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Run-off-The Road Crash Severity and Crash Severity-Based Black Spot Identification in Oromia Region, East Wallega Zone

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Run-off-the Road Crash Severity and Crash Severity-Based Black Spot Identification in Oromia Region, East Wallaga Zone.

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This is to certify that the thesis prepared by Wendimu Tefari, entitled Run-off-the Road Crash Severity and Crash Severity Based-Black Spot Identification in Oromia Region, East Wallaga Zone and submitted in partial fulfillments of the requirement for the degree of master of (Road and Transport Engineering) complies with the regulation of the university and meet the accepted standard with respect to originality and quality.

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Abstract

Statistics clearly demonstrate that run-off-the road crashes contribute to a significant percentage of high-severity crashes. It is therefore important for the highway safety community to identify the characteristics and contributory causes of these types of crashes. This paper assesses the trends, causes, and severity of run-off-the road traffic accidents and black spot identification by weight severity index method on rural road of East Wallega Oromia regeion Ethiopia. Despite efforts made by various stakeholders to reduce the massacre on country roads, road traffic accidents have been a serious health problem issue in the country and the most severed accident are caused when vehicle run-off-the road and a vehicle that leaves its travel lane at a non-intersection location and collides with another vehicle or with a fixed object or overturns is considered to be involved in a run-off-road crash. The study used data on road traffic accidents for the period 2005-2008 E.C and data were obtained from East Wallega Police Commission and the data obtained is totally of 374 out of this about 187 of them are ROR crashes and data has been analyzed using descriptive statistics or Bayesian statistic equation approach/model for identifying the primary contributing factor associated with run-off-the road crashes (ROR). The most frequently identified contributing factor among the ROR events from the model are excessive speeding/exciding speed limit, fatigue, distraction, sleeping of driver and tire blow out and brake are out of control, while wrong side driving, too fast for condition and loss distance, improper turning, motor problem and strapping are more related with NROR crashes. Further the study describes that the degree of hazardousness of a given rural road section/stretch has been directly associated with the availability of risk indicating on the road such as surface type, geographic location, volume of vehicle on the road and traffic factors. The study finding shows that human errors mainly drivers' behavior and actions are found as the major cause of road traffic accident in Ethiopia. So that to reduce fatalities and injuries on the roads, the paper recommends that road safety policy and law enforcement; capacity building, education, and awareness creation; and cooperation and integration between and/or among all transport stakeholders should be the focus of the government as well as the responsibility of every individual living in the country.

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Chapter one

Introduction

1.1 Basic Overviews

Everybody travels from one place to another place either to work or to do business or to study or to enjoy using various transport options. Vehicle is one of the most widely used transport alternative and the major source of road traffic accidents in the world. Statistically there are more motor vehicles on the road than ever before in the world and this trend is expected to continue to grow. Unfortunately, as the number of motor vehicles traveling on our roadways increases, so too will the number of traffic crashes unless ways can be found to prevent them, especially in developing country (Kunuz Abdella, 2008).

While Ethiopia is one of the developing countries, road accidents are major problems of Road safety. According to data from the Federal Police Commission of Ethiopia, in 2016/17 G.C, 4479 lives were lost due to traffic accidents and more than 1.2 billion ETB in property damage (Federal Traffic Police Report, 2010 E.C). As per the evidence from those stakeholders report, the major cause of these accidents are attributed to the low driving skill which was believed to account for 75-80 percent of all accidents; poor technical qualities of vehicles, inadequate law enforcement, more than half of the cars in the country are older than ten years, poor road condition or quality, overloading, bad driving behavior such as drunk and drugged driving, excessive speed, failure to give way to pedestrians and violating traffic laws and geographical and environmental location of the road are the contributing factor for the accident (Tibebe Beshah et al,. 2014) and the detail was cited on this site (http://addisstandard.com/sweden-shares-experience-in-road-safety-to-ethiopia).

In addition to this, one of the most cause for the sever accident in traffic crash specifically around the rural road is when the vehicle run-off-the road (ROR) or rollover due to different factor; where ROR crashes have been identified as an important leading cause of traffic fatalities on highways and have consequently been identified as a significant problem in traffic safety and such type of crashes are defined as types of crashes/ accident where a vehicle leaves the travel lane of the road or the transport way it is traveling on and hits one or more objects or overturns and also known as roadway departure crashes resulted with significant severed type of accident (Abdullah, 2014). A significant portion of ROR crashes are fatal and according to NHTSA

reports that run-off-the road crashes cause 60 percent of all traffic accident and run- off-road crashes contribute about 71 percent of these fatal single-vehicle crashes (Leroy et al., 2008). In 2008, American Association of State Highway and Transportation Officials (AASHTO) reported that out of all crashes in the state of Idaho, 24 percent were ROR crashes, and 73 percent of the ROR crashes happened on rural roadways and in that year, about 39 percent of vehicle fatalities were due to ROR crashes (AASHTO, 2008).

In relation to this, The National Highway Traffic Safety Administration (NHTSA) reports that in 2011; 32,367 people were killed and 2,217,000 were injured out of 5,338,000 police-reported motor vehicle traffic crashes in the United States. Furthermore, the Federal Highway Administration (FHWA)'s Roadway Departure Safety Program reports that 51 % of all fatal crashes that occurred in the United States in 2011 involved the run-off-road crash types.

In similar way Run-off-road (ROR) crashes become a major concern in our country as they continue to cause severe fatalities and major injuries to motorist vehicle user. According to earlier research in Ethiopia, (Getu, 2015) out of the total traffic accident occurred during (2005-2011), 17.34 % are fatal and 17.17% are injuries are due to rollover crash. As per this research several factors are contributing to ROR traffic crash becomes fatal. These include roadside features to be hit by an errant vehicle, vertical and horizontal curving of the road, high speed of an errant vehicle, width of the shoulder, and different type bad driving behavior, vehicle defect, life animal and pedestrian action around the travel way of the road.

In relation to this most of the previous studies identified the contributing factors for the occurrences of this single-vehicle ROR crashes and these may include alcohol use, weather condition, being rural roads, traveling at high speed, design of the roadway, poor quality of the road, carelessness of driver, overloading of vehicle, internal and external distraction, fatigue during driving due restless or night driving, animal and pedestrian action on the road, sight obstruction or in adequate visibility due to the existence of fixed road side feature, inexperienced driving habit and curved road segments (Liu et al,. 2009 , Omar Eid Almutairi , 2013) .

In this work it is intended to study the severity of ROR in rural roadways and isolate the most contributing factor related to the accident and prioritizing them by using Bayesian statistical approach equation with reference to the crash data collected from the area of study i.e. from East Wallega, Oromia region, Ethiopia. Furthermore, there is a need to investigate the correlation

between the accident severity and road section black spot based weight severity index method (Black spot manual, 2001). Therefore, corresponding results included herein provide the description, the nature of the relationship between road section black spot and accident severity attributes.

1.2. Problem statement

Ethiopia is one of the highly developing country in east Africa and the number and the movements of traffic vehicle are increasing from year to year throughout the country. With increase traffic volume the rate of accident is proportionally increasing and most of highly severed accident are happened due to the Run-off-the road crash, which is increase in number from time to time and ranked as one of the most highly loss of the life and property damage, once such type of accident is occurred explicitly on rural part the road and many factors may be responsible for causing a vehicle to leave its design travel lane and result with Run-off-the road crash.

1.3. Objective of the study

The main objective of this thesis is to identify the factor that contribute to the occurrence of Runoff-the-road (ROR) crashes in order to discover which of these factor are the most predominant in causing severed accident.

The specific objectives of this research are to:-

- Examine the trends in Run-off- the road crash and investigate run-off-the-road crashes severity
- Identify the most common factors that are likely to contribute to the occurrence of Run - off-the road (ROR) crashes
- Identify of road section black spot based on accident severity.
- Develop recommendation on how to minimize the run-off-the-road crashes.

1.4. Scope of the Research

While there are many traffic collision type and factors that are believed to influence traffic accident, the scope of this study will be focused solely upon identification of factor contributing to run-off-the road crashes and the effect of accident severity on localizing black spot along the road section, and furthermore, traffic crash data analysis component will be limited to the data sourced from East Wollega Zone between 2005 and 2008 Etc.

1.5. Organization of the Thesis

This thesis is organized into five chapters. Fist chapter introduce about the research and the second chapter presents the literature review and summarizes some of the topics that relate to this study. The third chapter describes data collection and the methodology used in this thesis and descried descriptive overview of the data for analysis by providing an explanation of each variable studied in the research. Chapter four presents results and discussion of results and finding of the research. Chapter five includes conclusions and recommendations which summarize the studies.

Chapter Two

Literature review

2.1 Introduction

The theme of crash severity has been of interest to traffic safety community because of the direct impact on occupants involved. In fact, it is well-known that a traffic accident is usually caused by the failure of one or more of a multitude of factors, including the safety condition of the vehicle, the safety condition of the road and its environment and finally the safe behavior of the driver and road user (Haddon, 1970).

Reducing the number of traffic accidents therefore requires an integrated approach known as shared responsibility. The way forward would be to identify factors contributing to either a more or less severe crash in many researches and many factors are contributing to the occurrence of traffic crashes, so that one cannot expect that only one factor leads to traffic crash because multiple factors may be involved. On the basis of factor classification, traffic crash factors can be clustered into the following categories (Abdullah, 2014)

- Driver characteristics: Factors related to the driver, such as driver errors, speed choice, age of driver, driver gender, status of the driver's condition such as intoxication, drowsiness, inattention, avoidance maneuvers, and errant vehicles etc.
- Geometric factors or road factor: Includes the road design such as the lane width, the width of shoulders, the curvature of the road, number of lanes in each direction, and quality of the road surface, type of the road and other roadside features and obstacles.
- Environmental factors: These are factors, which are very difficult to control; for example, the condition of the weather, the condition of the road, the light condition, and the time of the day and the day of the week.
- Traffic factors: These factors include collision type, traffic volume, and speed limit.
- Vehicle factor: such as vehicle speeding status, vehicle type, age of vehicle etc.

This chapter documents the literature review performed on roadway departure or run-off- road (ROR) crashes and summarizes key studies that have been conducted in various developed and developing countries. In connection to this, this section provide the approaches used to model injury severities in traffic safety analysis and its variation from one to another, depending on the

purpose of the study and data availability. Farther, subdivision provides review of recent trends in motor vehicle crashes, factors influencing motor vehicle traffic safety and various methodologies commonly used in traffic safety studies as well as a discussion of findings in the field of traffic safety. The prose review focuses primarily on road safety situations specifically on the influence of roadside feature on driving in different road environment and the factor contributing the severity of the Run-off-the road crash, the types of analyses available and the factors that relates to severity of road accidents in order to identify black spot along road section that are previously used in our country as well as though out the world.

2.2 Current Traffic Accidents Situations in Ethiopia

The number of motor vehicles in Ethiopia is increasing rapidly and coupled with population growth, is contributing to a rise in the number of road traffic injuries and fatalities. Road safety has become a major national issue receiving front-page coverage in the F.M radio program, press and National TV news on a regular basis. Fortunately, the government and donor community have reacted quickly and increased funding to the National Road Safety Commission (NRSC), enabling the NRSC to expand and implement new targeted road safety initiatives i.e. WHO, Swedish Embassy in Addis Ababa, International Road Federation (IRF) for safety of Africa road, etc. has been a primary supporter of government road safety activities in Ethiopia.

Table: 2.1. Accident involvement of vehicles in 2004/5 E.C

Types of vehicle	No. of inspected & registered vehicles		Fatal accident		Total accidents	Risk per 100 vehicles	% involvement
	Number	% age	Number	% age			
Car	71,672	43	362	20	6,786	9	38
Taxi	14,504	9	259	14	2,707	19	15
Bus	14,152	9	204	11	2,373	17	13
Trucks	61,710	37	859	48	5,363	9	30
Others	4,271	3	117	6	493	12	4
	166,309	100	1801	100	17,722	11	100

Data Source: Federal Police Commission; compiled by the consultant

Similar to the other sub Saharan African Regions, road traffic accident trend in Ethiopia is increasing from time to time. For example, on a research conducted in Addis Ababa referring accident data from 2001 to 2008 the trend was increased from 9.27% to 13.9% with a typical pick in 2006, which was 15.1% (Tekebash Araya et al,. 2009) and the trend of fatal accident as per the regional state of ours country has been shown below (Getu, 2015).

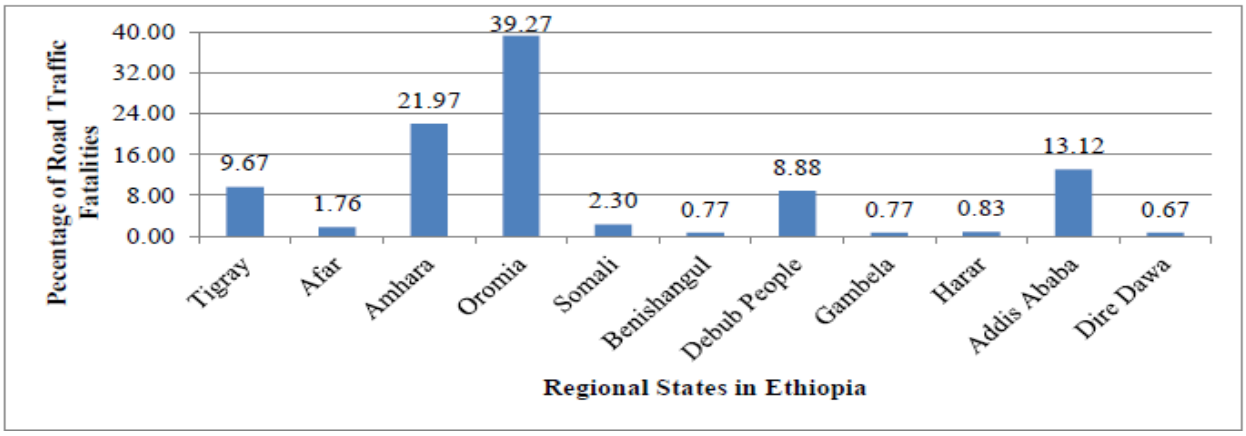


Figure: 2.1 Percentage of Road Traffic Fatalities Distribution by Regional States of Ethiopia in 2012/13 (2005 E.C.)

