 |
| 3 | Wednesday | 863 | 1406 | 1747 | 2338 | 2656 | 2967 | 3305 |
| 4 | Thursday | 952 | 1432 | 1740 | 2449 | 2582 | 2861 | 3350 |
| 5 | Friday | 928 | 1497 | 1598 | 2261 | 2582 | 3185 | 3525 |
| 6 | Saturday | 957 | 888 | 1614 | 2551 | 2980 | 3178 | 3215 |
| 7 | Sunday | 670 | 1033 | 1292 | 1779 | 1875 | 2339 | 3004 |
| **Total** | | 6285 | 9134 | 11529 | 15815 | 17904 | 20432 | 23254 |

Table A-2:- Addis Ababa City Accident Statistics based on times of the days for year 2001/02-2007/08

Addis Ababa City Accident Statistics based on times of the days for year 2001/02-2007/08

| No. | | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| 1 | 01:00-02:00 AM | 104 | 120 | 2020 | 225 | 181 | 319 | 742 |
| 2 | 02:00-03:00 AM | 112 | 174 | 241 | 206 | 197 | 342 | 627 |
| 3 | 03:00-04:00 AM | 89 | 161 | 226 | 167 | 204 | 321 | 302 |
| 4 | 04:00-05:00 AM | 84 | 159 | 247 | 204 | 213 | 293 | 398 |
| 5 | 05:00-06:00 AM | 127 | 167 | 279 | 294 | 269 | 419 | 315 |
| 6 | 06:00-07:00 AM | 198 | 268 | 408 | 501 | 568 | 720 | 964 |
| 7 | 07:00-08:00 AM | 368 | 489 | 655 | 880 | 1026 | 1181 | 1245 |
| 8 | 08:00-09:00 AM | 371 | 528 | 466 | 977 | 1221 | 1236 | 1009 |
| 9 | 09:00-10:00 AM | 386 | 534 | 704 | 949 | 1178 | 1362 | 1637 |
| 10 | 10:00-11:00 AM | 389 | 608 | 741 | 1081 | 1267 | 1334 | 1420 |
| 11 | 11:00-12:00 AM | 400 | 336 | 717 | 1067 | 1229 | 1439 | 1358 |
| 12 | 12:00-13:00 PM | 337 | 538 | 633 | 947 | 1051 | 1136 | 1270 |
| 13 | 13:00-14:00 PM | 343 | 430 | 600 | 848 | 1028 | 1183 | 1561 |
| 14 | 14:00-15:00 PM | 371 | 541 | 626 | 979 | 1175 | 1222 | 1139 |
| 15 | 15:00-16:00 PM | 366 | 553 | 708 | 949 | 1177 | 1309 | 1286 |
| 16 | 16:00-17:00 PM | 397 | 552 | 729 | 976 | 1055 | 1171 | 1355 |
| 17 | 17:00-18:00 PM | 361 | 529 | 661 | 918 | 1019 | 1071 | 1227 |
| 18 | 18:00-19:00 PM | 271 | 464 | 591 | 775 | 886 | 1028 | 1357 |
| 19 | 19:00-20:00 PM | 374 | 465 | 525 | 702 | 858 | 1008 | 1123 |
| 20 | 20:00-21:00 PM | 265 | 395 | 476 | 588 | 681 | 682 | 912 |
| 21 | 21:00-22:00 PM | 181 | 337 | 403 | 515 | 577 | 488 | 801 |
| 22 | 22:00-23:00 PM | 167 | 532 | 199 | 460 | 420 | 471 | 625 |
| 23 | 23:00-24:00 PM | 126 | 167 | 260 | 345 | 300 | 396 | 223 |
| 24 | 24:00 -01:00 AM | 98 | 112 | 214 | 262 | 184 | 301 | 358 |
| | **Total** | **6285** | **9134** | **11529** | **15815** | **17904** | **20432** | **23254** |

Table A-3:- Reasons for high number of road traffic accident throughout the study area (2001/02-2007/08)

| | | **Degree of Severity** | | | | | |
|---|---|---|---|---|---|---|---|
| **No.** | **Description** | **Fatal** | **Serious** | **Slight** | **Property** | **Total** | **Percentage** |
| | | | **Injury** | **Injury** | **Damage** | | |
| 1 | Drunk Driving | 23 | 4 | 0 | 5 | 32 | **0.26** |
| 2 | Drug Driving | 18 | 3 | 2 | 3 | 26 | **0.22** |
| 3 | Driving Without respecting Right hand Rule | 112 | 69 | 91 | 312 | 584 | **4.83** |
| 4 | Failure to give-way for vehicle | 56 | 153 | 107 | 481 | 797 | **6.59** |
| **5** | **Failure to give-way for Pedestrian** | **514** | **587** | **1405** | **84** | **2590** | **21.43** |
| **6** | **Following to close** | **61** | **98** | **51** | **1148** | **1358** | **11.24** |
| 7 | Overtaking on crust vertical curve | 22 | 1 | 0 | 26 | 49 | **0.41** |
| 8 | Overtaking on winding | 9 | 17 | 4 | 317 | 347 | **2.87** |
| 9 | Improper turning | 98 | 101 | 17 | 713 | 929 | **7.69** |
| **10** | **Speeding** | **715** | **310** | **205** | **1183** | **2413** | **19.97** |
| 11 | Improper Overtaking | 106 | 12 | 33 | 11 | 162 | **1.34** |
| 13 | Not respecting Traffic Rules | 140 | 31 | 64 | 217 | 452 | 3.74 |
| 19 | Driving with Fatigue | 20 | 2 | 0 | 56 | 78 | **0.65** |
| 20 | Driving Without Attention | 31 | 29 | 3 | 121 | 184 | **1.52** |
| 21 | Driving above Speed Limit | 37 | 26 | 13 | 11 | 87 | **0.72** |
| 22 | Failure in vehicle | 118 | 9 | 135 | 133 | 395 | **3.27** |
| 27 | Due to road Environment | 149 | 64 | 129 | 14 | 356 | **2.95** |
| 28 | Pedestrian failure to respects traffic rule | 87 | 53 | 78 | 41 | 259 | 2.14 |
| 29 | Others | 217 | 127 | 91 | 212 | 647 | **5.35** |
| 30 | Unknown | 129 | 25 | 89 | 98 | 341 | **2.82** |
| **Total** | | **2662** | **1721** | **2517** | **5186** | 12086 | **100.00** |

## APPENDIX II; - Data Collected for the Study Area

Table B-1:- Accident Data collected for the Study Area Based on Times of the Day for Year 2001/02-2007/08

| TRAFFIC ACCIDENT DATA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time of a day | YEAR | | | | | | | Total | Average Traffic Accident |
| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | |
| 01:00-02:00 AM | 40 | 66 | 59 | 82 | 119 | 158 | 139 | 663 | 94.71 |
| 02:00-03:00 AM | 38 | 54 | 69 | 66 | 83 | 181 | 218 | 709 | 101.29 |
| 03:00-04:00 AM | 35 | 39 | 48 | 72 | 87 | 101 | 121 | 503 | 71.86 |
| 04:00-05:00 AM | 24 | 27 | 55 | 47 | 97 | 92 | 123 | 465 | 66.43 |
| 05:00-06:00 AM | 57 | 80 | 88 | 76 | 148 | 88 | 157 | 694 | 99.14 |
| 06:00-07:00 AM | 48 | 72 | 98 | 102 | 131 | 165 | 147 | 763 | 109.00 |
| 07:00-08:00 AM | 32 | 43 | 86 | 92 | 116 | 127 | 151 | 647 | 92.43 |
| 08:00-09:00 AM | 49 | 57 | 66 | 61 | 80 | 102 | 68 | 483 | 69.00 |
| 09:00-10:00 AM | 48 | 52 | 89 | 68 | 68 | 82 | 87 | 494 | 70.57 |
| 10:00-11:00 AM | 48 | 57 | 104 | 113 | 128 | 172 | 204 | 826 | 118.00 |
| 11:00-12:00 AM | 46 | 51 | 85 | 109 | 160 | 187 | 149 | 787 | 112.43 |
| 12:00-13:00 PM | 41 | 43 | 63 | 65 | 89 | 136 | 164 | 601 | 85.86 |
| 13:00-14:00 PM | 32 | 43 | 45 | 52 | 78 | 95 | 170 | 515 | 73.57 |
| 14:00-15:00 PM | 34 | 43 | 77 | 50 | 99 | 137 | 133 | 573 | 81.86 |
| 15:00-16:00 PM | 41 | 48 | 58 | 57 | 88 | 94 | 74 | 460 | 65.71 |
| 16:00-17:00 PM | 38 | 49 | 58 | 69 | 140 | 99 | 128 | 581 | 83.00 |
| 17:00-18:00 PM | 37 | 46 | 53 | 47 | 39 | 72 | 88 | 382 | 54.57 |
| 18:00-19:00 PM | 25 | 29 | 43 | 58 | 25 | 88 | 27 | 295 | 42.14 |
| 19:00-20:00 PM | 24 | 29 | 39 | 89 | 29 | 100 | 92 | 402 | 57.43 |
| 20:00-21:00 PM | 21 | 18 | 32 | 74 | 24 | 92 | 82 | 343 | 49.00 |
| 21:00-22:00 PM | 13 | 10 | 19 | 45 | 12 | 42 | 11 | 152 | 21.71 |
| 22:00-23:00 PM | 6 | 5 | 16 | 11 | 8 | 6 | 24 | 76 | 10.86 |
| 23:00-24:00 PM | 0 | 2 | 4 | 52 | 33 | 28 | 25 | 144 | 20.57 |
| 24:00 -01:00 AM | 74 | 77 | 8 | 40 | 41 | 112 | 176 | 528 | 75.43 |
| **Total** | **851** | **1040** | **1362** | **1597** | **1922** | **2556** | **2758** | **12086** | **1726.57** |