As per the above two research, concentration of road traffic accident was more related with population density and the finding from the study indicate that road users between 18-30 and 31-50 years are the most vulnerable age group to road crash fatalities both driver and passenger in such way that about 76.98% of persons killed in road crashes are males and 22.02% are female.

2.2.1 Crashes by Collision Type

According to the earlier research experienced in our country, most crashes occurred while vehicles were driving straight ahead on tangent road sections (68.69% of fatal crashes and 71.44% of injury crashes) and maneuvering at intersections, overtaking, U-turns, entering and exiting from driveways, and other types of maneuver contributed relatively less to the occurrence of fatal and non-fatal crashes (Girma, 2000; Getu, 2015). In relative with the research finding during the six years accident data analysis in Ethiopia due to traffic accident, pedestrian collisions comprised 48.55% of fatalities, while rollovers or ROR accounted for 17.34% and for injuries according to the finding indicate the respective figures of 53.16% and 17.17% respectively.

In general assumption of road crash, Rollover which is one typical type of ROR crashes often occurred on horizontal curved sections of roads, however, most rollover crashes in Ethiopia occurred on tangent road sections which contradict the assumption. There are many causes of rollover crashes on tangent sections of roads and the leading could include excessive speeding, which has been found to contribute as much as 45% to rollover crashes (Bonneson et al,. 2011).

Recently not observing priority of pedestrians and speeding were major causes of fatal and non-fatal crashes from the finding of different research. The two combined contributed to 44.80% and 45.89% of fatal and injury crashes respectively and additional observational studies undertaken in Ethiopia indicate that disobeying traffic control devices is a major problem (Miranda et al,. 2011). This disobedient behavior of drivers also extends to other causes of crashes which support above finding and some of the factor identified in the literature causing traffic accident are speeding, failure to give priority to pedestrians, and incorrect overtaking, young drivers in the age category of under and within 18-30, particularly in professional driving are riskier in their behavior (Schneider et al., 2008). In contrast, drink driving and drug driving made non-significant contributions in terms of fatalities and injuries during that period. The figure might be non-significant due to the lack of testing for alcohol and drugs, but know it is practiced in some part of the country included in the feature research.

Table: 2.2 Crashes by Maneuver, Collision and Vehicle Type

Description	Fatal Crashes	%	Injury Crashes	%
Collision Types				
Head –on collisions	604	4.98	608.98	4.48
Rear-end collisions	333	2.74	335.74	4.16
Broadside collision	284	2.34	286.34	2.85
Sideswipe collision	260	2.14	262.14	2.72
Rollover	2105	17.34	2122.34	17.17
Collision with pedestrians	5894	48.55	5942.55	53.16
Fall from vehicles	1024	8.43	1032.43	6.46
Collision with animals	609	5.02	614.02	4.23
Collision with roadside parked vehicles	219	1.8	220.8	1.49
Collision with road side objects	370	3.05	373.05	1.43
With Train	233	1.92	234.92	0.07
Others	100	0.82	100.82	0.74
Unknown	105	0.86	105.86	1.04
Total	12140	100	12240	100
Type of Vehicles				
Cycle and Motorcycle	451	3.71	1258	4.27
Automobile and Land Cruiser	1204	9.92	5606	19.03
Commercial Vehicle	5780	47.61	11124	37.77
Minibuses and Buses	4191	34.52	10569	35.88
Earth Moving	183	1.51	248	0.84
Rail	2	0.02	5	0.02
Animal Drawn Cart	48	0.40	126	0.43
Others	70	0.58	173	0.59
Unknown	211	1.74	345	1.17
Total	12140	100.00	29454	100.00

2.2.2. Involvement of Vehicle Types in Crashes

According to Beforehand through investigation in Ethiopia, traffic crashes were analyzed in terms of vehicle type, and its findings indicated that commercial vehicles were involved in 38.4% of fatalities and 37.8% of injuries in the six-year period crash analysis. Minibus taxis and buses were also involved in 34.5% of fatalities. However, these trucks and buses during that time make up only 18.22% and 12.49% respectively of the vehicle population in the country during the research period and finding was consistent with other research which has found that trucks were more involved in crashes in less developed countries (Mohan, 2002).

On the other hand, automobile vehicles had low fatality and injury records; however, there were significantly high numbers of property damage crashes during that period. This may be due to the lower annual kilometers travelled by this group of vehicles and vehicle roadworthiness may be a problem, since 36% of imported vehicles and 65% of the vehicle population have been found to have an age of over 15 years. Given these figures, it is not surprising that vehicles aged over 5 years were involved in the majority of crashes in Addis Ababa (Oh, et al., 2004).

2.2.3. Possible Reasons for High Number of Road Traffic Accidents in Ethiopia

According to the report provided by the Interim National Road Safety Coordination Office and recent studies in developing country; the reasons for the relatively high number of road traffic accidents are due to (Traffic Police Commission Report, 2008 E.C):

- Lack of driving skills;
- Luckless knowledge of traffic rules and regulations;
- Abuse of speed Limit;
- Insufficient enforcement;
- Lack of vehicle maintenance; poor technical quality of vehicle
- Animal drawn carts or local-Garry and animals frequently using in main highways;
- Lack of safety conscious design and planning of road network;
- Impudence of traffic rules and regulations;
- Lack of general safety awareness by pedestrians; and
- Lack of medical facility in general or first aid support immediately while accident are happened, which increase the severity of accidents.

2.3. Crash-Associated Factors in Single-Vehicle ROR Crashes

Numerous studies have been conducted in recent years on roadside safety crashes. In 2001 study examined longitudinal trends 1975-1997 in fatal roadside crashes in the USA (McGinnis et al., 2001) and the research investigate how different driver characteristics such as age, gender, and alcohol usage relate to ROR crashes, the study used data from the Fatality Analysis Reporting System and the National Personal Transportation Studies. The study found out that ROR crash rates peaked in 1980 and had decreased after the year to 40% for both male and female drivers, even after adjusting for driving exposure, it was found that male crash rates were higher than female crash rates. Hence the studies prove also ROR crash rates were found to be higher for young inexperienced drivers and older drivers aged 70 years older and in similar function teenage female drivers had a 3.75 times higher crash rate than average female.

(Spain hour et., 2008) in Florida examined human, roadway, vehicle, and environmental factors associated with overcorrection as opposed to traditional ROR crashes using binary logistic regression analysis. Overcorrection occurs when a vehicle begins drifting off the road one way and the driver over steers in the opposite direction, leading the vehicle to cross over into oncoming lanes of traffic, sideswipe an adjacent vehicle, or travel off the road into a hazard.

The study used data from Florida Traffic Crash Report (FTCR) and Florida Department of Transportation (FDOT) Crash Analysis Reporting System (CAR) database for ROR crashes in 2000 in Florida. The analysis of the data revealed the fact that approximately 36% of the vehicles crossed the entire roadway and departed on the opposite side from the initial roadway departure. Among different contributory factors, alcohol was the major one, followed by speed, inattention, and fatigue/sleep and it was also suggested that overcorrection had a strong positive association with the presence of rumble strips inclement weather, rural locations, incapacitated drivers, and running off the road to the left or straight. The authors found strong negative association with male drivers, speeding, paved or curbed shoulders, wet or slippery roads, and larger vehicles and fewer than 20% of fatal ROR crashes occurred where rumble strips were present; drivers were more than 50% more likely to overcorrect than when they were not present.

(Liu et., 2009) used the Fatality Analysis Reporting System database for fatal ROR crashes occurring during the period 1991 to 2007 and Logistic regression analysis was used in the study and the results revealed that ROR crashes were more likely to take place on curved roads, rural roads, and roadways with fewer lanes. Speeding vehicles, vehicles with high occupancy, adverse

weather conditions, dark conditions, vehicles driven by male and young drivers, and passenger cars posed special challenges for roadside safety improvement efforts.

In another study conducted by (Dissanayake, 2003), a sequential binary logistic regression model was used to identify the most important causes of ROR crashes and to estimate the severity of young driver ROR crashes by extracting the data from the Florida Traffic Crash Database from 1997-1998. The study found that use of alcohol or drugs, ejection in the crash, gender, impact point of the vehicle, restraint device usage, urban/rural location, and grade/curve existence of the crash location, lighting condition, and speed were the most important factors affecting the severity of young driver single-vehicle ROR crashes.

Based on different factors stated in different finding, the researcher can give the Global definition for Run-off-road crashes and in contrast all single vehicle crashes where the first harmful event occurs off the roadway, except for backing and pedestrian related crashes.

A statistical review of the 1992 General Estimation System (GES) and Fatal Accident Reporting System (FARS) databases indicate that run-off-road crashes are the most serious of crash types within the US crash population. These crashes account for over 20% of all police reported crashes, and over 41 % of all in-vehicle fatalities 15,000 / year (Lloyd Emery, I997) and some of the most important characteristics of roadway departure crashes predicted from the finding of the research are: - they occur most often on straight roads 76%, on dry roads 62%, in good weather 73%, on rural or suburban roads 75% and evenly split between day and night.

Unlike many of the other traffic crash types, run-off-road crashes are caused by a wide variety of factors. Detailed analysis of 200 NASS CDS crash reports indicates that run-off-road crashes are primarily caused by the following six factors as per their research analysis of the data in their finding (in decreasing order of frequency):- Excessive speed 32.0%; traveling too fast to maintain control, Driver incapacitation 20.1%; typically drowsiness or intoxication, Lost directional control 16.0%; typically due to wet or icy pavement, Evasive maneuvers 15.7%; driver steers off road to avoid obstacle, Driver inattention 12.7%; typically due to internal or external distraction, and Vehicle failure 3.6%; typically due to tire blowout or steering system failure (Dissanayake, 2003).

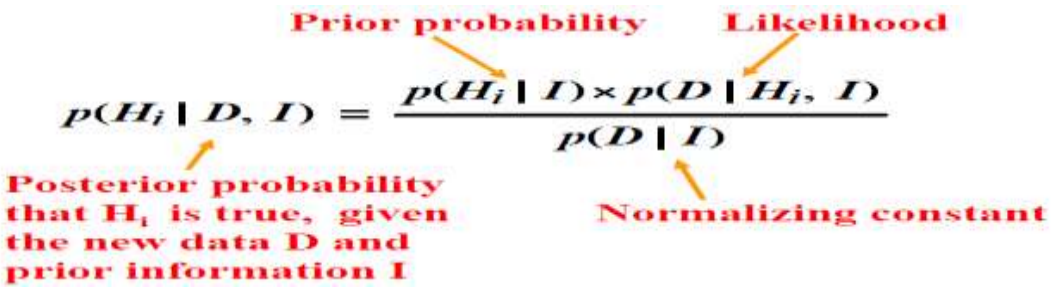
In connection with model used in the analysis part in this research, the model was previously used to identify factor contributing to fatal commercial truck and the result shows that one-ninth of all traffic fatalities in the United States have involved large trucks in the past five years,

although large trucks contributed to only 3% of registered vehicles and 7% of vehicle miles travelled. This contrasting proportion indicates that truck crashes in general tend to be more severe than other crashes though they constitute a smaller sector of vehicles on the road and to study the issue, fatal crash data from the FARS was used to analyze characteristics and factors contributing to truck-involved crashes. Factor like Driver, vehicle, and crash-related contributory causes were identified, and as an extension the likelihood of occurrence of these contributory causes in truck-involved crashes with respect to non-truck crashes was evaluated using the Bayesian Statistical Equation approach (Uttara Roy et., 2011).

Likely, the Likelihood ratios which were important parameter in the model equation indicated that factors such as stopped or unattended vehicles and improper following have greater probability of occurrence in truck crashes than in non-truck crashes (Sundanda, 2010).

In contrast (Uttara Roy et., 2011) circuit his research on the Comparison of Factors Associated with Run-Off-Road and Non-Run-Off Road Crashes in Kansas using the Kansas Accident Reporting System (KARS) database with the application of Bayesian Statistical Equation Approach. From their research finding Nighttime, weekends, adverse weather, rural area, gravel and curved roads, higher speed limits, wet and icy road surface, and utility vehicles are found to be the common characteristics of ROR crashes and in the same agreements factor like Fell asleep, ill or medical condition, driving under the influence, too fast for conditions, tires and wheels, strong winds, freezing rain, shoulders, ruts, holes, and bumps are found to have the greatest likelihood ratios and as such have a greater role in contributing to ROR crashes than NROR crashes.

In the same way the conclusion from (Uttara Roy et., 2011) indicate that majority of fatal run-off-the-road crashes occur from drivers drifting or losing control of the vehicle and leaving the designated lane and an effort should be made to increase the visibility and awareness of each driver's respective lane in order to encountering such type of accident in the overall road safety. Here is the typical Bayesian Statistical Approach Equation used by (Uttara Roy et., 2011) and referencing the applicability of this equation in identification of factor contributing to single vehicle accident run out from the road in different research would motivate to use this equation in this studies and mathematical form as shown.



2.4 Contributing Factors of Run-Off-Road Crash

A study by (Calspan Corporation conducted, 1994) shows that ROR crashes on both straight and curved roads were caused by the six major factors: driver inattention (e.g., retrieving a fallen object), driver relinquished steering control (i.e. heart attack or intoxication), excessive vehicle speed, evasive maneuver, loss of directional control on road surface (i.e., slippery surface due to rain or snow), and vehicle failure (e.g., tire blowout or loss of power steering). The driver's ability and willingness to perform the required task play a role in the majority of run-off-road crashes (Pape et al., 1996).

Alternatively recent ARRB publication (ARRB, 2011) has listed some known causes of ROR crashes, which include:

- Driver behaviors such as speed, inattention, avoidance maneuvers, errant vehicles
- Driver impairment including fatigue, alcohol, drugs, mood state
- Road conditions such as horizontal alignment, shoulder deficiencies (e.g. excess loose material or steep edge of seal drop-off), slippery surface, poor delineation, damaged surfaces, poor surface quality, being a rural road, animal and improper pedestrian use of roadway traffic lane and driver to save them go in to different action result with sever accident
- Vehicle failure and Environmental conditions such as rain, fog, snow etc.

Based on the cat-agree of vehicle collision, Run-off-road (ROR) crashes are usually involving only a single vehicle accident and contribute to a large portion of fatalities and serious injuries to motor vehicle occupants including the driver. In study by (Eustace et al. 2013), the National Motor Vehicle Crash Causation Survey (NMVCCS) data collected at crash scenes between 2005 and 2007 was used to identify the ROR critical pre-crash event and assess the critical reason for the ROR critical event, and examine associated factors present in the pre-crash phase of the ROR crash. The results of his research shows that over 95 percent of the critical reasons for single-

vehicle ROR crashes were driver-related and the researcher came up with the most frequently occurring category of critical reasons attributed to drivers was driver performance errors 27.7% such as "overcompensation" and poor directional control, followed by driver decision errors 25.4% such as "too fast for curve" and "too fast for conditions," critical non-performance errors 22.5% such as "sleeping" and "heart attack/other physical impairment," and recognition errors 19.8% such as "internal distractions" and "external distractions."

With the presence of alcohol in the driver blood as high as 46.9 percent of driver-related critical reasons for single-vehicle ROR crashes were driver performance errors. In connection with the above argument, the components of the ROR crash factors grouped in to roadway and its environment, the vehicle and the driver (Zhu et al., 2010). These components considered together are a system that must operate in harmony and on the basis of different category of studies, several variables considered with that of factor associated with ROR detail has been discussed in below section

2.4.1. Road and its Environment

Road Alignment

One of the most important tasks in traffic safety is to investigate the relationship between motor vehicle crashes and the geometric characteristics of roadways. A study by (Eustace et al., 2013) investigated characteristics of ROR injury severity by using Ohio crash data with the help of logistic regression analysis. In that study, they found that 21 percent of the total traffic injuries that occurred on Ohio's public roads and streets between 2008-2010 involved run-off-road crashes and from the finding in terms of injures, curved level roads and curved graded roads were more dangerous than straight roads as depicted in Figure below.

It is generally assumed that vehicles will more easily leave their lane on a curve rather than tangent section because of the centrifugal force that acts on the vehicle when it enters the curve (Glennon et al., 1985) and the studies have found that the risk of leaving the traveled way on a curve is about 1.5 to 4 times higher than on a tangent segment

Roadway alignment plays a significant role in the occurrence of ROR crashes and Highway curves have been identified as one of the most significant geometric factors that affect fatal and injuries crashes on street (Wang et al., 2009; Zhu et al., 2010; Eustace et al., 2011; Roy et., 2011). On the basis of the studies (Cejun et., 2011) on road geometry and applying logistic

regression analysis, their statistical result show that among all fatal single-vehicle crashes that occurred on the curved roads, 90.2 percent were ROR crashes, while among crashes that occurred on straight roadways, 62.1 percent were ROR crashes and there by the analysis indicate that the curved road segments are more likely to be the scene of ROR crashes as compared to the straight roadways. Improving roadway design (e.g., flattening curves, signing or more general curve delineation) could reduce the likelihood of ROR crashes.

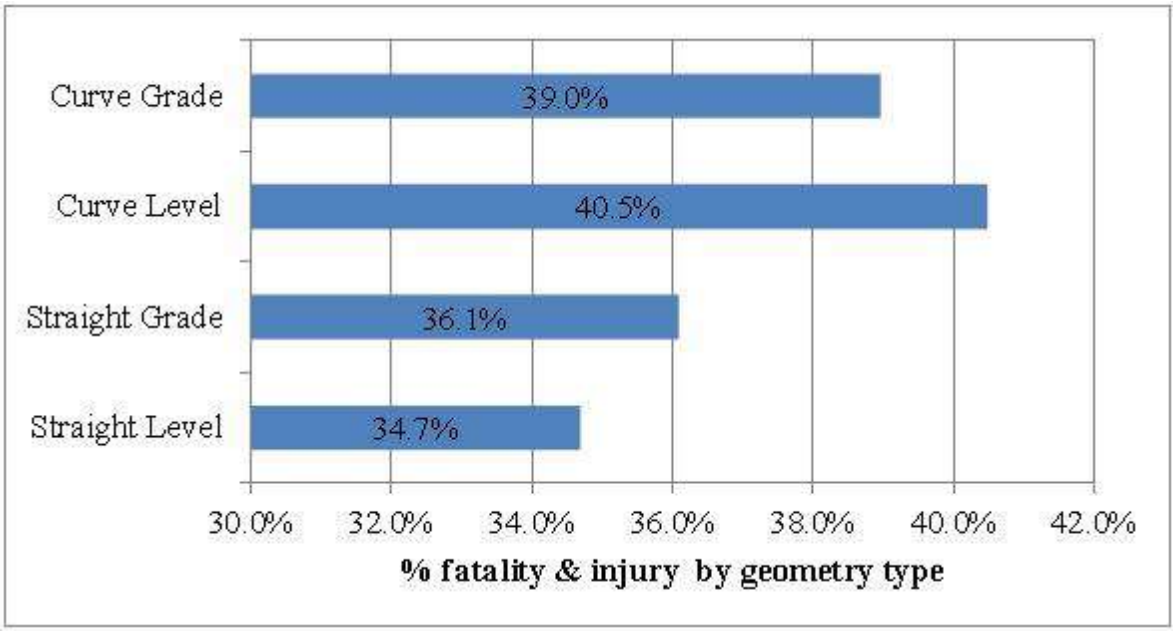


Figure: 2.2. Percentage of Fatality and Injury Due to ROR Crashes by Road Contour

Roadway Function Class

Different classifications of roads have significant influence on traffic safety, so that they determinate the safety related task ought to be undertaken in order to provide an acceptable safety level. It means that it is impossible to prevent traffic accidents altogether unless movement of traffic on highway are completely stopped. But it is possible to alleviate the consequences of a collision to make roads and vehicles become safer, and drivers become more careful and moreover, the risk can be reduced through greater insight into the impact of various roads classifications and functional classification on road safety. Consequently, many municipalities are faced by the paradox that they are unable to identify any black spots on the basis of accident recordings in rural areas even though more than 2/3 of the persons killed in road accidents are on rural roads. In order for the road authorities to continue to spend traffic safety budget money

most effectively there is a requirement for workable non-accident based approaches (Girma, 2000).

It is also of attentiveness to see if the roadway function class makes a difference in the occurrence of ROR crashes. According to the studies of (Cejun Liu et., 2009) on Run-Off-Road Crashes: An On-Scene Perspective of fatal analysis by applying logistic regression model to identify weather the road functional class influence ROR, and they prove from their data of crash analysis, in fatal single-vehicle crashes, among those that occurred on rural roads, 80.6 % were due to ROR crashes, while among those fatal that occurred on urban roadways, 56.2 % were due to ROR crashes, this shows that the rural roads are more likely to be the scene of ROR crashes as compared to the urban roads.

The Organization for Economic Co-operation and Development (OECD, 1999) has identified rural road safety as a road safety concern among its member countries. The OECD published "Safety Strategies for Rural Roads" 1999, which showed that fatal collisions on rural roads are gradually increasing among member countries and the majority of rural fatal collisions (approximately 80%) are single-vehicle collisions, particularly run-off-road occurrences (at least 35% of fatal rural road collisions), head-on collisions (almost 25% of fatal rural road collisions) and collisions at intersections approximately 20% fatal rural road collisions.

Road Posted Speed Limit

Speeding is one of the major problems confronting traffic safety engineers. It was estimated that about one third of all fatal crashes in the United States are speed related (NHTSA, 2003). High speeds have been shown to be associated with higher risks of crash and increased injury severity on roadways (Kloeden *et al.,* 1997). This is explained by the fact that higher speeds lessen the time available for drivers to make evasive maneuvers to avoid or respond to unexpected situations, such as other vehicles turning into or out of driveways or the sudden appearance of pedestrians (Kloeden *et al.,* 1997). Some studies have focused on the impact of speed limit on roadway crashes. The posted speed limit is the main instrument in roadway speed management in most jurisdictions. Speed and excessive speed remains a main contributing factor to road crashes and is an important factor in road safety. In a sense, not only does it affects the severity of a crash, but is also related to the risk of being involved in a crash. The research has been done by (Jinsun Lee) on the influence of posted speed limit on ROR and the findings indicated that

run-off-roadway accidents involving higher posted speed limits at accident crash sites were more likely to result in evident injury and disabling injury/fatality.

In most cases, the actual vehicle's pre-crash travel speed is unknown and as per research done by (Cejun Liu et., 2009), among fatal single-vehicle crashes that occurred on roadways with posted speed limits of 60 mph and above, 81 percent were ROR crashes, while among the crashes that occurred on roadways with posted speed limits less than 60 mph, 69 percent were ROR crashes. This in turn shows that the high speed limit roads are more likely to be the scene of ROR crashes as compared to the low speed limit roads.

In addition to this (Roy et., 2012) has been realizing the influence of posted speed limit on traffic accident using data from Kansas and found that driving too fast for condition/speeding was one of the major factors contributing to ROR crashes. Studies by (Elvik, 2013) showed that fatal crashes decline more substantially with the same amount of mean speed reduction than all injury crashes. In other words, severity of crashes decreases with reduced mean speed. One model in particular has been adopted in Australia and New Zealand to illustrate the effect of impact speeds on severity of selected crash types and (Wramborg, 2005) proposed the three impact speed–fatality probability relationships as shown in Figure 2.3.

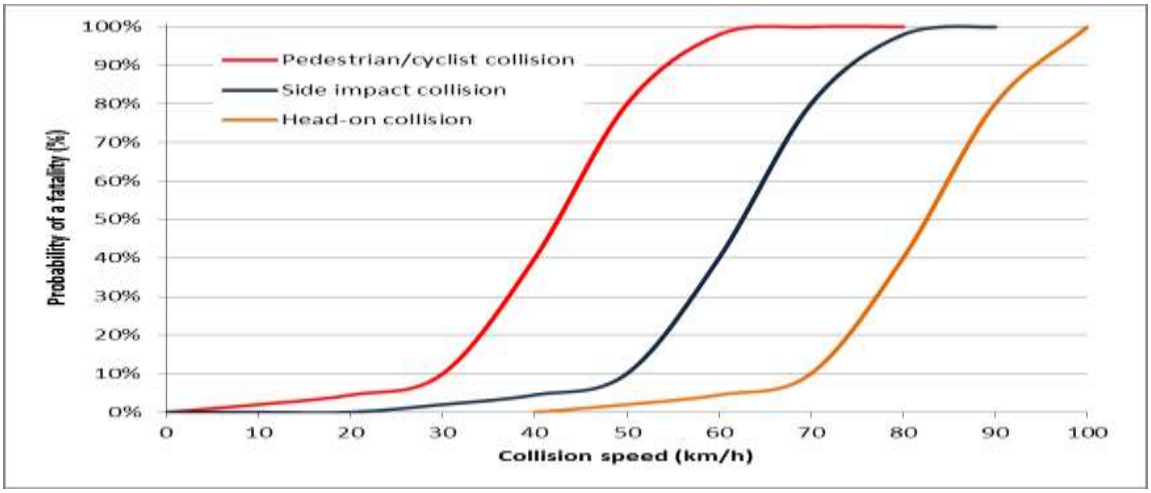


Figure: 2.3. Wramborg's model for fatality probability vs. vehicle collision speeds

In the same way, crash was considered speeding-related if any drivers involved in the crashes were charged with a speeding-related offense or if a police officer racing indicates that driving too fast for the conditions, or exceeding the posted speed limit was a related factor in the crash.

Shoulder width, lateral clearance side slope

Wider shoulder width has a significant positive impact on ROR crash frequency and its severity, were the impact increases with the increase of traffic flow. The reason is that if the driver loses the control and runs-off-the road then a wider shoulder increases the opportunity to return to the traveled way. Similar to the shoulder width, wider lateral clearance has a significant positive impact on ROR crash frequency and crash severity. If the lateral clearance increases then the chance of hitting an object decreases. The ROR crash frequency and severity will decrease significantly if the side slope condition is improved. One can expect a significant reduction of crashes by 90% for a given ADT when the side slope condition is changed from 5 to 1 (Yichuan., 2011)

A study by (Peng et al., 2012) investigated the relationship between single vehicle ROR crashes and the geometric characteristics of rural two lane roads, and they found that crash frequency and severity will increase when there is a decrease in lateral clearance or shoulder width. The low friction of pavement can cause vehicles to skid and run-off- the road on the basis of study performed in New York by (Neuman T.R. et al., 2003) reported that low skid resistance increases crash risk on wet pavement by 50 percent.

Roadway Number of Lanes

Another factor that was worth investigating the influence of roadway number of lanes on ROR crashes. In particular argumentation with number of lane, four categories of roadways were considered one or two lanes (divided or undivided) and three or more lanes (divided or undivided) in the study (Őrnek et al., 2007), were in their reflection the number of lanes refers to the travel lanes of a continuous cross-section of roadway. For example, a local roadway with one lane going north and one lane going south would be coded as two lanes.

However, if a traffic way was a divided highway, with two lanes going north, a median, and two lanes going south, then the number of lanes were coded as two. If traffic way has two lanes going north immediately adjacent to two lanes going south, one continuous cross-section of roadway, and then the number of lanes were coded as four. The results in the research show that among the fatal single-vehicle crashes that occurred on roadways with fewer lanes (one or two lanes), 67.8 percent (divided) and 76.6 percent (undivided) were ROR crashes, while among the crashes that occurred on roads with three and more lanes, 62 percent (divided) and 40 percent (undivided) were ROR crashes. The statistically of this analysis difference shows that the roadways with

fewer lanes (one or two lanes) are more likely to be the scene of ROR crashes as compared to the roadway with three and more lanes (divided or undivided). The roadway design or rehabilitation strategy such as building more lanes were likely to reduce ROR crashes.

To investigate if certain weather conditions contribute to the occurrence of ROR crashes, the percentage frequency distributions of passenger vehicles involved in fatal ROR crashes by weather conditions were obtained by (Őrnek et al., 2007). They considered two weather conditions for sake their analysis tenacity: adverse (rain, sleet, snow, fog, and others - smog, smoke, blowing sand, or dust) and good weather conditions (normal, or clear). Their results shows that among fatal single-vehicle crashes that occurred during adverse weather conditions, 75.5 percent were ROR crashes, while among crashes that occurred during good weather conditions, 70 percent were ROR crashes.

This significance shows that ROR crashes are more likely to occur in adverse weather conditions as compared to good weather conditions and based on the research endorsement, improving roadway design (e.g., providing skid-resistant pavement surfaces) could reduce the likelihood of ROR crashes in different road environmental condition.