Table B-2:-Accident Data Collected for the East Direction of Lukuwanda – Megenagna road for Year 2001/02-2007/08

| Km | Fat02_08 | NonFat02_08 | | | | Tot02_08 |
|---|---|---|---|---|---|---|
| | | Ser.Inj | Slit.Inj | PDO | Sub Total | |
| 0.5 | 0 | 2 | 0 | 5 | 7 | 7 |
| 1 | 7 | 0 | 0 | 4 | 4 | 11 |
| 2.6 | 0 | 3 | 5 | 7 | 15 | 15 |
| 3 | 0 | 0 | 4 | 12 | 16 | 16 |
| 3.9 | 0 | 0 | 3 | 14 | 17 | 17 |
| 0.9 | 0 | 3 | 6 | 11 | 20 | 20 |
| 10.6 | 0 | 0 | 9 | 14 | 23 | 23 |
| 7.2 | 1 | 6 | 8 | 11 | 25 | 26 |
| 8.8 | 5 | 1 | 5 | 16 | 22 | 27 |
| 8.2 | 3 | 9 | 2 | 18 | 29 | 32 |
| 11.1 | 5 | 0 | 9 | 20 | 29 | 34 |
| 11.7 | 0 | 0 | 25 | 10 | 35 | 35 |
| 1.7 | 14 | 1 | 0 | 21 | 22 | 36 |
| 3.5 | 16 | 0 | 7 | 13 | 20 | 36 |
| 8.3 | 11 | 8 | 3 | 14 | 25 | 36 |
| 12.5 | 8 | 2 | 12 | 25 | 39 | 47 |
| 2.2 | 6 | 10 | 13 | 19 | 42 | 48 |
| 8.6 | 14 | 3 | 2 | 29 | 34 | 48 |
| 5.9 | 14 | 7 | 9 | 18 | 34 | 48 |
| 6.1 | 2 | 9 | 14 | 23 | 46 | 48 |
| 13 | 4 | 9 | 12 | 24 | 45 | 49 |
| 10.8 | 11 | 5 | 8 | 26 | 39 | 50 |
| 8.4 | 18 | 0 | 10 | 24 | 34 | 52 |
| 11.8 | 11 | 4 | 10 | 27 | 41 | 52 |
| 10.7 | 7 | 9 | 11 | 27 | 47 | 54 |
| 8 | 14 | 4 | 9 | 27 | 40 | 54 |
| 11.6 | 0 | 8 | 14 | 33 | 55 | 55 |
| 11 | 10 | 21 | 15 | 10 | 46 | 56 |
| 12.6 | 10 | 2 | 13 | 31 | 46 | 56 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.6 | 15 | 4 | 11 | 27 | 42 | 57 |
| 10.1 | 12 | 6 | 17 | 23 | 46 | 58 |
| 12.8 | 12 | 8 | 14 | 24 | 46 | 58 |
| 0.2 | 18 | 5 | 12 | 24 | 41 | 59 |
| 7.6 | 25 | 0 | 5 | 29 | 34 | 59 |
| 7.4 | 8 | 3 | 18 | 31 | 52 | 60 |
| 7.8 | 19 | 8 | 2 | 31 | 41 | 60 |
| 9.5 | 16 | 4 | 12 | 29 | 45 | 61 |
| 7 | 14 | 10 | 3 | 35 | 48 | 62 |
| 10.5 | 12 | 4 | 15 | 31 | 50 | 62 |
| 2.4 | 12 | 1 | 20 | 31 | 52 | 64 |
| 1.3 | 5 | 21 | 9 | 29 | 59 | 64 |
| 8.1 | 20 | 0 | 4 | 41 | 45 | 65 |
| 12.1 | 13 | 19 | 6 | 28 | 53 | 66 |
| 5.3 | 22 | 5 | 8 | 32 | 45 | 67 |
| 10.9 | 17 | 12 | 9 | 29 | 50 | 67 |
| 8.9 | 16 | 5 | 14 | 33 | 52 | 68 |
| 10.2 | 0 | 14 | 21 | 33 | 68 | 68 |
| 10 | 15 | 12 | 5 | 38 | 55 | 70 |
| 11.5 | 9 | 6 | 22 | 35 | 63 | 72 |
| 5.4 | 11 | 17 | 6 | 39 | 62 | 73 |
| 9 | 25 | 10 | 5 | 33 | 48 | 73 |
| 12.7 | 17 | 15 | 6 | 35 | 56 | 73 |
| 9.4 | 10 | 12 | 15 | 37 | 64 | 74 |
| 12.3 | 12 | 3 | 14 | 47 | 64 | 76 |
| 5.7 | 15 | 12 | 19 | 31 | 62 | 77 |
| 1.6 | 8 | 12 | 25 | 33 | 70 | 78 |
| 6.6 | 27 | 12 | 1 | 38 | 51 | 78 |
| 11.2 | 22 | 7 | 11 | 38 | 56 | 78 |
| 9.2 | 12 | 6 | 19 | 43 | 68 | 80 |
| 9.3 | 31 | 5 | 7 | 42 | 54 | 85 |
| 4.3 | 14 | 13 | 24 | 37 | 74 | 88 |
| 11.4 | 22 | 18 | 12 | 36 | 66 | 88 |
| 13.2 | 18 | 9 | 27 | 34 | 70 | 88 |
| 12.2 | 24 | 16 | 21 | 28 | 65 | 89 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | 24 | 14 | 13 | 43 | 70 | 94 |
| 9.1 | 36 | 25 | 5 | 31 | 61 | 97 |
| 9.6 | 20 | 5 | 46 | 27 | 78 | 98 |
| 10.4 | 10 | 15 | 27 | 48 | 90 | 100 |
| 8.5 | 19 | 33 | 12 | 40 | 85 | 104 |
| 6.9 | 26 | 14 | 21 | 45 | 80 | 106 |
| 10.3 | 25 | 24 | 32 | 25 | 81 | 106 |
| 12.9 | 25 | 15 | 24 | 42 | 81 | 106 |
| 12.4 | 26 | 14 | 27 | 40 | 81 | 107 |
| 4.9 | 23 | 15 | 21 | 49 | 85 | 108 |
| 11.3 | 35 | 21 | 14 | 41 | 76 | 111 |
| 8.7 | 33 | 11 | 25 | 44 | 80 | 113 |
| 9.9 | 27 | 15 | 32 | 43 | 90 | 117 |
| 5.8 | 27 | 20 | 13 | 67 | 100 | 127 |
| 9.8 | 47 | 11 | 15 | 54 | 80 | 127 |
| 13.1 | 41 | 29 | 12 | 48 | 89 | 130 |
| 7.3 | 46 | 33 | 6 | 49 | 88 | 134 |
| 2.9 | 27 | 11 | 17 | 103 | 131 | 158 |
| **0.3** | **54** | **32** | **27** | **97** | **156** | **210** |
| **8.3km** | **1310** | **797** | **1066** | **2633** | **4496** | **5806** |

Table B-3:- Accident Data Collected for the West Direction of Lukuwanda – Megenagna road for Year 2001/02-2007/08

| Km | Fat02_08 | NonFat02_08 | | | | Tot02_08 |
|---|---|---|---|---|---|---|
| | | Ser.Inj | Slit.Inj | PDO | Sub Total | |
| 2.5 | 0 | 0 | 2 | 8 | 10 | 10 |
| 0.2 | 0 | 0 | 4 | 12 | 16 | 16 |
| 8.9 | 0 | 0 | 6 | 10 | 16 | 16 |
| 11.2 | 0 | 0 | 5 | 13 | 18 | 18 |
| 10.8 | 0 | 0 | 14 | 6 | 20 | 20 |
| 9.6 | 0 | 4 | 2 | 15 | 21 | 21 |
| 6.8 | 0 | 3 | 6 | 14 | 23 | 23 |
| 8.6 | 0 | 1 | 8 | 14 | 23 | 23 |
| 5.7 | 0 | 0 | 7 | 18 | 25 | 25 |
| 6.5 | 0 | 6 | 14 | 5 | 25 | 25 |
| 8.3 | 0 | 8 | 5 | 14 | 27 | 27 |
| 10 | 0 | 0 | 8 | 24 | 32 | 32 |
| 9.4 | 0 | 6 | 18 | 10 | 34 | 34 |
| 1.4 | 0 | 0 | 10 | 26 | 36 | 36 |
| 0.1 | 6 | 3 | 11 | 17 | 31 | 37 |
| 7.8 | 0 | 6 | 14 | 20 | 40 | 40 |
| 13.2 | 5 | 3 | 9 | 23 | 35 | 40 |
| 5.3 | 6 | 0 | 10 | 25 | 35 | 41 |
| 1.2 | 20 | 6 | 15 | 3 | 24 | 44 |
| 12.2 | 2 | 6 | 12 | 27 | 45 | 47 |
| 7.7 | 9 | 5 | 12 | 23 | 40 | 49 |
| 2.6 | 7 | 12 | 8 | 24 | 44 | 51 |
| 8 | 10 | 11 | 7 | 23 | 41 | 51 |
| 0.5 | 10 | 9 | 12 | 24 | 45 | 55 |
| 0.8 | 10 | 12 | 14 | 22 | 48 | 58 |
| 7.1 | 14 | 8 | 9 | 27 | 44 | 58 |
| 11 | 5 | 9 | 14 | 30 | 53 | 58 |
| 2.4 | 8 | 5 | 16 | 31 | 52 | 60 |
| 3.6 | 16 | 6 | 20 | 19 | 45 | 61 |
| 8.5 | 17 | 12 | 4 | 31 | 47 | 64 |
| 12.1 | 14 | 10 | 21 | 19 | 50 | 64 |
| 6.6 | 27 | 6 | 10 | 23 | 39 | 66 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 9.3 | 15 | 8 | 18 | 25 | 51 | 66 |
| 1.3 | 10 | 12 | 14 | 31 | 57 | 67 |
| 2 | 12 | 11 | 17 | 27 | 55 | 67 |
| 4.5 | 18 | 8 | 16 | 25 | 49 | 67 |
| 7.4 | 28 | 5 | 12 | 22 | 39 | 67 |
| 12.4 | 15 | 12 | 14 | 26 | 52 | 67 |
| 1.9 | 18 | 12 | 14 | 24 | 50 | 68 |
| 3.9 | 12 | 18 | 16 | 22 | 56 | 68 |
| 10.6 | 18 | 14 | 14 | 23 | 51 | 69 |
| 5.6 | 23 | 6 | 11 | 30 | 47 | 70 |
| 3 | 6 | 13 | 18 | 34 | 65 | 71 |
| 4.2 | 21 | 11 | 18 | 22 | 51 | 72 |
| 5.4 | 18 | 11 | 12 | 31 | 54 | 72 |
| 5.9 | 21 | 10 | 18 | 24 | 52 | 73 |
| 9.1 | 10 | 20 | 16 | 28 | 64 | 74 |
| 6.1 | 14 | 9 | 20 | 32 | 61 | 75 |
| 10.1 | 18 | 12 | 20 | 26 | 58 | 76 |
| 5.2 | 11 | 19 | 18 | 29 | 66 | 77 |
| 11.1 | 24 | 10 | 17 | 26 | 53 | 77 |
| 4 | 26 | 9 | 10 | 34 | 53 | 79 |
| 2.2 | 18 | 12 | 16 | 34 | 62 | 80 |
| 3.2 | 14 | 10 | 19 | 37 | 66 | 80 |
| 6.9 | 24 | 11 | 9 | 36 | 56 | 80 |
| 11.4 | 10 | 16 | 24 | 30 | 70 | 80 |
| 6.4 | 18 | 11 | 25 | 28 | 64 | 82 |
| 12 | 10 | 16 | 22 | 34 | 72 | 82 |
| 12.7 | 16 | 12 | 19 | 35 | 66 | 82 |
| 1 | 19 | 11 | 21 | 32 | 64 | 83 |
| 4.9 | 19 | 20 | 13 | 31 | 64 | 83 |
| 9.7 | 21 | 9 | 20 | 34 | 63 | 84 |
| 12.9 | 21 | 15 | 10 | 40 | 65 | 86 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.9 | 27 | 21 | 17 | 25 | 63 | 90 |
| 11.8 | 22 | 12 | 21 | 35 | 68 | 90 |
| 12.5 | 16 | 12 | 20 | 42 | 74 | 90 |
| 3.4 | 16 | 20 | 17 | 38 | 75 | 91 |
| 0.7 | 17 | 11 | 23 | 41 | 75 | 92 |
| 4.8 | 23 | 10 | 24 | 35 | 69 | 92 |
| 1.5 | 19 | 15 | 24 | 36 | 75 | 94 |
| 1.6 | 32 | 11 | 12 | 41 | 64 | 96 |
| 0.4 | 22 | 10 | 28 | 38 | 76 | 98 |
| 8.7 | 31 | 12 | 27 | 32 | 71 | 102 |
| 10.3 | 24 | 17 | 22 | 39 | 78 | 102 |
| 13 | 32 | 13 | 17 | 43 | 73 | 105 |
| 2.8 | 23 | 19 | 23 | 42 | 84 | 107 |
| 10.9 | 28 | 26 | 23 | 37 | 86 | 114 |
| 11.3 | 38 | 20 | 23 | 34 | 77 | 115 |
| 2.9 | 25 | 6 | 29 | 57 | 92 | 117 |
| 11.6 | 29 | 26 | 28 | 34 | 88 | 117 |
| 4.3 | 37 | 12 | 21 | 53 | 86 | 123 |
| 1.1 | 26 | 24 | 35 | 40 | 99 | 125 |
| 5.8 | 24 | 12 | 34 | 61 | 107 | 131 |
| 9.8 | 29 | 26 | 32 | 47 | 105 | 134 |
| 13.1 | 31 | 10 | 37 | 62 | 109 | 140 |
| 7.3 | 32 | 25 | 38 | 54 | 117 | 149 |
| **0.3** | **35** | **24** | **38** | **75** | **137** | **172** |
| **8.7km** | **1352** | **924** | **1451** | **2553** | **4928** | **6280** |

Table B-4:- Accident Data Collected for Fatal Accident vs. Total Accident

## Commulative Accident Statiatics of Lukuanda - Megenagna, (East-West Direction of the Road)

| Km | Fatal Accident | Total Accident | Km | Fatal Accident | Total Accident |
|---|---|---|---|---|---|
| **0.1** | 6 | 37 | 3.2 | 14 | 80 |
| 0.2 | 18 | 75 | 3.4 | 16 | 91 |
| **0.3** | **89** | **382** | 3.5 | 16 | 36 |
| 0.4 | 22 | 98 | 3.6 | 16 | 61 |
| 0.5 | 10 | 62 | 3.9 | 12 | 85 |
| 0.6 | 15 | 57 | 4 | 26 | 79 |
| 0.7 | 17 | 92 | 4.2 | 21 | 72 |
| 0.8 | 10 | 58 | 4.3 | 51 | 211 |
| 0.9 | 27 | 110 | 4.5 | 18 | 67 |
| 1 | 26 | 94 | 4.8 | 23 | 92 |
| 1.1 | 26 | 125 | 4.9 | 42 | 191 |
| 1.2 | 20 | 44 | 5.2 | 11 | 77 |
| 1.3 | 15 | 131 | 5.3 | 28 | 108 |
| 1.4 | 0 | 36 | 5.4 | 29 | 145 |
| 1.5 | 19 | 94 | 5.6 | 23 | 70 |
| 1.6 | 40 | 174 | 5.7 | 15 | 102 |
| 1.7 | 14 | 36 | 5.8 | 51 | 258 |
| 1.8 | 18 | 68 | 5.9 | 35 | 121 |
| 2 | 36 | 161 | 6.1 | 16 | 123 |
| 2.2 | 24 | 128 | 6.4 | 18 | 82 |
| 2.4 | 20 | 124 | 6.5 | 0 | 25 |
| 2.5 | 0 | 10 | 6.6 | 54 | 144 |
| 2.6 | 7 | 66 | 6.8 | 0 | 23 |
| 2.8 | 23 | 107 | 6.9 | 50 | 186 |
| 2.9 | 52 | 275 | 7 | 14 | 62 |
| 3 | 6 | 87 | 7.1 | 14 | 58 |

| Km | Fatal Accident | Total Accident | Km | Fatal Accident | Total Accident |
|---|---|---|---|---|---|
| 7.2 | 1 | 26 | 10.3 | 49 | 208 |
| 7.3 | 78 | 283 | 10.4 | 10 | 100 |
| 7.4 | 36 | 127 | 10.5 | 12 | 62 |
| 7.6 | 25 | 59 | 10.6 | 18 | 92 |
| 7.7 | 9 | 49 | 10.7 | 7 | 54 |
| 7.8 | 19 | 100 | 10.8 | 11 | 70 |
| 8 | 24 | 105 | 10.9 | 45 | 181 |
| 8.1 | 20 | 65 | 11 | 15 | 114 |
| 8.2 | 3 | 32 | 11.1 | 29 | 111 |
| 8.3 | 11 | 63 | 11.2 | 22 | 96 |
| 8.4 | 18 | 52 | 11.3 | 73 | 226 |
| 8.5 | 36 | 168 | 11.4 | 32 | 168 |
| 8.6 | 14 | 71 | 11.5 | 9 | 72 |
| 8.7 | 64 | 215 | 11.6 | 29 | 172 |
| 8.8 | 5 | 27 | 11.7 | 0 | 35 |
| 8.9 | 16 | 84 | 11.8 | 33 | 142 |
| 9 | 25 | 73 | 12 | 10 | 82 |
| 9.1 | 46 | 171 | 12.1 | 27 | 130 |
| 9.2 | 12 | 80 | 12.2 | 26 | 136 |
| 9.3 | 46 | 151 | 12.3 | 12 | 76 |
| 9.4 | 10 | 108 | 12.4 | 41 | 174 |
| 9.5 | 16 | 61 | 12.5 | 24 | 137 |
| 9.6 | 20 | 119 | 12.6 | 10 | 56 |
| 9.7 | 21 | 84 | 12.7 | 33 | 155 |
| 9.8 | 76 | 261 | 12.8 | 12 | 58 |
| 9.9 | 27 | 117 | 12.9 | 46 | 192 |
| 10 | 15 | 102 | 13 | 36 | 154 |
| 10.1 | 30 | 134 | 13.1 | 72 | 270 |
| 10.2 | 0 | 68 | 13.2 | 23 | 128 |
| | | | **Total** | **1283** | **5786** |

# APPENDIX III; - Detail Analysis for the Selected HRL

**Table C-1:-Detail Analysis of Severity of Accident for the Selected HRLs Based on Types of Vehicles for Year 2001/02-2007/08**