Rainfall-related effect on crash severity outcomes has been also identified along with roadway characteristics. Ordered probit models were used in (Abdel, 2003) to predict driver injury severity in Central Florida, with crashes occurring in specific roadway sections, signalized intersections and toll plazas in expressway systems. It was found that crashes happening in signalized intersections with bad weather and dark street lighting had a significantly higher probability of severe injury and stated that an angle and turning collision in the adverse weather and dark street light conditions was a possible reason to contribute higher probability of injuries in signalized intersections.

In contrast, in a study by (Lee et., 2002), with nested logit analysis showed that wet roadway surfaces increased the likelihood of evident and disabling injury/fatality in run-off- roadway accidents. The conflicting results from these two studies suggest the need for a detailed analysis for weather-related crash severity by collision type.

Natural Lighting Conditions

Could visibility due to natural lighting be an issue in the occurrence of ROR crashes? To answer this question, frequency analysis was conducted by (Cejun Liu et., 2011) for two lighting

conditions; nighttime and daytime and among fatal single-vehicle crashes that occurred during nighttime (8 p.m. – 5:59 a.m.), 74.2 percent were ROR crashes, while among the crashes that occurred during daytime (6 a.m. – 7:59 p.m.), 66.5 percent were ROR crashes. In dissimilarity, the occurrence of on road crashes is more frequent during day time and analytical statistical data shows that the night time driving is more likely to result into ROR crashes as compared to the day time period (Dissanayake et al., 1999) and reduced lighting like adverse weather is associated with a significant increase in the likelihood of single-vehicle ROR crashes.

(Yau, 2003) considered five factors, namely, the month of occurrence of the accident, day of the week, time of the day, street lighting conditions and weather conditions, and his results revealed that the day of the week and time of the day are important factors affecting injury severity. It was also found that motorcycle accidents have higher risk during weekends than weekdays because motorcycle drivers driving on weekends may exhibit risky driving behaviors and furthermore, motorcycle accidents are also more likely to happen between night and midnight, this was perhaps due to, the drivers were more susceptible to driving at fast speeds due to the small number of vehicles on the road.

2.4.2. Occupant-Related Factors or driver related factor

It is of interest to see if the occupancy of a vehicle makes a difference in the occurrence of ROR crashes and with regard to the studies done by (Stutts et al., 2001), among fatal single-vehicle crashes involving a vehicle with only one occupant (driver alone), about 68.0 percent were ROR crashes, while among crashes involving a vehicle with two or more occupants, 74.8 percent were ROR crashes. This shows that vehicles with high occupancy (two or more occupants) are more likely to be involved in ROR crashes as compared to a vehicle with the driver alone and he complained the reason for this is not immediately clear.

However, the researcher draws some possible explanation and could be the fact that the presence of other occupants in the vehicle was a likely source of distraction to the driver due to conversation and other activities. With regard to this different research findings indicated that the driver's inability such as exceeding the speed limit, alcohol usage, driver performance-related factors, such as sleep, inattention, over-correction of the vehicle, distraction, lack of driving experience, and ignorance of safety hazards, driver's gender, age, can have a significant effect on the likelihood of severe injury in run-off-roadway accidents (Jinsun Lee)

In the period 2010-2011, SWOV conducted two in-depth studies to gain further insight in causes and effects of run-off-road crashes (Davidse et al., 2011) and in the studies various crash factors were found to have contributed to these causes and effects. But he found that the most frequent human-related crash factors from his finding are: distraction during the driving task 28%, fatigue 14%, alcohol 13% and speed (too high for the conditions) 23%. Most road-related factors are characteristics that should have prevented vehicles running off the road: hard strips being too narrow or absent 10% and semi-hard shoulders 12%.

Driver's Age, gender and personality

Even though older drivers tend to have more driving experience than younger drivers, their crash injury rates are higher, possibly because of reduced mobility and loss of judgment. (Hassan, et., 2012) studies 680 young driver behavior involvement in traffic crash in Florida, and the result revealed that aggressive violation, in vehicle distraction and demographic characteristics were the significant factor affecting young driver involvement in crash at the age of 16-17.

In similar way (Constantinou et al., 2011) found that young driver novice driver (<25 year) are in high risk related to traffic offence and his study was based on gender, sex, age and personality.

On the issue of age, the study of (Abdel et., 2000) with the use of negative binomial model reveals that young and older drivers have a larger possibility of accident involvement than middle-aged drivers when experiencing heavy traffic volume do and the researcher support the evidence that young drivers are also subject to involvement in speeding, increasing the risk of getting into an accident.

In terms of fatality involvement rate young drivers have also been identified as a high-risk group among several special population groups (Dissanayake et al., 1999). The group of young drivers 15 to 20 years old had the highest fatality involvement rates per hundred thousand drivers, where the rate was 64.6 %. Fatality crash involvement per hundred thousand drivers for the 21-24 year old driver age group was 45.0 and it was the second largest among all the age groups (National Center for Statistics for Analysis, Traffic Safety Factors 1999 U.S.A). This was supported by the fact that, poor safety performance by young drivers could in general be attributed to three major factors, inexperience, risk taking behavior and immaturity, and greater risk exposure (Index.html, 2001).

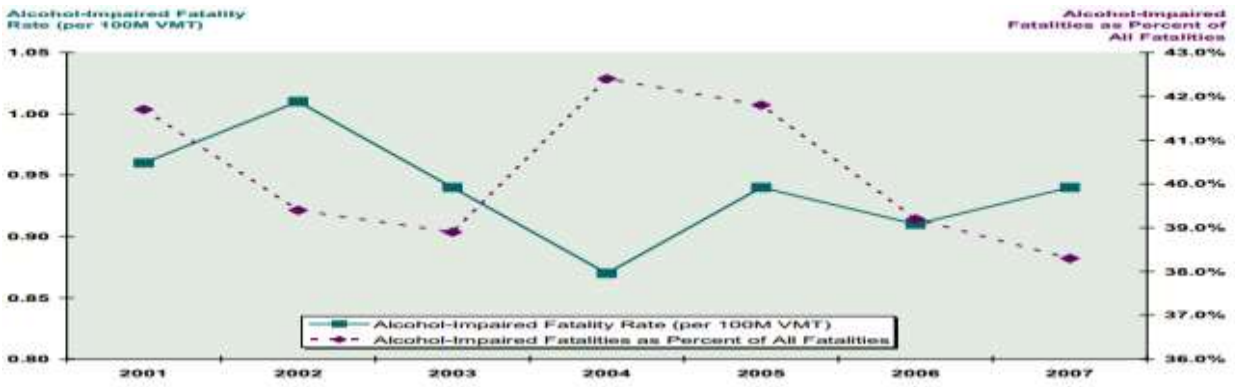
According to the evidence above young drivers who start with little technical ability, lack of proper judgment and inexperience are therefore more likely to be involved in highway crashes

and they are also more likely to be engaged in high-risk behaviors such as not wearing seat belts, speeding, impaired driving, and inattention. While those are factors that tend to increase the crash risk in combination with nighttime driving and having other young passengers are also more common among young drivers. The crash experience of young drivers was different from that of other drivers in terms accident severity and young drivers are involved in more single vehicle fatal crashes than any other driver age group (Index, 2001).

In relation with more highly severed type of fatal crashes and crash due to ROR were the vehicle usually leaves the road and overturns or hits a roadside object such as a tree or a pole. In arguing with above observation different literature look into driver age as a contributing factor in ROR crashes principally and study by (Cejun Liu et., 2011) applying logistic regression analysis and in their studies four age groups were considered: 15-24, 25-44, 45-64, and 65 and older. Among fatal single-vehicle crashes involving young drivers 15 to 24, a higher percentage 75.2% were of ROR crashes as compared to other age groups and this shows that vehicles with young drivers 15 to 24 are more likely to be involved in ROR crashes as compared to other three age groups which are consistent with the overhead judgment by the researcher.

Alcohol-Related Driving

Alcohol increased injury risk for run-off-roadway accidents. As shown in the vast literature on alcohol's effects on traffic accidents such that if drivers have been drinking and are ability impaired, the likelihood of possible injury relative to PDO increases because of their decreased ability to control a vehicle (Jinsun Lee). Alcohol involvement of a driver often leads to safety issues such as loss of vehicle control that may result into a ROR crash. Study by (Liu, 2009) found that the possibility of being involved in ROR crashes for the driver with alcohol use is higher than the sober drivers. Montana Department of Transportation (MDOF) reports that there were 38.3 percent alcohol related fatalities in 2007 caused by ROR crashes. Figure 2.1 shows alcohol-impaired fatality rates for the state of Montana between 2001 and 2007 (NHTSA, 2010).



Year	Alcohol-Impaired Fatality Rate (per 100 M VMT)	Alcohol-Impaired Fatalities as Percent of all Fatalities
2001	0.96	41.7%
2002	1.01	39.4%
2003	0.94	38.9%
2004	0.87	42.4%
2005	0.94	41.8%
2006	0.91	39.2%
2007	0.94	38.3%

Figure: 2.4. Alcohol-Impaired Fatality Rates for Montana, 2001-2007

Driver-Performance-Related Factors

Some of the driver performance-related factors that are likely to contribute to the occurrence of ROR crashes were also examined by different researcher. These include: drowsy, fatigued, and sleepy; inattentive talking, eating, etc. over-correcting of the vehicle; avoiding (avoiding, swerving, or sliding due to severe crosswind, tire blow-out or flat, live animals in road, vehicle in road, etc.); distractions inside vehicles (cellular telephone, computer, fax machine, etc.); and other driver performance related factors, such as mentally challenged, following improperly, failure to signal intensions (Neuman et al., 1998), etc.

(Cejun Liu et., 2011) consider the percentage frequency distributions of passenger vehicles involved in fatal single-vehicle ROR crashes based on the driver performance related factors in their studies. Their statistical analysis show that the percentages of sleepy 91.2%, inattentive 75.4%, over correction of the vehicle 85.6%, and crash avoiding 79.8% drivers involved in fatal single-vehicle ROR crashes are significantly greater than the drivers with 'Other driver performance-related factors' that account for 67 percent of ROR crashes. This research finding signifies that drivers with these performance-related factors (sleepy, inattentive, over correction,

avoiding, etc.) are more likely to be involved in ROR crashes as compared to drivers with other performance-related factors.

2.4.3. Vehicle-Related Factors

Study by (Getnet, 2009) investigated the potential application of data mining tools to develop models supporting the identification and prediction of major driver and vehicle risk factors that cause RTAs. The research used the WEKA version 3-5-8 tool to build the decision tree (using the J48 algorithm) and rule induction (using PART algorithm) techniques and conclude that performance of the J48 algorithm was slightly better than that of the PART algorithm.

The license grade, vehicle service year, vehicle type, and experience were identified as the most important variables for predicting accident severity. (Jovanis et., 1986) found a number of problems with the use of linear regression in their study by applying Poisson regression as a means to predict accidents. For example, they discovered that as vehicle-kilometers traveled increases, so does the variance of the accident frequency. From (Alberta, 2014) studies it is generally believed that ROR crashes are likely to occur due to some vehicle-related factors, such as vehicle speeding or vehicle type defects as per the following table.

Table: 2.3. Different vehicle related factor for ROR crash

Vehicle Factors	N	%	Vehicle Factors in Total Casualty Collisions (All Vehicle Types) %
No Apparent Defect	560	97.1	99.0
Defective Brakes	5	0.9	0.3
Tires Failed	4	0.7	0.2
Lighting Defect	3	0.5	0.1
Improper Load/Shift	--	--	0.0
Other	5	0.9	0.4
Total Number of Motorcycles	**577**	**100.0**	

From this observational result out of different factor affecting accidents, Vehicle factors were identified for 2.9% of the motorcycles involved in casualty collisions compared to 1.0% for all types of vehicles involved in casualty collisions (Alberta, 2014).

The percentage frequency distributions of passenger vehicles involved in fatal single-vehicle ROR and on road crash crashes by passenger vehicle type: passenger car, light truck (LT) including pickup, utility, minivan, other van, and other light trucks) has been studied by different

researcher and most of the finding of them shows that passenger cars are more likely to be involved in ROR crashes as compared to other passenger vehicle types. Rapid growth in population, motorization and urbanization has a direct consequence on road accident.

(Shahnewaz, 2014) undertake the research on Heavy Truck Rollover Model for Single Vehicle Run–off–Road Crashes in Bangladesh by taking accident and casualty statistics of 13 years and he develop analytical model, the result of his observation model shows that among various types of accidents overturning accident is about 9% of total accidents and is responsible for 15% of total fatalities. Based on the result it was concluded that heavy vehicles usually buses and heavy trucks are mostly involved in this type of accident and from the analysis model observe that Passenger cars are involved in more than 70% of fatal Run-off-road crashes.

Table: 2.4; Average number of registered ROR fatalities and serious road injuries itemized by mode of transport.

Mode of transport	Fatal run-off-road crashes		Run-off-road crashes with serious road injuries	
	Number	Share	Number	Share
Bicycle	6	3%	26	3%
Light moped	2	1%	22	3%
Moped	9	4%	97	12%
Motorcycle/motor scooter	23	11%	88	11%
Passenger car	155	72%	521	62%
Delivery van	13	6%	57	7%
Lorry	4	2%	9	1%
Bus	0.2	0%	1	0%
Other	4	2%	12	1%
Total	**198**	**100%**	**758**	**100%**

(Hasanat et., 2013) stated in his hypothesis that rollover of vehicles may not be the sole result of driver performance, rather it was due to the result of complex interaction among vehicle loading pattern, tire characteristics, improper super elevation, cross slope, shoulder drop off, vehicle speed. Vehicles with high center of gravity (CG) are more prone to rollover accident and he lower the position of CG the lesser is the chance to overturn. The location of CG of a vehicle largely depends on the loading height and weight and heavily loaded vehicles with high height usually have higher CG. While the vehicle is in motion, it undergoes continuous jerking and vibration effect from the potholes and rough road surface. If the loading where loosely fastened and of high height, bulging and shifting of load occurs.