Table C-1a:- Severity of Accident for Asrasimint(Location 0.3Km) Based on Types of Vehicles for Year 2001/02-2007/08

## ASRASIMNT

**Location: 0.3Km**

382

| No. | Vehicle Type | 1 Fatal | 2 Serious Injury | 3 Slight Injury | 4 PDO | Total |
|---|---|---|---|---|---|---|
| 1 | Bicycle | 0 | 0 | 0 | 2 | 2 |
| 2 | Motor Cycle | 1 | 0 | 2 | 6 | 9 |
| 3 | Automobile | 5 | 3 | 7 | 33 | 48 |
| 4 | Pick Up<10 Quintal | 4 | 5 | 4 | 21 | 34 |
| 5 | Truck 11-40 Quintal | 9 | 1 | 2 | 27 | 39 |
| 6 | Truck 41-100 Quintal | 15 | 6 | 11 | 18 | 50 |
| 7 | Truck with Trailer | 6 | 3 | 1 | 5 | 15 |
| 8 | Bote | 4 | 1 | 0 | 3 | 8 |
| 9 | Taxi | 22 | 10 | 21 | 41 | 94 |
| 10 | Mini Bus < 12 seats | 7 | 6 | 10 | 7 | 30 |
| 11 | Bus 13-45 Seats | 9 | 7 | 3 | 2 | 21 |
| 12 | Bus > 46 | 3 | 4 | 2 | 4 | 13 |
| 13 | Special Truck | 1 | 0 | - | 0 | 1 |
| 14 | Special Truck with Trailer | - | - | - | 3 | 3 |
| 18 | Unidentified | 3 | 10 | 2 | 0 | 15 |
| | Total | 89 | 56 | 65 | 172 | 382 |

## ARAT KILLO

**Location: 7.3Km**

283

| No. | Vehicle Type | 1 Fatal | 2 Serious Injury | 3 Slight Injury | 4 PDO | Total |
|---|---|---|---|---|---|---|
| 1 | Bicycle | 2 | 3 | 0 | 3 | 8 |
| 2 | Motor Cycle | 5 | 4 | 1 | 8 | 18 |
| 3 | Automobile | 19 | 9 | 5 | 21 | 54 |
| 4 | Pick Up<10 Quintal | 3 | 7 | 3 | 9 | 22 |
| 5 | Truck 11-40 Quintal | 1 | 2 | 3 | 8 | 14 |
| 6 | Truck 41-100 Quintal | 0 | 4 | 2 | 8 | 14 |
| 7 | Truck with Trailer | 2 | 0 | 1 | 2 | 5 |
| 8 | Bote | 3 | 1 | 1 | 3 | 8 |
| 9 | Taxi | 28 | 21 | 13 | 29 | 91 |
| 10 | Mini Bus < 12 seats | 4 | 2 | 3 | 1 | 10 |
| 11 | Bus 13-45 Seats | 3 | 4 | 2 | 6 | 15 |
| 12 | Bus > 46 | 5 | 1 | 3 | 1 | 10 |
| 13 | Special Truck | 1 | 0 | - | 2 | 4 |
| 14 | Special Truck with Trailer | - | - | - | 2 | 2 |
| 18 | Unidentified | 2 | 0 | 7 | 0 | 9 |
| | Total | 78 | 58 | 44 | 103 | 283 |

**AUTOBUSTERA**

**Location: 2.9Km**

275

| No. | Vehicle Type | 1<br>Fatal | 2<br>Serious Injury | 3<br>Slight Injury | 4<br>PDO | Total |
|---|---|---|---|---|---|---|
| 1 | Bicycle | 0 | 0 | 1 | 2 | 3 |
| 2 | Motor Cycle | 2 | 1 | 2 | 4 | 9 |
| 3 | Automobile | 6 | 1 | 8 | 28 | 43 |
| 4 | Pick Up<10 Quintal | 8 | 2 | 3 | 11 | 24 |
| 5 | Truck 11-40 Quintal | 2 | 1 | 1 | 3 | 7 |
| 6 | Truck 41-100 Quintal | 5 | 1 | 2 | 6 | 14 |
| 7 | Truck with Trailer | 0 | 0 | 2 | 0 | 2 |
| 8 | Bote | 2 | 1 | 1 | 3 | 7 |
| 9 | Taxi | 19 | 5 | 18 | 43 | 85 |
| 10 | Mini Bus < 12 seats | 3 | 0 | 4 | 16 | 23 |
| 11 | Bus 13-45 Seats | 2 | 0 | 2 | 23 | 27 |
| 12 | Bus > 46 | 1 | 4 | 1 | 18 | 24 |
| 13 | Special Truck | 2 | 1 | - | 3 | 6 |
| 14 | Special Truck with Trailer | - | - | - | 0 | 0 |
| 18 | Unidentified | 0 | 0 | 1 | 0 | 1 |
| | Total | 52 | 17 | 46 | 160 | 275 |

**MEGENAGNA**

**Location: 13.1Km**

270

| No. | Vehicle Type | 1<br>Fatal | 2<br>Serious Injury | 3<br>Slight Injury | 4<br>PDO | Total |
|---|---|---|---|---|---|---|
| 1 | Bicycle | 3 | 1 | 0 | 7 | 11 |
| 2 | Motor Cycle | 4 | 1 | 2 | 4 | 11 |
| 3 | Automobile | 15 | 6 | 13 | 21 | 55 |
| 4 | Pick Up<10 Quintal | 5 | 4 | 2 | 5 | 16 |
| 5 | Truck 11-40 Quintal | 2 | 0 | 1 | 3 | 6 |
| 6 | Truck 41-100 Quintal | 1 | 0 | 0 | 5 | 6 |
| 7 | Truck with Trailer | 1 | 1 | 1 | 6 | 9 |
| 8 | Bote | 2 | 3 | 1 | 7 | 13 |
| 9 | Taxi | 24 | 14 | 10 | 26 | 74 |
| 10 | Mini Bus < 12 seats | 7 | 4 | 7 | 10 | 28 |
| 11 | Bus 13-45 Seats | 4 | 3 | 2 | 11 | 20 |
| 12 | Bus > 46 | 3 | 2 | 4 | 4 | 13 |
| 13 | Special Truck | 1 | 0 | 3 | 0 | 4 |
| 14 | Special Truck with Trailer | - | - | - | 1 | 1 |
| 18 | Unidentified | 0 | 0 | 3 | 0 | 3 |
| | Total | 72 | 39 | 49 | 110 | 270 |

## KEBENA

**Location: 9.8Km**

261

| No. | Vehicle Type | 1 | 2 | 3 | 4 | Total |
|---|---|---|---|---|---|---|
| | | Fatal | Serious Injury | Slight Injury | PDO | |
| 1 | Bicycle | 3 | 0 | 1 | 3 | 7 |
| 2 | Motor Cycle | 1 | 3 | 2 | 5 | 11 |
| 3 | Automobile | 12 | 6 | 8 | 10 | 36 |
| 4 | Pick Up<10 Quintal | 5 | 2 | 5 | 4 | 16 |
| 5 | Truck 11-40 Quintal | 7 | 0 | 2 | 6 | 15 |
| 6 | Truck 41-100 Quintal | 3 | 1 | 4 | 4 | 12 |
| 7 | Truck with Trailer | 0 | 0 | 3 | 7 | 10 |
| 8 | Bote | 4 | 1 | 3 | 5 | 13 |
| 9 | Taxi | 18 | 13 | 8 | 35 | 74 |
| 10 | Mini Bus < 12 seats | 6 | 5 | 2 | 9 | 22 |
| 11 | Bus 13-45 Seats | 9 | 4 | 3 | 6 | 22 |
| 12 | Bus > 46 | 8 | 2 | 1 | 4 | 15 |
| 13 | Special Truck | 0 | 0 | - | 2 | 2 |
| 14 | Special Truck with Trailer | - | - | - | 1 | 1 |
| 18 | Unidentified | 0 | 0 | 5 | 0 | 5 |
| | Total | 76 | 37 | 47 | 101 | 261 |

## PIAZZA

**Location: 5.8Km**

258

| No. | Vehicle Type | 1 | 2 | 3 | 4 | Total |
|---|---|---|---|---|---|---|
| | | Fatal | Serious Injury | Slight Injury | PDO | |
| 1 | Bicycle | 5 | 1 | 0 | 6 | 12 |
| 2 | Motor Cycle | 1 | 2 | 2 | 4 | 9 |
| 3 | Automobile | 8 | 6 | 8 | 21 | 43 |
| 4 | Pick Up<10 Quintal | 1 | 1 | 4 | 5 | 11 |
| 5 | Truck 11-40 Quintal | 2 | 2 | 3 | 8 | 15 |
| 6 | Truck 41-100 Quintal | 3 | 1 | 1 | 7 | 12 |
| 7 | Truck with Trailer | 0 | 2 | 0 | 1 | 3 |
| 8 | Bote | 2 | 1 | 1 | 4 | 8 |
| 9 | Taxi | 18 | 9 | 14 | 27 | 68 |
| 10 | Mini Bus < 12 seats | 4 | 2 | 5 | 13 | 24 |
| 11 | Bus 13-45 Seats | 3 | 2 | 3 | 15 | 23 |
| 12 | Bus > 46 | 3 | 1 | 4 | 8 | 16 |
| 13 | Special Truck | 0 | 1 | - | 2 | 3 |
| 14 | Special Truck with Trailer | - | - | - | 5 | 5 |
| 18 | Unidentified | 1 | 1 | 2 | 2 | 6 |
| | Total | 51 | 32 | 47 | 128 | 258 |

**Table C-2:- Detail Analysis of Severity of Accident for the Selected HRLs Based on Types of Road Users for Year 2001/02-2007/08**

Table C-2a:- Table C-2:- Detail Analysis of Severity of Accident for Asrasimint(Location 0.3Km) Based on Types of Road Users for Year 2001/02-2007/08

**ASRASIMNT**

**Location: 0.3Km**

382

| No. | Casualty | Age | Fatal | | Serious Injury | | Slight Injury | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | Male | Female | Male | Female | Male | Female | |
| 1 | Driver | Below 18 Years | 1 | - | 2 | - | 3 | 4 | 10 |
| | | 18-30 | 3 | - | 5 | - | 3 | 2 | 13 |
| | | 30-50 | 2 | - | 4 | 2 | 2 | 1 | 11 |
| | | Above 51 | 2 | - | 1 | - | 1 | 1 | 5 |
| | ድምር | | 8 | | 12 | 2 | 9 | 8 | 39 |
| 2 | Pedestrain | Below 7 Years | 4 | 1 | 5 | 2 | 1 | 7 | 20 |
| | | 7-13 yrs. | 3 | 3 | 3 | 1 | 2 | 2 | 14 |
| | | 14-17 | 2 | 5 | 4 | 5 | 3 | 3 | 22 |
| | | 18-30 | 7 | 5 | 3 | 4 | 2 | 1 | 22 |
| | | 31-50 | 4 | 3 | 4 | 6 | 1 | 3 | 21 |
| | | Above 51 | 5 | 7 | 5 | 2 | 2 | 1 | 22 |
| | Total | | 25 | 24 | 24 | 20 | 11 | 17 | 121 |
| 3 | Passenger | Below 7 Years | 5 | 1 | 2 | 0 | 2 | 3 | |
| | | 7-13 yrs. | 4 | 2 | 0 | 0 | 1 | 1 | 8 |
| | | 14-17 | 3 | 1 | 3 | 1 | 3 | 2 | 13 |
| | | 18-30 | 7 | 3 | 6 | 4 | 1 | 1 | 22 |
| | | 31-50 | 4 | 3 | 3 | 3 | 3 | 4 | 20 |
| | | Above 51 | 3 | 2 | 0 | 2 | 2 | 2 | 11 |
| | Total | | 21 | 11 | 12 | 10 | 10 | 10 | 74 |
| | | Grand Total | 54 | 35 | 24 | 32 | 30 | 35 | 210 |

**ARAT KILLO**

**Location: 7.3Km**

283

| No. | Casualty | Age | Fatal | | Serious Injury | | Slight Injury | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | Male | Female | Male | Female | Male | Female | |
| 1 | Driver | Below 18 Years | 3 | - | 1 | - | 1 | - | 5 |
| | | 18-30 | 2 | - | 4 | 2 | 2 | 2 | 12 |
| | | 30-50 | 1 | - | 1 | 1 | 0 | 1 | 4 |
| | | Above 51 | 0 | - | 3 | - | 1 | - | 4 |
| | ድምር | | 6 | | 9 | 3 | 4 | 3 | 25 |
| 2 | Pedestrain | Below 7 Years | 1 | 2 | 5 | 2 | 1 | 0 | 11 |
| | | 7-13 yrs. | 3 | 5 | 2 | 1 | 3 | 2 | 16 |
| | | 14-17 | 1 | 1 | 3 | 2 | 1 | 3 | 11 |
| | | 18-30 | 8 | 11 | 2 | 0 | 4 | 1 | 26 |
| | | 31-50 | 2 | 3 | 1 | 1 | 2 | 0 | 9 |
| | | Above 51 | 5 | 7 | 2 | 3 | 3 | 5 | 25 |
| | Total | | 20 | 29 | 15 | 9 | 14 | 11 | 98 |
| 3 | Passenger | Below 7 Years | 0 | 2 | 1 | 2 | - | - | |
| | | 7-13 yrs. | 1 | - | 3 | 1 | 1 | 1 | 7 |
| | | 14-17 | 3 | 1 | 0 | 4 | 0 | 2 | 10 |
| | | 18-30 | 6 | 2 | 4 | 2 | 1 | 2 | 17 |
| | | 31-50 | 4 | 3 | 1 | 4 | 1 | 3 | 16 |
| | | Above 51 | 3 | - | 2 | 1 | 0 | 1 | 7 |
| | Total | | 17 | 6 | 10 | 12 | 3 | 9 | 57 |
| | | Grand Total | 43 | 35 | 34 | 24 | 21 | 23 | 180 |

**AUTOBUSTER**

**Location: 2.9Km**

275

| No. | Casualty | Age | Fatal | | Serious | | Slight Injury | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | Male | Female | Male | Female | Male | Female | |
| 1 | Driver | Below 18 Years | 2 | - | 0 | 0 | 0 | 1 | 3 |
| | | 18-30 | 5 | 1 | 1 | 0 | 4 | 1 | 12 |
| | | 30-50 | 1 | - | 0 | 0 | 1 | - | 2 |
| | | Above 51 | 0 | - | 0 | 1 | 1 | - | 2 |
| | ድምር | | 8 | | 1 | 1 | 6 | 2 | 18 |
| 2 | Pedestrain | Below 7 Years | 2 | 1 | 1 | 0 | 1 | 2 | 7 |
| | | 7-13 yrs. | 2 | 3 | 2 | 1 | 3 | 1 | 12 |
| | | 14-17 | 5 | 2 | 0 | 0 | 2 | 2 | 11 |
| | | 18-30 | 3 | 1 | 1 | 2 | 2 | 2 | 11 |
| | | 31-50 | 1 | 3 | 1 | 0 | 1 | 3 | 9 |
| | | Above 51 | 5 | 4 | 0 | 1 | 7 | 2 | 19 |
| | Total | | 18 | 14 | 5 | 4 | 16 | 12 | 69 |
| 3 | Passenger | Below 7 Years | 1 | 2 | 0 | 0 | 2 | 1 | |
| | | 7-13 yrs. | 2 | - | 1 | 1 | 1 | 1 | 6 |
| | | 14-17 | 2 | 1 | 1 | 0 | 0 | 2 | 6 |
| | | 18-30 | 1 | 2 | 0 | 1 | 2 | 1 | 7 |
| | | 31-50 | 0 | 3 | 1 | 0 | 1 | 2 | 7 |
| | | Above 51 | 1 | - | 0 | 1 | 0 | 0 | 2 |
| | Total | | 6 | 6 | 3 | 3 | 4 | 6 | 28 |
| | | Grand Total | 32 | 20 | 9 | 8 | 26 | 20 | 115 |

**MEGENAGNA**

**Location: 13.1Km**

270

| No. | Casualty | Age | Fatal | | Serious Injury | | Slight Injury | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | Male | Female | Male | Female | Male | Female | |
| 1 | Driver | Below 18 Years | 1 | 0 | 1 | 0 | 0 | 0 | 2 |
| | | 18-30 | 3 | 2 | 1 | 0 | 3 | 2 | 11 |
| | | 30-50 | 1 | 0 | 0 | 2 | 1 | 0 | 4 |
| | | Above 51 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | ድምር | | 5 | | 2 | 2 | 4 | 2 | 15 |
| 2 | Pedestrain | Below 7 Years | 3 | 3 | 0 | 3 | 1 | 2 | 12 |
| | | 7-13 yrs. | 2 | 5 | 3 | 5 | 1 | 3 | 19 |
| | | 14-17 | 3 | 2 | 4 | 2 | 3 | 1 | 15 |
| | | 18-30 | 8 | 4 | 1 | 3 | 2 | 3 | 21 |
| | | 31-50 | 2 | 9 | 1 | 0 | 1 | 2 | 15 |
| | | Above 51 | 5 | 1 | 1 | 2 | 6 | 1 | 16 |
| | Total | | 23 | 24 | 10 | 15 | 14 | 12 | 98 |
| 3 | Passenger | Below 7 Years | 1 | 1 | 0 | 1 | 1 | 2 | |
| | | 7-13 yrs. | 2 | 3 | 1 | 1 | 0 | 2 | 9 |
| | | 14-17 | 1 | 1 | 2 | 0 | 1 | 1 | 6 |
| | | 18-30 | 3 | 2 | 2 | 1 | 1 | 2 | 11 |
| | | 31-50 | 4 | 3 | 1 | 2 | 2 | 0 | 12 |
| | | Above 51 | 1 | - | 0 | 0 | 3 | 5 | 9 |
| | Total | | 11 | 9 | 6 | 4 | 7 | 10 | 47 |
| | | Grand Total | 39 | 33 | 18 | 21 | 25 | 24 | 160 |