Due to this, the horizontal component of CG gradually shifts towards the direction of roadway slope that makes a vehicle more prone to overturn or run out of the travel lane (Hasanat et., 2013). Shoulder drop off were another factor to rollover and it reduce vehicle stability besides impede a driver's ability to handle a vehicle. When left wheels go onto the shoulder, the drop-off causes load difference between left and right tires. In effect, the resultant moment increases due to tilting of vehicles and consequently a rollover moment develops which was observed from studies by (Hasanat et., 2013)

Traffic Volumes

The prominent factors which affect the frequency and severity of road traffic accidents are mainly traffic volume, traffic speed and traffic composition. besides those as the volume of traffic grows the increase of opposing vehicles increases, intervals for passing vehicles are less available, the accidents due to improper passing become frequent, and the frequency of accidents grows approximately in direct proportion to the average volume of traffic volume agreeing to (Babkov, 1975) cited in (Girma, 2000). Here again as the volume of traffic increases, the speed of vehicles drops and the main kind of accident becomes a nose-tail collision.

Another factor, which affects the frequency and severity of road traffic accidents, is composition of traffic since there are different types of vehicles in a traffic stream and different types of vehicles have different physical, geometric, and performance characteristics. Speed and acceleration can vary greatly from one vehicle type to another. High differential speeds in traffic streams result in more overtaking maneuvers and more probable danger of accidents.

The traffic volume of a roadway was an effective predictor of a run-off-the-road crash occurring; besides this study by (Derek Leuer) would examined the traffic volumes to identify patterns between the fatal crashes and the corresponding traffic volume by using Logistical Regression model. The result shows that, there was a non-linear relationship between traffic volume and fatal run-off-the-road crashes. Crash records were matched with the average daily traffic (ADT) of the roadway.

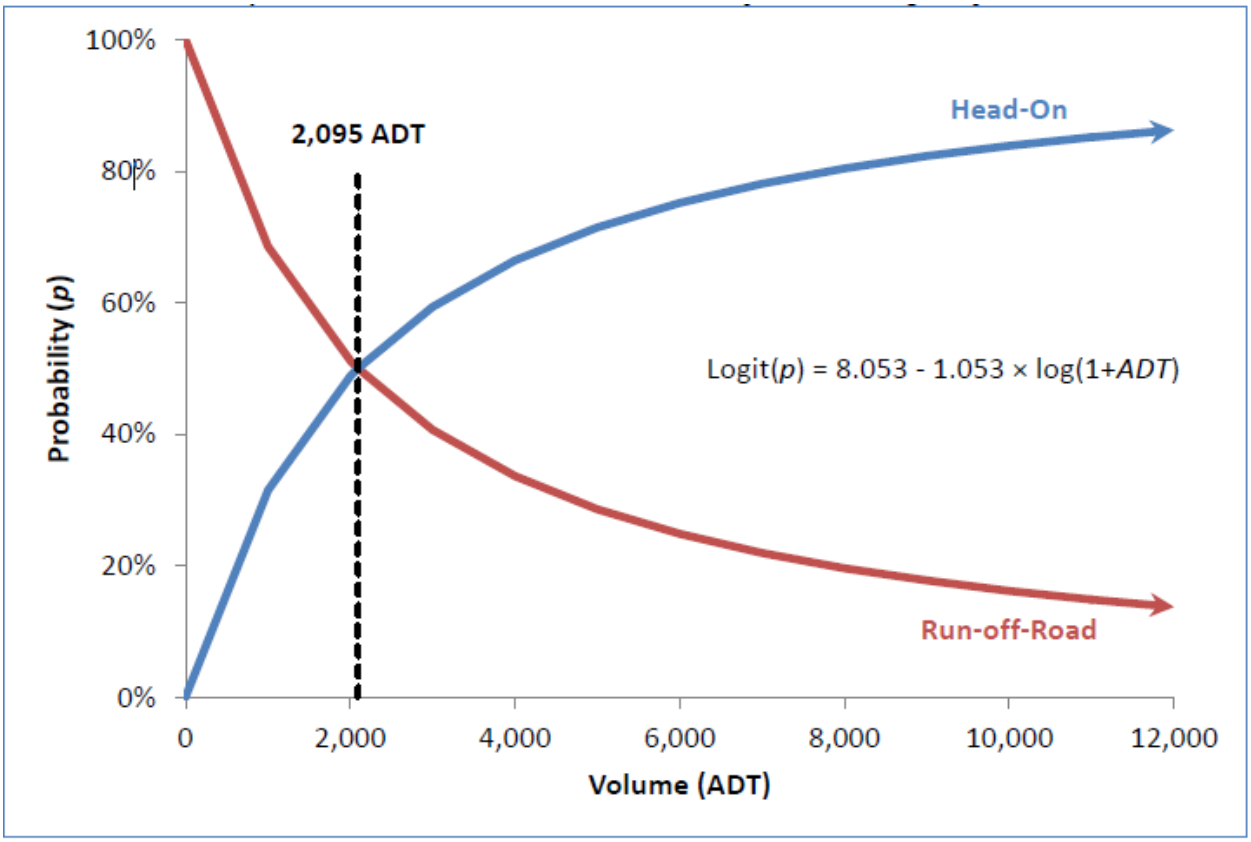


Figure: 2.5. Logistical Regression estimating the probability of a fatal head-on crash or fatal run-off-the-road crash compared to the traffic volume on a two-way two-lane highway

All of the above illustrations explain the trend, effect, cause, outcome, the counter measure taken to reduce, main contributing factor and the severity of road traffic accidents all over the world including our country; and as the life standards of the peoples are getting down the road traffic accident was increasing, and the more developed the lesser traffic accident rate and better safety. In whole part of the world, there are different magnitudes of road traffic accidents and it depends upon the life standards of the people and policies, strategy used for the road transportation system in order to reduce road traffic accidents. Not only one factor reduces the fatalities and injuries due to road traffic accident. But also the mitigation development after the accident happened will play a great role.

2.5 Countermeasures for reducing Run-Off-Road Crash

The National Cooperative Highway Research Program (NCHRP) has developed a number of guidelines relevant to prevent ROR collisions. A multi volume report (NCHRP Report 500; Guidance for Implementation of the AASHTO Strategic Highway Safety Plan, 2006) provides guidance for implementing a strategic highway safety plan. The sixth volume of this report provides strategies that can be employed to reduce the number of run-off-road collisions and in the report the countermeasures are grouped according to three general objectives:

- keep vehicles from encroaching on the roadside;
- minimize the likelihood of crash or overturning if the vehicle leaves the traveled way;
- Reduce the severity of a crash.

In similar way Federal Highway Administration, Roadway Departure Safety: A Manual for Local Rural Road Owners, (FHWA-SA-11-09 Washington, 2011) which is sited on: http://safety.fhwa.dot.gov/local_rural/training/fhwasa1109/ is stating how to reduce the number and severity of roadway departure crashes, and recommend safety practitioners focus on three objectives:

1. Keep vehicles on the roadway and in their travel lane.
   - Strategies include rumble strips, signing, delineation, and high friction surface treatments.
2. Reduce the potential for severe crashes when vehicles do leave the roadway or cross into opposing traffic lanes.
   - Strategies include shoulder installation; widen the separation between opposing direction lanes, removing fixed objects, and slope flattening.
3. Minimize the severity of a roadway departure crash if it occurs.
   - Strategies include breakaway supports, traversable drainage grates, barriers such as guard rail (or guide rail), and end treatments.

In most cases, lower-cost, highly-effective solutions are available at the top of the hierarchy. For example, warning sign installation has proven to have a significant effect on the reduction of curve-related crashes. It is important to note that some treatments are less likely to prevent crashes. For example, guard rail can reduce the severity of a roadway departure crash when it occurs, but it does not prevent the crash event. When considering the cost of a treatment, it is

important to remember that the agency will need to maintain the countermeasure, and this can vary significantly between the various treatments.

There are typically three implementation approaches to consider in reducing roadway departure crashes or ROR crash, these are; systemic approach, the spot location approach, and the comprehensive approach and these approaches may be done alone or in combination with each other (National Roads Safety Coordinating Office, 1997, http://safety.fhwa.dot.gov http://safety.fhwa.dot.gov).

Systemic Approach

A systemic approach was focused on installing crash reduction countermeasures over a wide range or number of sites that share a high risk factor. Examples of risk factors could be lane width, speed, traffic volume, horizontal curvature, or traffic control devices. An agency can develop a list of risk factors through an analysis of the crash reports for an area.

This approach was not limited by finding the exact location of crashes, because the approach considers multiple locations with the same risk factors. Countermeasures are selected that can be deployed among all locations that share specific risk factors. These countermeasures are typically low-cost and can be deployed easily and although roadway departure crash locations are difficult to predict, the most common contributing factors to severe roadway departure crashes are predictable and consistent from year to year, so a systemic approach to safety mitigation can be quite effective. When addressing roadway departure crashes, the systemic approach typically includes the application of low-cost treatments along segments of roadway or entire routes (Parkhill, 2006).

The following low-cost countermeasures have been identified as being effective in reducing roadway departure crashes and resulting injuries and fatalities when applied systemically:

- Basic traffic control such as signing and pavement markings in advance of and within curves.
- Centerline and edge line pavement marking to assist drivers to maintain their position within their lane.
- Center line rumble strips to reduce head-on and opposing-direction sideswipe crashes
- Edge line and shoulder rumble strips to reduce single vehicle run-off-road crashes

- Safety Edge treatment on the edge of pavement to reduce edge drop-off crashes
- Speed-feedback signing measures to reduce speed-related roadway departure crashes
- Selected fixed object removal especially trees and utility poles to reduce fixed object crashes.

Spot Location Approach

Another approach for reducing roadway departure crashes is focused on spot (site) locations. This approach is traditionally used to deal with locations that may not be addressed by a systemic approach. These locations may be characterized by a high number of crashes for a small length of roadway and in such cases; the analysis of the site drives the type of countermeasures that are implemented. This analysis could involve moderate to higher cost improvements as dictated by the conditions at the location. For example, poor pavement surface may cause ponding, leading to a high number of wet roadway related crashes. Rehabilitating the pavement surface will correct the situation.

Comprehensive Approach

In addition to infrastructure issues, the comprehensive approach addresses human factors issues such as speeding, impaired driving, distracted driving, and seatbelt use, all of which can contribute to roadway departure crashes.

Speeding; a large percentage of roadway departure crashes are speed-related, and reduced speed may have prevented the crash. Countermeasures to reduce excessive speeding or reduce the severity of the crash include speed enforcement and traffic calming measures.

Impaired Driving; Impaired drivers have trouble navigating the roadway, especially around curves. Strategic enforcement that targets impaired driving coordinated with education and safety awareness efforts can reduce impaired driving.

Distracted Driving; Similar to impaired drivers, distracted drivers have trouble navigating horizontal curves and can drift out of their lane when distracted (e.g., texting, cell phone use, radio, passenger distractions, drowsiness). Treatments include rumble strips and flashing beacons at curves combined with targeted enforcement.

Seatbelt Use; Seatbelts have been proven to save lives, yet the percentage of use especially in rural areas remains very low in developing country. Education and enforcement can help increase seatbelt use, which in turn can reduce the severity of crashes when they occur.

In addition to this (Parkhill, 2006) stated that both the severity and frequency of run-off-road collisions may possibly be reduced through roadway and roadside design. The frequency of ROR collisions can be managed by roadway characteristics that facilitate maintaining the lane or recovering of the lane. And the severity of these collisions can be managed by roadside design that is "forgiving"; i.e. roadsides that are clear of obstacles which might be unavoidable for a driver who has left the roadway.

(Jin sun Lee et., 2009), investigation represent an attempt to define the relationships among roadway geometry, roadside characteristics, and run-off-roadway accident frequency. As per their research several conclusions were drawn regarding the effect of roadway geometry and roadside features and Evidence from their results strongly indicated that run-off-roadway accident frequencies can be reduced by

- Increasing lane and shoulder widths; widening medians;
- Expanding the approaches to bridges;
- Shielding, relocating, or removing roadside hazardous objects; and
- Flattening side slopes and median.
- Correct and predictable road layout, and a forgiving layout with rumble strips, hard strips and semi-hardened road shoulder

2.6. Black spot identification

Road accidents cannot be totally prevent/stop, but by using suitable traffic engineering, safety plan and management measures, the accident rate can be decrease and inline to this one of the most important factors to reduce traffic accident was identification of hazard locations. To do that a precondition for the management of road traffic safety and reduction of road accidents were the systematic collection of data on traffic accidents that will enable the identification and determination of the place or section where there are high concentrations of road accidents, and in contrast determination of hotspots was the first step to improve the level of traffic safety on the roads. The definitions of black spot were different from country to country.

Based on different categories of previously encountered research it could be defined as such highway black spots are highway locations or section of the roadway where the potential for accidents were unacceptably high. According to this definition the most common assumption for black spot location was that there should be any road environmental or geometric issues resulting in the repetition of accidents (Black spot manual, 2001).

Independent, specific definition black spot as defined by (Montella, 2010), were a segment of road in which the geometry and/or the traffic control of the segment contribute significantly to the likelihood of a crash occurring and leading to the crash frequency being higher than expected for the particular road segment and accident-prone section the road segments whose occurrence was higher among comparable ones.

In Thailand, a black spots definition was given by the SweRoad of Sweden in 1999 when the Ministry of Transport and Communications commissioned, the SweRoad of Sweden together with local consultants to carry out a comprehensive road safety project in Thailand. Among various proposed strategies, black spot improvement program was also presented. The study team defined a black spot as a location or section where many accidents have occurred and/ or the risk of being involved in an accident was high, and the risk of being injured in an accident was high, so that black spot may be an intersection, or a section of road, or any other location that fulfills the definition.

Different researcher could identify black spot using different types of method such as simulation, statistical model, existing software such as SSPS, GIS, Microcomputer Accident Analysis Package (MAAP), etc. with the reference to traffic accident data as secondary data and field investigation, (**Guyu, 2013)** identify the major accident black spots in each sub-city of Addis Ababa separately by using statistical frequency and intensity of road accidents and the findings of the study revealed that there were 125 major accident black-spots in Addis Ababa as a whole. According to his realize the distribution by sub-city shows, 10, 11, 24, 10, 21, 10, 20, 6, 4 and 9 RTABSs in Kirkos, Bole, Arada , Yeka, Lideta, Nifas-Silk/Lafto, Addis-Ketema, Akaki, Kolfe and Gullele sub-cities respectively.

In relation with method of identification, (Snehal., et al., 2015) hinted that accident-prone locations/section can be identified by ranking the parameters based on their severity and calculating the severity index. To do this physical survey was carried out at the actual location

for selected stretches of Mumbai- Pune Expressway and Pune- Solapur Highway. The parameters which caused maximum number of accidents were assigned maximum weightage and top rank. The summations of the weightages were calculated to find out the total severity and the severity index was then calculated by adding the weightages of each parameter present divided by the total severity.

Wichuda Kowtanapanich found out that both conventional method and public participation method were used to identify the black spot locations, in parallel way the methods used for identification of black spots in his research were Accident Rate Method, Accident Density Method, Severity Index Method, Number of Accidents Method, Quality Control Method and Combined Method are special method for rural road section categorizations. (Gashaw et., 2016) precluded study in Ethiopia and there objective were to identify the hazardous locations of road traffic accidents and suggest countermeasures to mitigate the occurrence of traffic accidents and the studies was based on districts exposed to high traffic volume in Oromiya region with the use of purposive sampling method by considering road accident data collected from all administrative districts from 2005 -2007 E.C, on the study area. To rank each of the sample districts, evaluation of Priority value had been used consisting of a number of deaths, minor and major injuries occurred for three years and the result of the studies shows that there was a significant increase in terms of the number of deaths occurring due to road traffic accident as a result of the increase in the coverage of road crashes and its consequences at different single black spot.

According to the above researcher view, in order to minimize the frequency of road traffic accidents at the identified hazardous road locations, countermeasures were recommended, addressing to the concerned agency which includes speed breakers, installation of guardrails at curvatures, installation of hazard light to minimize night time road accidents, motivation of road safety education, removing roadside obstructions, repair and maintenance of pavement defects to restore to as-is good condition, and building additional facilities for pedestrians in urban area.

However, literature points out that there were no universally accepted definition of what should be considered as ‘dangerous’ (Geurts et., 2003). Indeed, according to (Hauer, 1996) some researchers rank locations by accident rate (accidents per vehicle-kilometers or per entering vehicles), some use accident frequency (accidents per km-year or accidents per year) and some

use a combination of the two. Furthermore, there was a wide range of methodologies available, ranging from simple models based on actual accident counts to advanced statistical models based on estimates. According to (Taylor et., 1977), seven methods can be used to identify dangerous sites on the road network, each with different order of importance and precision (European Union Road Federation, 2002):- Accidents frequency, Hazard potential ratio, Joint method with accident frequency and accident risk ratio, Confidence interval method, Method of the accident severity ratio, Risk rate method and inventory of the accident risk elements on the road.

In a previous paper cited in different research, a sensitivity analysis was carried out to investigate the strengths and weaknesses of the method that was currently used in Flanders (the Flemish speaking community of Belgium) to identify and rank dangerous accident locations (Geurts et al., 2004). These accident sites are selected by the Flemish government by means of their historic accident data for the period 1997-1999. Based on these data, each site where in the last 3 years or more accidents have occurred was selected. Then, locations were considered to be dangerous when its score for priority (S), calculated using the following formula, equals 15 or more (Ministry of Flemish Community, 2001):

$$S=1*X +3*Y +5*Z,$$

Where X = Total number of light injuries, Y = Total number of serious injuries:-Each casualty that admitted more than 24 hours in hospital) Z = Total number of deadly injuries: - (Each casualty that died within 30 days after the accident)

(Deshpande et al., 1987) developed an index which consists of all the factors and provided a proper comparison of actual accident rates and found out that this index can identify the factors influencing it. (Srinivasan et al., 1987) observed that for identification of accident black spots on national highway in Kerala, there are three scientific methods which can be used namely i) Quantum of Accident Method; ii) Accident Prone Index (API) method and ii) Weighted Severity Index (WSI) method and it was concluded that weighted severity index method was found to be most suitable black spot identification along the stretch or on the section of the road during their research method comparism, and in there study they draw different conclusion and recommendation in order to find severity index they use so that mathematical ratio as follows.

Weighted Severity Index, (WSI) = (41 x K) + (4 x GI) + (1 x MI)

Where:- K - the number of persons killed, GI - the number of grievous injuries, MI - the number of minor injuries and in order to deciding the location in to black spot the set; locations having WSI above 40 are termed as accident black spots

(Meuleners et al., 2008) studied the international black spot programs in 12 different countries including the USA, Belgium, the UK, the Netherlands, Denmark, Portugal, Canada, New Zealand, Germany, Sweden, Austria and Norway. According to Meulenerset, the majority of the countries use a non-model based (crash number and crash frequency) black spot identification method. Meanwhile, a few countries, such as Canada, Texas, Austria and the UK use the "crash rate" method (crashes per vehicle km) which was simple model based. Only three countries identified the use of model-based methods of identification, including category analysis in Kentucky, USA, the Poisson statistical method in Denmark and the Empirical Bayes approach in Portugal. All three of these countries use these methods in combination with the non-model based "crash number" method.

Similarly, (Sorensen et., 2007) examined the black spot method used European countries and reported their studies under the title of "Best Practice Guidelines on Black Spot Management and Safety Analysis of Road Networks" in the six European Framework Programs. They rated Model-based methods as best practice for black spot identification, because of the usage of statistical techniques that take into account systematic variation determined by general road design and traffic volume, as well as random variation. The Empirical Bayes technique, traditional approaches including the Poisson or Negative Binomial Distribution and Category analysis are rated as Model-based methods, considered the best from a theoretical point of view. They declared the weakness of these model-based methods, as they require comprehensive and connected crash, road and traffic data. When such data was not available they suggested using non-model based methods of identification and the best non-model based black spot identification methods are ranked as crash frequency-rate, crash rate, crash frequency and crash number, respectively in this report.

Study by (Saffet, 2015, Black Spot Manual, 2001, Wichuda Kowtanapanich) propose the method used to call as black spot for the road section which was called the Rate–Quality–Control Method consists of calculating three different parameters for each road section but those three methods are independent.

A) Crash Frequency: -

Crash frequency was one of the simplest forms of crash data analysis and it was defined as the number of crashes occurring within a specific period on a highway segment. In this way highway network divided to (nearly 1 km) segments and applying this method, segments are ranked in descending order so that, in order to compare segments of different lengths, the total numbers of crashes were divided by the segment length within the same time period so that the result observed in this part should have to greater than critical value (Fc), were Fc calculated with the formulae as shown below (SWEROAD, 2001).

$$Fc = Fa + \frac{K\alpha\sqrt{Fa}}{L} - 0.5/L$$

Where, Fa- average F value which was determined from accident severity occurred in the whole section in consideration combined with total number of accident occurred on the section and Kα was the significance level.

B) Crash rate: -

The crash rate (CR) method normalizes the frequency of crashes with exposure data and crash rate analysis typically uses exposure data in the form of traffic volumes. Traffic volumes are expressed in the form of Annual Average Daily Traffic. The crash rate analysis provides a more effective comparison for similar locations and in order to compare the segments of different lengths, the total number of crashes (TA) was multiplied with 1,000,000 then divided by the segment length and Annual Average Daily Traffic data in the same time period. These results are compared with a critical value (CRc); were crash rate has been estimated using formulae given below and in similar way the value calculated in each section should have to be greater than critical crash rate value to be black spot (SWEROAD, 2001).

$$CRc = \lambda + K\alpha\sqrt{(\lambda/m)} - 0.5/m \quad and \quad CR = TA * 1000000/(AADT * 365 * L)$$

Where λ - the average crash rate for the similar segments, m - AADT for that segment and k_α - the significance level

C) Crash severity:-

Hence this method has been used in this study so that brief explanation was drown based on the former literature, and in this method, amount of severity measured for road section can assist

officially in determining its safety improvements. In addition, if two similar sections have the same number of accidents, it may be appropriate to select the section with more severe crashes for improving. In order to compare the segments of different sections, as defined in (SWEROAD, 2001); the accident severity of a section was calculated by using statistical equation which was function accident severity combined with some ratio in terms cost of accident (Wichuda Kowtanapanich, Saffet Erdogan, 2015, black spot manual, 2001).

Severity (S) =Number of Fatalities x 9 + Number of Injured Persons x 3 + Damaged property x1.

This value can be divided by some suitable value and one such a value could be the number of accidents (Ai), were number of accidents on section i during a certain time period

Hence road network has been classified into different road segment/section and the relative severity value Q_i for a (segment/section) i was then calculated as follows:-

$$Qi = Si/Ai$$

The average severity value is estimated with

$$Qaverage = \frac{\sum_{i=1}^{n} Si}{\sum_{i=1}^{n} Ai}$$

And the variance σ^2 is estimated with the equation written below

$$\sigma^2 = \frac{1}{n-1}\sum_{i=1}^{n}(Qi - Qave)^2$$

Finally for critical judgment, the result values compare with a critical value (Qc) that was calculated with the formulae,

$$Qc = Qaverage + K\alpha\sqrt{\sigma^2}$$

Hence after classifying road network in to sub categorical section and considering accident severity in terms of above formula; then, road section were considered to be a black spot, from the severity point of view, if $Q_i >= Q_C$.

(Mohammad, 2014) research intended to develop a systematic prioritization technique to identify winter-weather crash hotspots by using Empirical Bayes technique that addresses the serious limitations of the traditional methods to screen road networks for identifying high crash

locations, in line to thus, the time interval used in the process of black spot identification should preferably be a multiple of a year due to the use of multiples of a year will prevent possible distortions of crash trends by seasonal factors. A short time interval, such as one year, will enable early action to be taken at sites at which sudden increases in crash numbers or crash severity have occurred. However, due to random fluctuations in crash data, the reliability of the data increases with a longer time interval.

A longer time interval allows the smoothing of random fluctuations, revealing the underlying trend. However, the use of a relatively long time interval may distort the analysis, because changes in underlying road and traffic conditions could cause changes in the pattern of crashes. (May, 1964) used crash data collected over a 13-year period at 433 intersections to study the effect of time interval on the reliability with which black spots can be identified. On the basis the finding from his research it was concluded that the optimal time interval should be three years and that there was no significant gain in reliability beyond a three-year period. In other studies by (Nicholson, 1987) suggests that a period of five years be used for optimum statistical reliability. In general, the optimal time interval for traffic crash data analysis has been decided to be three to five year (Black spot manual, 2001).

Chapter 3

Research Methodology

3.1. Introduction

This section discusses the methodology used in order to achieve the objectives of the study and deals with the clear-over view about the study area, crash data, and method of data collection and how the data should be organized for the application Bayesian Statistical Approach equation for analysis of the data. It also contains detailed discussion of the main statistical techniques specifically the historical overview and basic equation of Bayesian Statistical Approach equation and black spot identification statistical method used in the analysis of the crash data has been discussed in detail.

3.2. The Study Area

The study was conducted in the south western part of the Ethiopia in Oromia region, East Wollega zone having different wareda. This zone is divided into different administrative districts and has one administrative city which is the capital Nekemte having latitude and longitude of 9°5′N 36°33′E and an elevation of 2,088 meters and is located at 331km from Addis Ababa centered in Southwest part of the country. This zone is bounded by Amhara National region in North, West Shawa zone in the East, Jimma zone in Southeast, Ilu Aba Bora zone in Southwest, West Wollega zone and Beni Shangul Gumuz National region in West direction. This zone is bounded by all mentioned parts of the country and there are also national road networks connecting the capital of the zone with the neighbors including the wereda in the zone. The road network shows towards Addis Ababa in the East, Amhara National Region in the North, to Jimma and Ilu Aba Bora zone in the Southwest, to West Wollega and Beni Shangul Gumuz National Region in the West from the capital Nekemte.

Figure: 3.1. Study road network **Source: Google earth.**

3.3. Traffic Accident Data

Road traffic accident data were collected from report of the traffic police in East Wallaga zone for the study period of 2005 to 2008. These reports include general information about the crashes, the motor vehicles and all people were involved in the Crashes. Out of this accident, parts of them were found in less built–up areas (local towns) along the stretch road and the rests or most proportion of the accident were occurred in rural areas. In contrast the source of road accident data were accident booklets compiled by Traffic stastician officers and to acquire reliable data, a road traffic accident form was designed with the help of excel software sheet conforming with national statistical data base.

The form included:-

- Number
- Date, day, time of accident, year
- Vehicle type, plate code and plate number of the vehicle ,their registered place
- Driver sex, age, license grade and state of their license and education level,
- Weather, road type, and illumination condition,
- Accident type, Degree of severity,

- Number of victims (driver, passenger, and pedestrian), sex, age, severity;
- Location of accident, and
- Contributing cause of the accident from the narration of the traffic police during accident has been occurred

Integrating or compiling the Crash data Files

Once the data has been obtained and since the file was disordered, to use the file in the required format and equipped for analysis work, each of the files used in the study has been categorized in to the following class for simplifying the compilation;- crash records, vehicle and people records, where each of them has been described below and there classification follows that the pattern of the format required in the research proposal and deviation from the format were based on the data acquired from the source of data.

Crash Records

This file covers all the information about the crash, and reports all the details constraint of crash and specific information of crash recorded in the file including crash record number, crash type or collision type (i.e. run-off-the road, pedestrian involvement. vehicle/vehicle collision), degree of crash severity, vehicle class, date of crash, time of crash, crash location, type of road, contributing factor for the crash i.e. Alcohol or drugs were involved even if they are not tested, speeding and vehicle, road was involved in the crash and detail about the driver etc.

People Records

In this part of crash record; all the information about each person involved in the crash has been recorded. Information recorded in people record file includes; driver license grade, state of their license, unit number or the number of person affected by the accident in each type of severity listed in the crash record data format, person type (e.g., driver, occupant, or pedestrian), age, gender, safety equipment used, etc. but, the data has no complete information especially driver education level, experience, driver in relation with the vehicle has not being stated in the format they use in field crash data collection or the traffic police recording accident data on the site has no such form.

Vehicle record

This file contain the vehicle involved in the crash: vehicle in collision type, type of vehicle, their plate code, their registration number in relation with where they are registered in terms of region or national or international name, and from their plate code the owner of the vehicle has been

identified, i.e. government or privet sector since there were no quotation observed from the crash data form about the owner of the vehicle and also the format they use doesn't dictate the detail information of the vehicle involved in the crash.