**KEBENA**

**Location: 9.8Kr**

261

| No. | Casualty | Age | Fatal | | Serious Injury | | Slight Injury | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | Male | Female | Male | Female | Male | Female | |
| 1 | Driver | Below 18 Years | 2 | 0 | 0 | - | 1 | 1 | 4 |
| | | 18-30 | 2 | 0 | 1 | - | 1 | 2 | 6 |
| | | 30-50 | 0 | 0 | 0 | 1 | 2 | 0 | 3 |
| | | Above 51 | 1 | 0 | 1 | - | 1 | 1 | 4 |
| | ድምር | | 5 | | 2 | 1 | 5 | 4 | 17 |
| 2 | Pedestrain | Below 7 Years | 2 | 6 | 1 | 2 | 2 | 1 | 14 |
| | | 7-13 yrs. | 3 | 1 | 2 | 4 | 3 | 2 | 15 |
| | | 14-17 | 4 | 3 | 1 | 3 | 2 | 2 | 15 |
| | | 18-30 | 5 | 3 | 2 | 2 | 1 | 2 | 15 |
| | | 31-50 | 1 | 5 | 2 | 1 | 3 | 3 | 15 |
| | | Above 51 | 4 | 4 | 0 | 1 | 2 | 3 | 14 |
| | Total | | 19 | 22 | 8 | 13 | 13 | 13 | 88 |
| 3 | Passenger | Below 7 Years | 2 | 2 | 1 | 0 | 2 | 0 | |
| | | 7-13 yrs. | 2 | 5 | 2 | 1 | 1 | 2 | 13 |
| | | 14-17 | 4 | 6 | 1 | 1 | 1 | 0 | 13 |
| | | 18-30 | 5 | 2 | 2 | 2 | 2 | 3 | 16 |
| | | 31-50 | 1 | 2 | 1 | 2 | 0 | 1 | 7 |
| | | Above 51 | 1 | 2 | 0 | 1 | 0 | 2 | 6 |
| | Total | | 13 | 17 | 6 | 7 | 4 | 8 | 55 |
| | | Grand Total | 37 | 39 | 16 | 21 | 22 | 25 | 160 |

**PIAZZA**

**Location: 5.8Kr**

258

| No. | Casualty | Age | Fatal | | Serious Injury | | Slight Injury | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | Male | Female | Male | Female | Male | Female | |
| 1 | Driver | Below 18 Years | 0 | - | 1 | - | 2 | 0 | 3 |
| | | 18-30 | 1 | - | 2 | - | 2 | 1 | 6 |
| | | 30-50 | 0 | - | 1 | 2 | 1 | 2 | 6 |
| | | Above 51 | 2 | - | 0 | - | 1 | 1 | 4 |
| | ድምር | | 3 | | 4 | 2 | 6 | 4 | 19 |
| 2 | Pedestrain | Below 7 Years | 1 | 4 | 0 | 2 | 1 | 2 | 10 |
| | | 7-13 yrs. | 3 | 2 | 2 | 3 | 3 | 2 | 15 |
| | | 14-17 | 4 | 2 | 2 | 1 | 2 | 2 | 13 |
| | | 18-30 | 4 | 3 | 1 | 2 | 3 | 3 | 16 |
| | | 31-50 | 3 | 2 | 0 | 2 | 2 | 2 | 11 |
| | | Above 51 | 1 | 1 | 1 | 3 | 1 | 2 | 9 |
| | Total | | 16 | 14 | 6 | 13 | 12 | 13 | 74 |
| 3 | Passenger | Below 7 Years | 2 | 2 | 1 | 2 | 1 | 1 | |
| | | 7-13 yrs. | 3 | 3 | 1 | 0 | 2 | 2 | 11 |
| | | 14-17 | 1 | 2 | 2 | 0 | 0 | 1 | 6 |
| | | 18-30 | 2 | 1 | 0 | 2 | 1 | 0 | 6 |
| | | 31-50 | 1 | 2 | 0 | 1 | 2 | 1 | 7 |
| | | Above 51 | 0 | 3 | 1 | 0 | 1 | 2 | 7 |
| | Total | | 7 | 11 | 4 | 3 | 6 | 6 | 37 |
| | | Grand Total | 26 | 25 | 14 | 18 | 24 | 23 | 130 |

Table C-3:- Identification of HRLs Based on Total Weight of Priority for Year 2001/02-2007/08

**Identification of HRL Based on Total Weight of Priority**

| Km | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 2 | 2.2 | 2.4 | 2.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Accident | 37 | 75 | 382 | 98 | 62 | 57 | 92 | 58 | 110 | 94 | 125 | 44 | 131 | 36 | 94 | 174 | 36 | 68 | 161 | 128 | 124 | 10 |
| 1. Number of lanes in each direction | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 2. Number of vehicles per day | 4 | 4 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 3. Width of the road | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 4. Drainage facilities provided | 7 | 7 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 5. Surface condition of the pavement | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 5. Frequent vehicle type on the road | 4 | 4 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 6. Presence of shoulders | 10 | 10 | 8 | 4 | 4 | 4 | 4 | 4 | 4 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 7. Presence of edge obstructions | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 8. Provision of median barriers to channlize the traffic | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 10 |
| Tech.Wt. of Priority | 47 | 47 | 40 | 33 | 33 | 33 | 33 | 33 | 33 | 47 | 47 | 47 | 47 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 55 |
| | 52.22 | 52.22 | 44.44 | 36.67 | 36.67 | 36.67 | 36.67 | 36.67 | 36.67 | 52.22 | 52.22 | 52.22 | 52.22 | 54.44 | 54.44 | 54.44 | 54.44 | 54.44 | 54.44 | 54.44 | 54.44 | 61.11 |
| Hazard Level | Midium | Midium | High | High | High | High | High | High | High | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium |

| Km | 2.6 | 2.8 | 2.9 | 3 | 3.2 | 3.4 | 3.5 | 3.6 | 3.9 | 4 | 4.2 | 4.3 | 4.5 | 4.8 | 4.9 | 5.2 | 5.3 | 5.4 | 5.6 | 5.7 | 5.8 | 5.9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Accident | 66 | 107 | 275 | 87 | 80 | 91 | 36 | 61 | 85 | 79 | 72 | 211 | 67 | 92 | 191 | 77 | 108 | 145 | 70 | 102 | 258 | 121 |
| 1. Number of lanes in each direction | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 3 | 3 |
| 2. Number of vehicles per day | 6 | 6 | 8 | 8 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 8 | 8 |
| 3. Width of the road | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 4. Drainage facilities provided | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 7 | 7 |
| 5. Surface condition of the pavement | 6 | 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 6 | 6 | 6 | 8 | 8 | 8 | 8 |
| 6. Frequent vehicle type on the road | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 7. Presence of shoulders | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 8. Presence of edge obstructions | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 9. Provision of median barriers to channlize the traffic | 10 | 10 | 4 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 4 | 4 | 4 | 4 | 10 | 10 | 4 |
| Tech.Wt. of Priority | 55 | 55 | 53 | 59 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 54 | 54 | 54 | 45 | 45 | 45 | 48 | 54 | 60 | 54 |
| | 61.11 | 61.11 | 58.89 | 65.56 | 63.33 | 63.33 | 63.33 | 63.33 | 63.33 | 63.33 | 63.33 | 63.33 | 60.00 | 60.00 | 60.00 | 50.00 | 50.00 | 50.00 | 53.33 | 60.00 | 66.67 | 60.00 |
| Hazard Level | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Midium | Low | Midium |

Table D-1:-Collision by Road Alignment 2001/02-2007/08

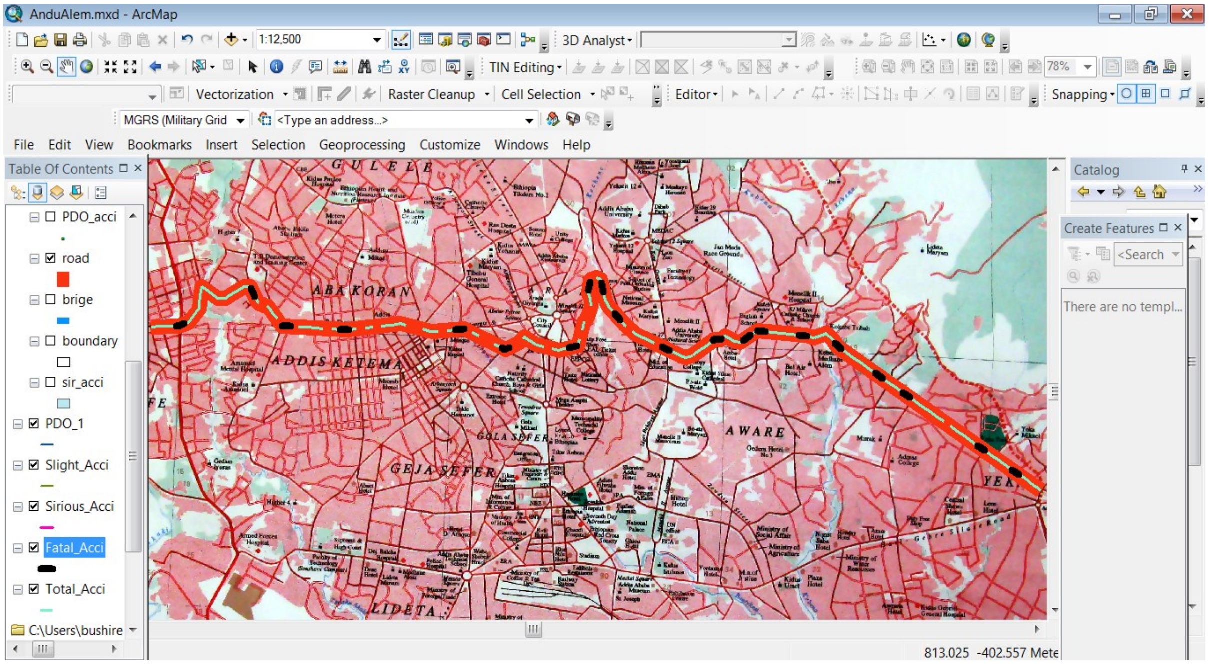
| No. | Road | Total | % |
|---|---|---|---|
| 1 | Level&Tangent Curve | 9624 | 79.63 |
| 2 | Straight &Steep | 265 | 2.19 |
| 3 | Straight&Very Steep | 234 | 1.94 |
| 4 | Straight&Grade | 386 | 3.19 |
| 5 | Level&Horizontal Curve | 594 | 4.91 |
| 6 | Curve | 152 | 1.26 |
| 7 | Graded | 214 | 1.77 |
| 8 | Steep | 455 | 3.76 |
| 9 | Others | 162 | 1.34 |
| | Total | 12086 | |

Table E-1:- Collision by Road Junction 2001/02-2007/08

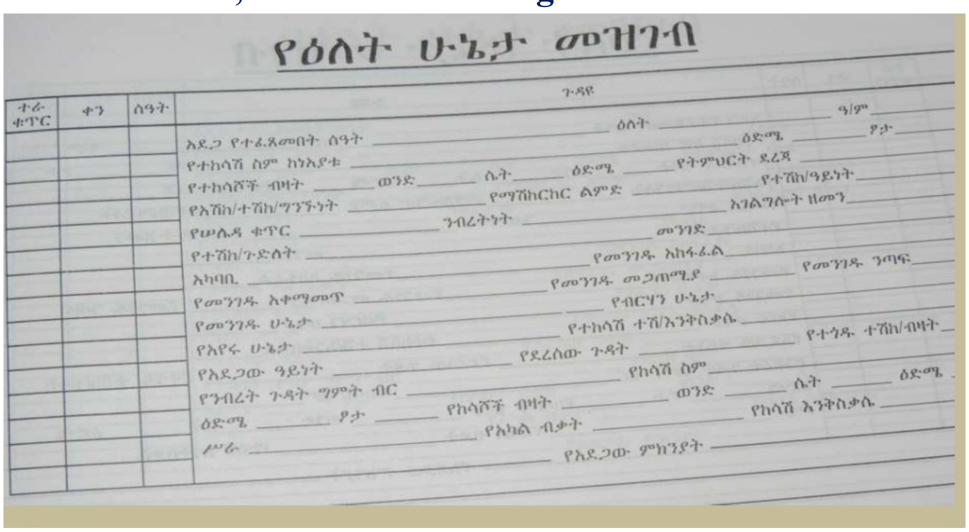
**Collision by Roadway Junction**

| No. | Road Junction | Total | % |
|---|---|---|---|
| 1 | With One Direction | 17047 | 16.10 |
| 2 | With Two Direction | 29260 | 27.63 |
| 3 | Divide with Island | 51143 | 48.29 |
| 4 | With Zebra Cross | 3974 | 3.75 |
| 5 | With Line of Strips | 4475 | 4.23 |

## APPENDIX IV; - Digitized Map of the Study Area




## APPENDIX V; -Traffic Recording Booklet



የዕለት ሁኔታ መዝገብ

| ተራ ቁጥር | ቀን | ሰዓት | ጉዳዩ |
|---|---|---|---|
| | | | ዕለት ____ ዓ/ም ____ |
| | | | አደጋ የተፈጸመበት ሰዓት ____ ዕድሜ ____ ፆታ ____ |
| | | | የተከሳሽ ስም ከነአያቱ ____ የትምህርት ደረጃ ____ |
| | | | የተከሳሾች ብዛት ____ ወንድ ____ ሴት ____ ዕድሜ ____ የተሽከ/ዓይነት ____ |
| | | | የአሽከ/ተሽከ/ግንኙነት ____ የማሽከርከር ልምድ ____ አገልግሎት ዘመን ____ |
| | | | የሠሌዳ ቁጥር ____ ንብረትነት ____ መንገድ ____ |
| | | | የተሽከ/ጉድለት ____ የመንገዱ አከፋፈል ____ |
| | | | አካባቢ ____ የመንገዱ መጋጠሚያ ____ የመንገዱ ንጣፍ ____ |
| | | | የመንገዱ አቀማመጥ ____ የብርሃን ሁኔታ ____ |
| | | | የመንገዱ ሁኔታ ____ የተከሳሽ ተሽ/እንቅስቃሴ ____ |
| | | | የአየሩ ሁኔታ ____ የደረሰው ጉዳት ____ የተጎዱ ተሽከ/ብዛት ____ |
| | | | የአደጋው ዓይነት ____ የከሳሽ ስም ____ |
| | | | የንብረት ጉዳት ግምት ብር ____ ወንድ ____ ሴት ____ ዕድሜ ____ |
| | | | ዕድሜ ____ ፆታ ____ የከሳሾች ብዛት ____ የከሳሽ እንቅስቃሴ ____ |
| | | | ሥራ ____ የአካል ብቃት ____ |
| | | | የአደጋው ምክንያት ____ |

## APPENDIX VI; - Typical Highway Level of Service

Table E-1: Typical Highway Level of Service (LOS) rating (Source: HCM 2000)

| LOS | Description | Speed | Flow (Veh/hr/l | Density |
|---|---|---|---|---|
| A | Traffic flows at or above posted speed limit. Motorists have complete mobility between lanes. | Over 60 | Under 700 | Under 12 |
| B | Slightly congested, with some impingement of maneuverability. Two motorists might be forced to drive side by side, limiting lane c hanges | 57-60 | 700-1100 | 12-20 |
| C | Ability to pass or change lanes is not assured. Most experienced drivers are comfortable and posted speed maintained but roads are close to capacity. This is the target LOS f or most urban highways | 54-57 | 1100-1550 | 20-30 |
| D | Speeds are somewhat reduced, motorists are hemmed in by other vehicles. Typical urban peak-period highway conditions. | 46-54 | 1550-1850 | 30-42 |
| E | Flow becomes irregular, speed vary and rarely reach the posted limit. This is considered a system failure. | 30-46 | 1850-2000 | 42-67 |
| F | Flow is forced; with frequent drops in speed to nearly zero mph. Travel time is unpredictable. | Under 30 | Unstable | 67- max |

Table E-2: Typical Intersection Level of Service (LOS) rating (source: HCM 2000)

| Level of Service | Delay at signalized intersection | Delay at un signalized intersection |
|---|---|---|
| A | 10 sec | 10 sec |
| B | 10-20 sec | 10-15 sec |
| C | 20-35 sec | 15-25 sec |
| D | 35-55 sec | 25-35 sec |
| E | 55-80 sec | 35-50 sec |
| F | 80 sec | 50 sec |

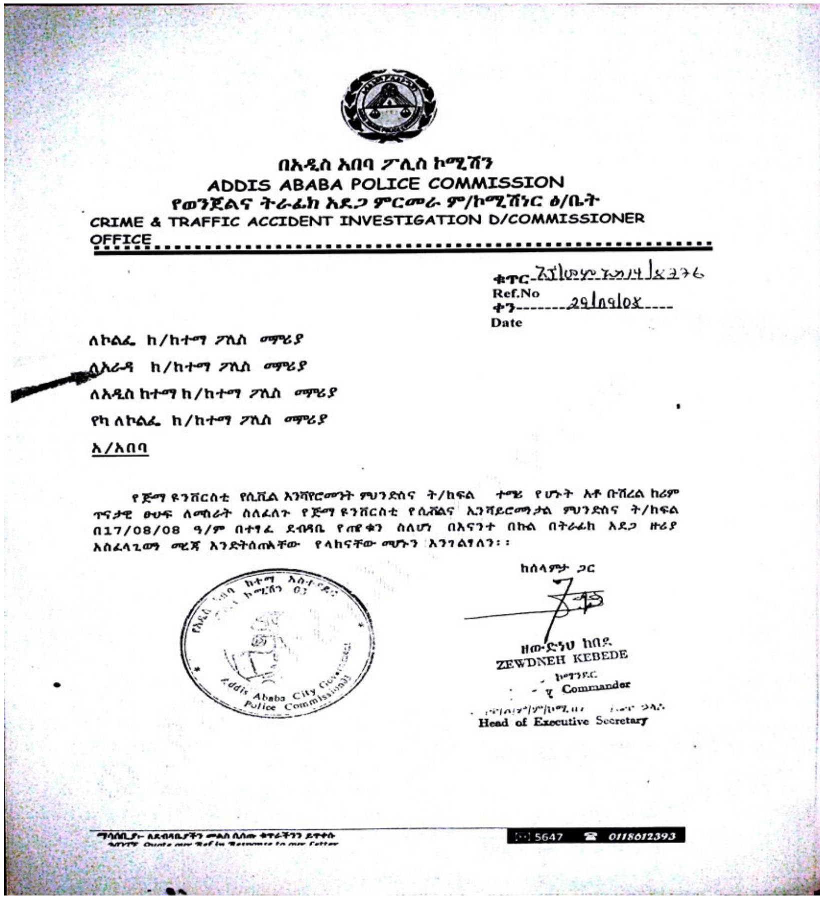
Table E-3: Major Intersections along corridor

| No. | Junction Name | Type of Junction | Remark |
|---|---|---|---|
| 1 | "Lukuanda-18" Junction | 4-leged Roundabout | |
| 2 | Lukanda-Kolfe Keraniyo Junct. | T-Junction | |
| 3 | Mesalemiya Junction | 5-Leg Roundabout | |
| 4 | Mesalemiya Junction | T-Junction | |
| 5 | Menahariya Taxi Tera | 4-leged-Junction | |
| 6 | Merkato Junction | T-Junction | |
| 7 | Chew Berenda Junction | T-Junction | |
| 8 | Gojam Berenda Junction | T-Junction | |
| 9 | "Anuar Mesjid Junction | T-Junction | |
| 10 | H/G Dildiy Junction | T- Junction | |
| 11 | Nur-Mesjid Junction | 5-Leg Roundabout | |
| 12 | Piaza Junction | 4-leged Junction | |
| 13 | Arat Kilo | 4-Leg Roundabout | |
| 14 | Kebena Junction | 4-leged Junction | |
| 15 | British Embassy | T-Junction | |
| 16 | Shola Junction | T-Junction | |
| 17 | Megenagna | 5-Leg Roundabout | |