3.4. Creating of Run-off-Road-Related Traffic Crash Record

By using the joined file, a new file that contains ROR crash records only was created by inquiring and sorting the records using a variable known as SEQUENCEEVENT1 shown in the figure:- 3.2, (Cole D et., 2013). The variable in SEQUENCEEVENT1 has been referred from cited literature and modified or developed as per the requirement objective before going to the data collection during literature review period or proposal preparation time interim with required information extraction for the crash type in the study. While developing SEQUENCEEVENT1, the decision for those criteria depends on the requirement for answering the objective of the research. A particular crash event was classified as an ROR crash if criteria in the SEQUENCEEVENT1 variable are satisfied or simply if it was recorded on the report of traffic booklet file as overturn/rollover; leave the road, run-off-road right, run-off-road left, cross median/centerline, or crash with a fixed object which was specifically written on sequence. If a record did not contain either one of the above mentioned events or in the SEQUENCEEVENT1 figure 3.2 shown below, then it was categorized as a NROR crash. Thus, the file was split into two files, i.e., ROR crashes only file and NROR crashes only file. Some records with either missing variables or recorded as unknown were deleted from the ROR crashes, and only file to create a final file of ROR-related traffic crashes with their associated information should have been considered.

Thus, registered accident booklet file containing total of 374 and 188 of the records are run-off-road traffic crashes with almost complete information while some are partial crash-related information and the rest are non-run-off-the road crashes. Considering this, observation from the crash record and result from the total crash collected indicates that, about 50.4 percent of the total crash records involved ROR crashes, and while 49.6 percent were NROR crashes. This data has been used to investigate ROR crashes, and calculating their frequencies and percentages/ in the data analysis based on the model selected. Further, the values obtained were compared at various levels to analyze trends and patterns of specific crash parameters with respect to time or type of crash, or the extent of fault for the drivers involved. Also, certain pairs of parameters were selected to observe differences in the combination of conditions prevailing during higher

crash-occurrence levels and eventually driver, vehicle, road and its environment related factors were extracted to compare the existence of these factors in both ROR and NROR crashes prediction.

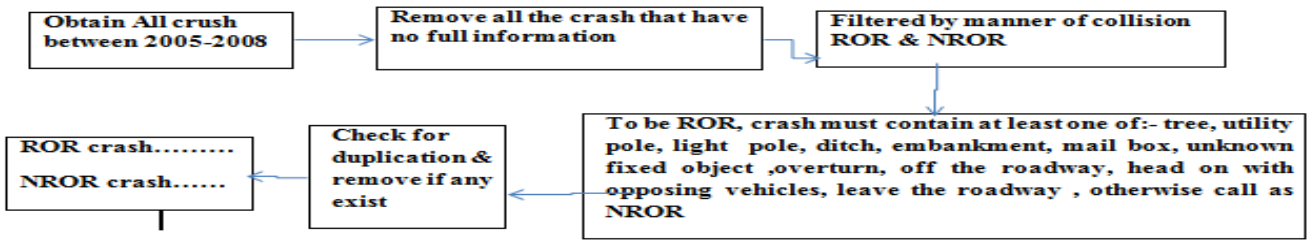


Figure: 3.2. SEQUENCE EVENT-1 developed for classification of the data

3.5. Identification of the contributing factor for the crash

The primary contributing factors were determined from the crash report filed; which included items such as the traffic police inspectors narrative that are included in the crash data collection, reviewing different type of research and documentary about the crash information around the area for identification of the contributing factor as well as black spot and sample observation road condition around the area by capturing photo/video record and vehicle categories passing mostly around the road network are the method used for identification of the contributing factor.

3.6. Basic Methods for Analysis – Bayesian Statistical Approach

Engineers often have to analyses accident data to estimate the level of safety at different road infrastructure elements (segments and intersections) in order to identify hazardous (unsafe) locations and to evaluate the effectiveness of road safety countermeasures. In order to accomplish this they may use different type of statistical analysis model or software and one of the models used by different traffic safety researcher was Bayesian statistical approach.

In similar way in this research methodology, Bayesian statistical approach equation was used in conjunction with basic statistical method and the basis of the selected methods and their suitability to injury severity data and identification of contributing factor for the accident with the use of probability equation in order to identify out of many factor contributing the crash which one were the most probable or frequently exist are discussed in detail this section.

This method of analysis approach has been applied in many previous studies i.e. Bayesian statistical approach can be used to estimate safety (accident rate/frequency) at any location (segment or intersection) or a group of locations, and how these estimates can then be used to identify Accident Prone Locations and to evaluate the effectiveness of remedial measures. It can

be utilized effectively in situations where sample sizes are inadequate and with this, reliable estimates of safety can be obtained using only one year's worth of accident data, providing the size of the reference group will be sufficiently large; (CJ Mollett, 2000).

Study by (Sundanda, 2010) use this method to characteristics and identify contributory Causes Related to Large Truck Crashes fatal Crashes: To study this issue, fatal crash data from the FARS was used to analyze characteristics and factors contributing to truck-involved crashes. Driver, vehicle, and crash-related contributory causes were identified, and as an extension, the likelihood of occurrence of these contributory causes in truck-involved crashes with respect to non-truck crashes was evaluated using the Bayesian Statistical approach.

In addition to this Bayesian statistics were an effective measure in recognizing the predominance of crash-related with Run-off-the road crash (ROR) based on the collected traffic accident on the roadway in order to identify which of the parameter used in traffic crash record would be the contributing factor by using basic probability method, and a mathematical procedure that applies probabilities to statistical problems; (Uttara Roy et., 2011) so that, this method uses the word probability in precisely the same sense in which this word were used in everyday language, as a conditional measure of uncertainty associated with the occurrence of a particular event, given the available information and the accepted assumptions.

The reason for adopting Bayesian estimation have twofold. Firstly, although the data seem to contain a wealth of information on different accident types, the numbers of explanations per accident location were very low and hence the choice for a Bayesian analysis was preferable. Secondly, the Bayesian treatment of the model enables us to obtain a probabilistic ranking of the locations in case where such methods are used. The latter were important to verify the impact of the uncertainty/variability that will be present in the data on the ranking of locations. Here, there were specific parametrical equation of Bayesian model used in this research work and the procedures followed in order to use the equation would be described below.

- The conditional probability of the occurrence of a driver, vehicle, road and its environment related contributory cause for an ROR crash can be obtained by using the following equation,

$$P(CC/ROR) = \frac{P(ROR/CC) * P(CC)}{P(ROR)} \quad \ldots\ldots (1)$$

Where, parameter in the equation has been defined and estimated according to the method displayed below.

- P(CC/ROR):- Probability of the specific driver, vehicle, road and its environment related factor causes being reported as a contributory cause for a particular ROR crash and this was a function of different parameter stated on this page.
- P(ROR/CC); - Probability that the crash was an ROR crash, given that a specific contributory causes were also reported. As shown in Equation (2), this value will be estimated from the data by considering the total number of crashes with the contributory cause and those in which an ROR crash and the contributory cause are coded together.

$$P\ (ROR/CC) = \frac{\text{Number of ROR crash with that contributory cause}}{\text{Number of all ROR and NROR crash with that contributory cause}} \quad (2)$$

- P(ROR); - Overall probability of a ROR crash and this would be estimated via equation.

$$P\ (ROR) = \frac{\text{Number of ROR crash}}{\text{Number of all ROR and NROR crashes}} \quad (3)$$

- P(CC):- Overall probability of the specific driver, vehicle, environment, and road-related causes being reported as a contributory cause for the crash, and thus estimated from the number of cases in which the contributory cause (CC) was reported.

$$P\ (CC) = \frac{\text{Number of crashes with that contributor cause}}{\text{Number of all ROR and NROR crashes}} \quad (4)$$

- Similarly, the conditional probabilities of a contributory cause for a given NROR crash were calculated following the same step.
- The likelihood ratio were then estimated with the following equation thus; the ratio of these probabilities generates the likelihood ratio of that contributory factor as shown in Equation 5:

$$\text{Likelihood ratio} = \frac{P\ (CC/ROR\ crash)}{P\ (CC/NROR\ crash)} \quad (5)$$

The computation of likelihood ratios, using Bayesian posterior probabilities were valid and useful. In similar way it makes good logical sense, while producing significant results from projected analysis of crash factors and the likelihood ratio of a given contributory factor being recorded in a ROR crash as compared with a NROR crash was assessed from crash records. This likelihood ratio will be the probability of a crash being a ROR crash when the contributory factor

was recorded, as compared with the probability of a crash being a NROR crash when the same contributory factor was identified in such way that the larger the likelihood ratio, the greater the association between the contributory factor and crashes type relative to NROR crash.

3.7. Specific equation used in black spot identification method

Considerable past studies were emphasized on identification of black spot and in their judgment accidents are caused because of not only one single factor. Thus, multi-disciplinary approaches were essentially needed in understanding the problems and providing better and appropriate solutions (Soemitro et., 2005). Identification of black spots that are more dangerous from accident point of view can help in better planning road safety policies, modification of design to make smooth traffic flow that will reduce density of accident at specific location and it was the most important factors to improve traffic character and reduce traffic accident.

A number of statistical models have been used to estimate accident rates and/or accident frequencies on a specific road section over a given interval of time (Hauer et., 1987, Hauer, 1996, Nassar, 1996, Geurts et., 2003)). Based on the above evidence; the technique to determine a black spot location varies from place to place and one of the methods used to identify road section black spot was considering or separating accident severity from the crash data base especially on the rural section of the road; since the exact location of accident concentration previewing/ estimation was difficult.

In order to use an accident severity for identification of road section black spot, thus would suggested to segregate the level severity of specific accident occurred using weighted Severity index method. This should be done by the use of a weighting principle where fatal accidents and accidents with seriously injuries are weighted more than accidents with only property damage.

In other word the purposes of using weights were to put more emphasize on severe accidents than on slight ones. In that case cautions should be exercised to select the proper weights when using this method. As it was observed from the literature review and specific equation used in this research work, there are several ways of determining such weights (black spot manual, 2001). One possibility will be to use weights based on socio-economic costs. All crashes are not created equal, since fatal and severe injury crashes are far more costly to society than are property damage only (PDO) crashes, it would important to give more weight to fatal and injuries than PODs only.

Another way to establish weights would be to base the weights on traffic safety goals if such were stated in strategically traffic accident reduction in the country's law and since the goal of this study method depends on (black spot manual, 2001) there selection of weights was based on socio-economic costs and the detail this was described in this section. (Murthy et al., 1991) conducted black spot study on selected roads of Bangalore city using the severity factors and found that; severity factors can use as a very effective method to quantify and categories road section with respect to accidents especially for rural area. Based on this view it was used in this studies accident severity as criteria in order to identify the specific road section was black spot/ not in the study area.

Taking into account the facts stated in the literature and above view, the method and weight used in the studies was applied in different previous studies i.e. (black spot manual, 2001, Saffet, 2015, ADI Ltd, 1981), recommend a ranking procedure for rural highways in which the accident rate were supplemented by a severity ratio (defined as the number of casualty accidents divided by the total accidents) and if either of these exceeds or equal to a critical value, the section would be considered to be identified as hazardous/ black spot. Major processes involved in identification of desired hotspots of road section and the equation used in this study has been described below.

- For the accident severity, the severity value for specific road section (Si) e.g. Section **i** can be calculated as follows.

$$Si = Wf \times (F) + Ws \times (I) + Wd \times (PDO)$$

Where F, I, PDO: - Number of fatal severity, injury severity and property damage only accidents at section i, respectively, Wf, Ws, Wd = Calibration factors (weight factors).

- The weighting factors in the above formula has been predicted based on the (black spot manual, 2001), the manual decide the value in the form ratio which was: - **9:3:1** for fatalities, injuries and involved property damaged respectively based on their economic values and the equation has been written in the form of;

$$Si = 9 \times (F) + 3 \times (I) + 1 \times (PDO) \qquad \ldots 6$$

The method would consider the road network in the study area to find the critical severity value and the road network has been categorized in to different section and the resulted accident on each road section could be estimated and the total severity was calculated according to

equation@6. Following this identification of section weather it was black spot or not has been judged based on the following statistical method described in step by step procedure.

Step 1: Divide the road into different section or district; hence this has been done based on origin destination of connecting the road between the Nakemt town to the Waredas' in the zone or based on taking the route they are radiating from the Nekamt town to the existing Waredas in the zone.

Step 2: Estimate number of accidents on section i during a time period considered in the study; which was called **(Ai)** and for the time in use, the time that was taken has been recommended in different studies as well as in (black spot manual, 2001) was three to five year and in this work four year crash data has been considered or Ai of four year crash data was extracted.

Step 3: Estimate the total severity on the section i using the equation@6 or (**Si)**

Step 4: - Determine the relative severity value **(Qi)** for each specific segment/ section; or call it as section i severity value,

$$Qi = Si / Ai \quad \ldots 7$$

Step 5: Calculate the average severity value on the entire road network under consideration (Qave) with this equation.

$$Qave = \frac{\sum_i^n Si}{\sum_i^n Ai} \quad \ldots 8$$

Step 6:- Once average severity value has been estimated, critical severity value (**Qc)** at 90 percent confidence interval is determined by this equation;

$$Qc = Qave + K\alpha \, (\sigma^2)^{0.5}; \quad \ldots 9$$

Where: **Kα** is confidence interval and its value has been estimated from normal distribution curve based on **α** and variance (**σ**^{2}) has been determine by considering severity value for each specific section and average severity value observed in the above equation.

$$\sigma^2 = \frac{1}{n-1} \sum_{i=1}^{n} (Qi - Qave)^2$$ n: is number of section

Step 7:- Finally as per manual comparism of the result observed in step4 with the result in step6 thus has good indication about the road section feature and finally based the two values, the road

section will be considered to be a black spot or/not following this criteria there should be or from the severity point of view, if **Qi >= Qc** then section were black spot.

Once the road network in the zone has been categorized into different district or sections the specific locations that are more prone to traffic accident in the district has been prioritized using the following formula.

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

Where, P= priority value, X = total number of slight injury,

Y = total number of serious injury, Z = total number of death.

Based on the priority value calculated, each locations those recording values greater than or equal to 15 were selected as road traffic accident black spots.