## APPENDIX VII; - Collected Accident Pictures



## Appendix VIII; - Request Letters



በአዲስ አበባ ፖሊስ ኮሚሽን
ADDIS ABABA POLICE COMMISSION
የወንጀልና ትራፊክ አደጋ ምርመራ ም/ኮሚሽነር ፅ/ቤት
CRIME & TRAFFIC ACCIDENT INVESTIGATION D/COMMISSIONER OFFICE

ቁጥር
Ref.No
ቀን 29/09/08
Date

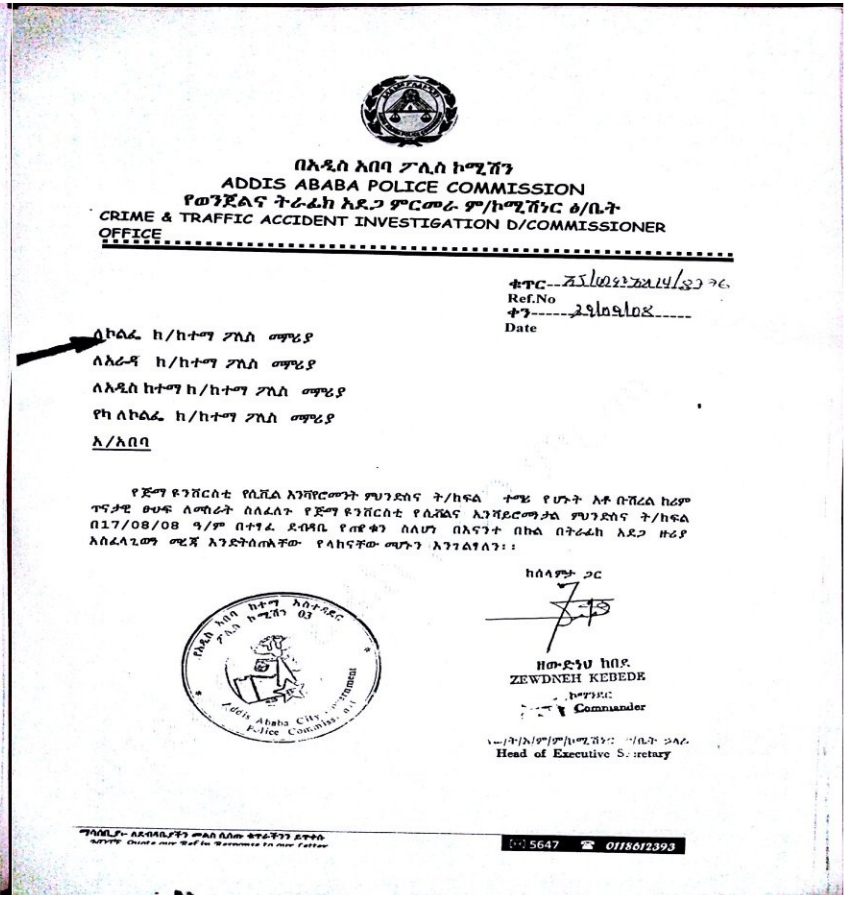
ለኮልፌ ክ/ከተማ ፖሊስ መምሪያ
ለአራዳ ክ/ከተማ ፖሊስ መምሪያ
ለአዲስ ከተማ ክ/ከተማ ፖሊስ መምሪያ
የካ ለኮልፌ ክ/ከተማ ፖሊስ መምሪያ
አ/አበባ

የጅማ ዩንቨርስቲ የሲቪል እንቫየርመንት ምህንድስና ት/ክፍል ተማሪ የሆኑት አቶ ቡሽረል ከሪም ጥናታዊ ፅሁፍ ለማሰራት ስለፈለጉ የጅማ ዩንቨርስቲ የሲቪልና እንቫይሮሜንታል ምህንድስና ት/ክፍል በ17/08/08 ዓ/ም በተፃፈ ደብዳቤ የጠየቁን ስለሆነ በእናንተ በኩል በትራፊክ አደጋ ዙሪያ አስፈላጊውን መረጃ እንድትሰጧቸው የላክናቸው መሆኑን እንገልፃለን::

ከሰላምታ ጋር

ዘውድነህ ከበደ
ZEWDNEH KEBEDE
Commander
Head of Executive Secretary

5647 ☎ 0118612393



በአዲስ አበባ ፖሊስ ኮሚሽን
ADDIS ABABA POLICE COMMISSION
የወንጀልና ትራፊክ አደጋ ምርመራ ም/ኮሚሽነር ፅ/ቤት
CRIME & TRAFFIC ACCIDENT INVESTIGATION D/COMMISSIONER OFFICE

ቁጥር
Ref.No
ቀን 29/09/08
Date

ለኮልፌ ክ/ከተማ ፖሊስ መምሪያ
ለአራዳ ክ/ከተማ ፖሊስ መምሪያ
ለአዲስ ከተማ ክ/ከተማ ፖሊስ መምሪያ
የካ ለኮልፌ ክ/ከተማ ፖሊስ መምሪያ
አ/አበባ

የጅማ ዩንቨርስቲ የሲቪል እንቫየርመንት ምህንድስና ት/ክፍል ተማሪ የሆኑት አቶ ቡሽረል ከሪም ጥናታዊ ፅሁፍ ለማሰራት ስለፈለጉ የጅማ ዩንቨርስቲ የሲቪልና እንቫይሮሜንታል ምህንድስና ት/ክፍል በ17/08/08 ዓ/ም በተፃፈ ደብዳቤ የጠየቁን ስለሆነ በእናንተ በኩል በትራፊክ አደጋ ዙሪያ አስፈላጊውን መረጃ እንድትሰጧቸው የላክናቸው መሆኑን እንገልፃለን::

ከሰላምታ ጋር

ዘውድነህ ከበደ
ZEWDNEH KEBEDE
Commander
Head of Executive Secretary

5647 ☎ 0118612393

በአዲስ አበባ ፖሊስ ኮሚሽን
ADDIS ABABA POLICE COMMISSION
የወንጀልና ትራፊክ አደጋ ምርመራ ም/ኮሚሽነር ፅ/ቤት
CRIME & TRAFFIC ACCIDENT INVESTIGATION D/COMMISSIONER OFFICE

ቁጥር 25/ወ.ም.ኮ/14/...
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ቀን 25/09/08 ዓ.ም
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ለኮልፌ ክ/ከተማ ፖሊስ መምሪያ

ለአራዳ ክ/ከተማ ፖሊስ መምሪያ

ዲስ ከተማ ክ/ከተማ ፖሊስ መምሪያ

የካ ለኮልፌ ክ/ከተማ ፖሊስ መምሪያ

አ/አበባ

የጅማ ዩንቨርስቲ የሲቪል እንጂነሪንግ ምህንድስና ት/ክፍል ተማሪ የሆኑት አቶ ቡሽረል ከሪም ጥናታዊ ፅሁፍ ለማሰራት ስለፈለጉ የጅማ ዩንቨርስቲ የሲቪልና እንቫይሮመንታል ምህንድስና ት/ክፍል በ17/08/08 ዓ/ም በተፃፈ ደብዳቤ የጠየቁን ስለሆነ በእናንተ በኩል በትራፊክ አደጋ ዙሪያ አስፈላጊውን መረጃ እንድትሰጡአቸው የላክናቸው መሆኑን እንገልፃለን::

ከሰላምታ ጋር

የአዲስ አበባ ከተማ አስተዳደር ፖሊስ ኮሚሽን 03
Addis Ababa City Government Police Commission03

ዘውድነህ ከበደ
ZEWDNEH KEBEDE
ኮማንደር
Commander
የወ/ት/አ/ም/ም/ኮሚሽነር ጽ/ቤት ኃላፊ
Head of Executive Secretary

ማሳሰቢያ፦ ለደብዳቤያችን መልስ ሲሰጡ ቁጥራችንን ይጥቀሱ
NOTE: Quote our Ref in Response to our Letter
P.O.Box 5647 ☎ 0118612393

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በአዲስ አበባ ፖሊስ ኮሚሽን
ADDIS ABABA POLICE COMMISSION
የወንጀልና ትራፊክ አደጋ ምርመራ ም/ኮሚሽነር ፅ/ቤት
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ለኮልፌ ክ/ከተማ ፖሊስ መምሪያ

ለአራዳ ክ/ከተማ ፖሊስ መምሪያ

ለአዲስ ከተማ ክ/ከተማ ፖሊስ መምሪያ

የካ ለኮልፌ ክ/ከተማ ፖሊስ መምሪያ

አ/አበባ

የጅማ ዩንቨርስቲ የሲቪል እንጂነሪንግ ምህንድስና ት/ክፍል ተማሪ የሆኑት አቶ ቡሽረል ከሪም ጥናታዊ ፅሁፍ ለማሰራት ስለፈለጉ የጅማ ዩንቨርስቲ የሲቪልና እንቫይሮመንታል ምህንድስና ት/ክፍል በ17/08/08 ዓ/ም በተፃፈ ደብዳቤ የጠየቁን ስለሆነ በእናንተ በኩል በትራፊክ አደጋ ዙሪያ አስፈላጊውን መረጃ እንድትሰጡአቸው የላክናቸው መሆኑን እንገልፃለን::

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የአዲስ አበባ ከተማ አስተዳደር ፖሊስ ኮሚሽን 03
Addis Ababa City Government Police Commission03

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ZEWDNEH KEBEDE
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Commander
የወ/ት/አ/ም/ም/ኮሚሽነር ጽ/ቤት ኃላፊ
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