Analytical frame work for identifying black spot based on accident severity

Simply the procedure stated in the above for identification of black spot based on accident severity can be explained by dividing in to different steps as shown in figure below;

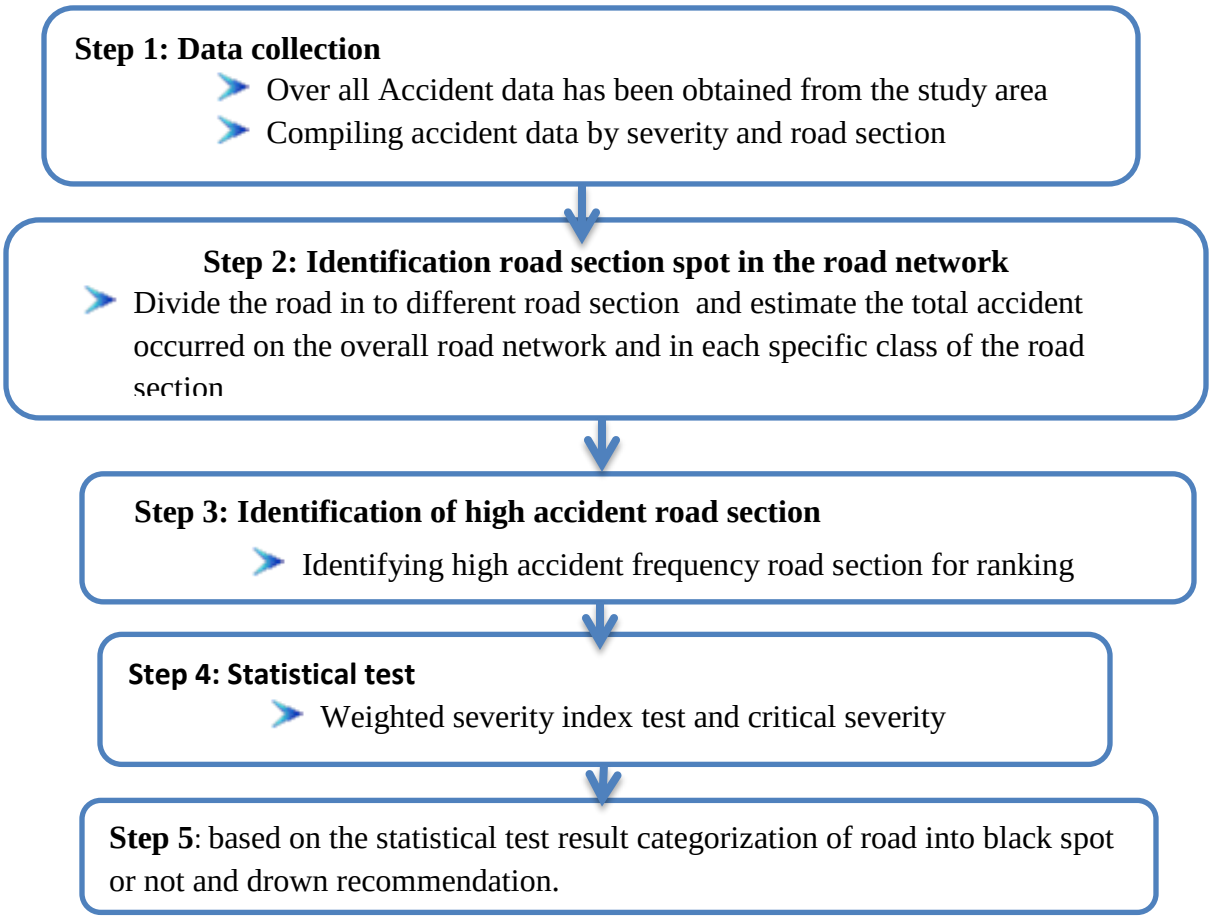


Fig: 3. Flow chart of black spot identification

Chapter Four

Results and Discussion

4.1. Introduction

This subdivision discusses the statistical analyses performed on the data to determine which characteristics were correlated to Run-off-the road crash characteristics, including geometric characteristics, environmental, vehicle and from driver aspect, accident rate in terms of severity, contributing factor and collision type.

In contrast data collected were compiled using Microsoft Office Excel 2010 software and different type of graph, tables in the study descriptive statistics like (percentage and trend plots), has been developed by excel and Bayesian Statistical equation approach model were used to identify factors affecting the occurrence of road traffic accidents, specifically factor contributing for Run-off-the road crash in East Wallega zone, Oromia regional state, Ethiopia. Finally based on the statistical analysis presented in the method black spot in different section of study road network has been identified and appropriate safety solution has been drown.

4.2. Description of Selected Variables in the Study

Data such as numbers of crashes and percentages or frequency of the crash in each year under study, different types of variable observed in the crash record, characteristic and contributory cause were presented in tabular form in these sections. The frequency of total crash, run-off-the road and non-run-off-the road crashes has been displayed in the table: 4.1 below for each consecutive year of the study period.

According to the trend from the data most of the crash reported during 2005, 2006, and 2007 are ROR crash and in 2008 the number of the NROR was more than ROR crashes.

Table: 4.1.Trend Analysis or Frequency Analysis

Trend Analysis or Frequency Analysis				
No	Year	Total number Crash	ROR number Crash	NROR number Crash
1	2005	71	37	34
2	2006	80	44	36
3	2007	114	60	54
4	2008	108	47	61

Source: Office of East Wallaga Police commission.

Table 4.2 summarizes the crash severity and vehicle characteristics frequency involved in the crash. Road traffic injuries are classified according to the level of severity, where severity refers to the extent of the injury sustained in an accident and in our country there are four type severities due to traffic crashes or when certain type of vehicle involved in an accident i.e. fatal, series injuries, slight injuries, and property damage. Variables in this category include crash severity, this has been recorded as when specific driver or vehicle involved in the crash the most severed accident from out of those accident happened during the crash has been registered by traffic police inspector were severity of the crash, and the frequency vehicle category which involved in the crash or specific vehicle in error during more than one vehicle involved has been reported in the crash has been shown below.

Table: 4.2. Description of Crash and Vehicle Characteristics

Description of Crash and Vehicle Characteristics			
No	Variable	Description	Frequency (Number)
1	Crash Severity	Fatal	119
		Series	81
		Slight	68
		POD	101
2	Vehicle Type	Cycle, Motor Cycle & Bajaj	20
		Automobile, Ambulance & Land Crusher	37
		Commercial Vehicle	164
		Minibus & Buses	110
		Earth Moving	5
2	Vehicle type	Animal Drawn Cart	0
		Uncategorized	38

Source: Office of the East Wallaga Police commission.

Table 4.3 summarizes human or driver characteristics, lighting condition, types of road considered in traffic crash data. The Variables in this category are gender, age and license type of the driver. As it was observed from the table most of the drivers involved in the crash are in the young age of 18-30 and further most of the accident was occurred on the asphalt road and during day time

Table: 4.3. Description of Roadway and Driver Characteristics

Description of Roadway and Driver Characteristics			
No	Variable	Description	Frequency (Number)
1	Lighting Condition	Day	289
		Night	81
2	Age Of Driver	Less than 18	1
		18-30	180
		31-50	93
		More than 50	7
		Unclassified Age	92
	Type Of Road	Asphalt Roads	237
		Gravel Roads	133
		Unclassified	3

Source: Office of the East Wallaga Police commission.

Factor contributing to the crash

In developing countries traffic accidents rates are still quite high, the same was like in Ethiopia. Therefore, the issue of road safety is a major concern in transportation engineering and the most effective way to reduce road accident was to better understand the causative of road traffic accidents and preventing the factor influencing occurrence of road accidents. One important aspect of the road safety problem was the means of identifying the causative factors to road accidents and to suggest this problem the study may apply some method of identifying factor contributing to the accident under study.

The study has considered every aspect of the causative factors leading to traffic accidents, such as the effects of weather, seasonal variation, vehicle factor, driver factor, road and lighting conditions. Based on the narrative written by traffic police report during the accident has been occurred, the following factor are the contributing factor for the accident to be occurred and most of the accident parameter has expected more than one contributing factor in the crash data observed but the leading one were reported as contributing factor or the detail problem of the crash has been studied by accident investigating parties in case where the accident will be highly severed which is observed from the informal interview from traffic inspector.

Table: 4.4. Contributing Factor verses Total number of crash &ROR Crash

Contributing Factor verses Total Number of crash and ROR Crash				
No	Crash Contributing Factor	Total Crash	ROR crash	NROR crash
1	Excessive Speed or violation of speed limit	116	66	50
2	Wrong Side Driving ,Too Fast For Condition & Loss Distance ,Improper Turning	6	1	5
3	Carelessness , Not Giving Attention	112	43	69
4	Failure to Give Frist	8	1	7
5	In-experienced	2	0	2
6	Fatigue, Distraction , Sleep	22	18	4
7	Over Loading	1	1	0
8	Pedestrian and Passenger Problem	5	0	5
9	Motor Problem	1	0	1
10	Tire Blow out or Tire failure	8	6	2
11	Brake are out of control	20	17	3
12	Strapping	7	3	4
13	Rain	2	2	0
14	Rut, Hole	2	2	0
15	Obstruction	2	2	0
16	Un-identified factor	60	24	36

Source: Office of the east Wallaga Police commission.

Table 4.5:- Shows road section based on the number of accident occurred on each section and the severity of an accident occurred. Accidents are usually dispersed along the road and traffic accidents vary along Nekamte town to different road section which is connected by road network and the result has been displayed.

As it was observed from the data, road traffic accidents were related to the volume of car flow rather than to the road geometry and road length. This was because of most the section identified below has a combination of straight, curved, mountainous and flat sections of roads that do not have either traffic police in some part of them or signals (traffic lights) totally section under study, which in turn encourages drivers to drive fast and would definitely result in more traffic accidents.

Table 4.5:- Specific road section as per their accident resulted.

No	Section Name	Section length	Road condition	Total number accident occurred on the Section	Severity Type		
		(Km)		(Ai)	Fatal (F)	Injuries(I)	POD
1	Nekamt to Argo	48	Asphalt	13	9	12	5
2	Nekamte to Gobu Sayo	164	Gravel	15	6	17	5
3	Nekamte to Gida Ayana	110	Gravel	49	31	124	12
4	Nekamte to Leqadulach	27	Gravel	23	5	35	10
5	Nekamte to Sasiga	18	Asphalt	41	12	87	16
6	Nekamte toWayu Tuka	12	Asphalt	47	15	61	31
8	Nekamte to Bila	122	Gravel	9	5	7	2
9	Nekamte to Sibu Sire	51	Asphalt	62	38	79	31
9	Nekamte to Diga	14	Asphalt	85	32	89	41

Source: Office of East Wallaga Police commission

4.3. Descriptive Characteristics of Study Area Related Crashes

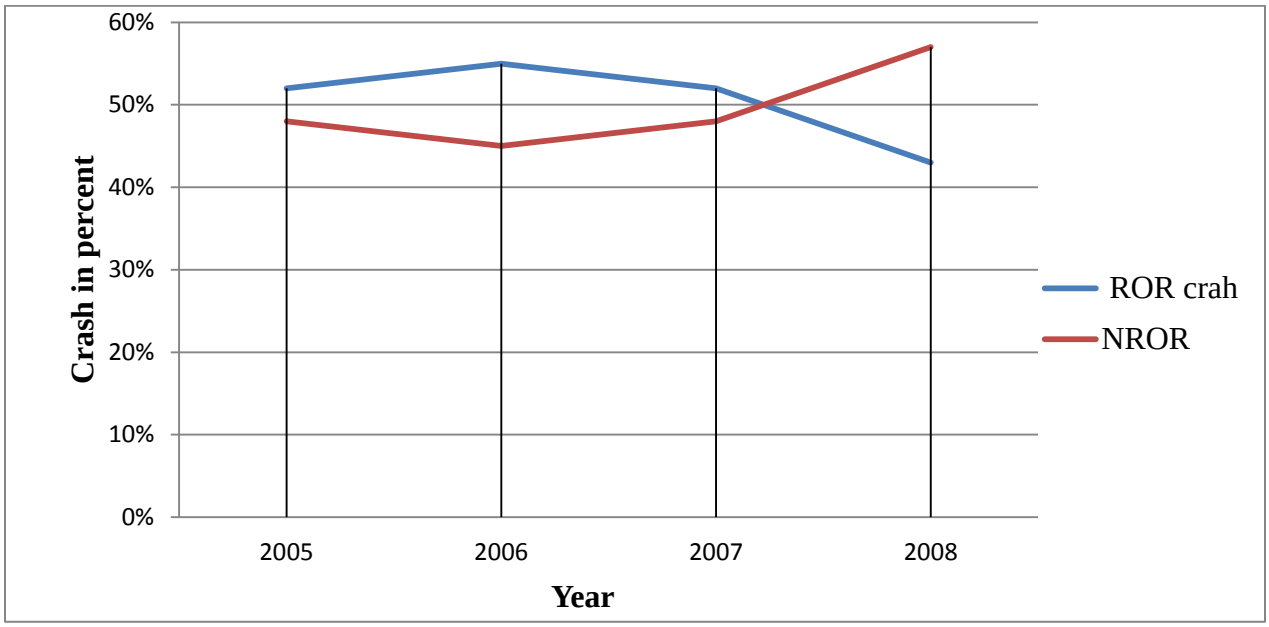
To understand the similarities and differences between ROR and NROR traffic crashes, a descriptive characteristic was first undertaken to understand the characteristics of these crashes in term of driver factor, vehicle factor, road and its environment factors. As it was observed from table 4.1, regarding road features the current study in this work shows that Run-off-the road crashes were common on rural roads which is consistent with the findings of (Saleh et al., 2010) that outside urban areas the most common and/or frequent collision type is Run-off-the road crash.

Trends of ROR and NROR Crashes, (2005 to 2008)

Figure: 4.1 below illustrate the trend in terms percentage of ROR and NROR crashes from that of total crashes. The result from the figure shows that the percentage of ROR crashes has increased during the consecutive four years with the lowest being observed in 2008 which is 43% and with the highest being observed in 2006 having rate of 55%. The percentage of NROR crashes, on the other hand, has increased highly over the four consecutive years. The rate of increase for ROR crashes appeared to be higher than that for NROR crashes up to 2007 and the rate vice versa after that year.

This is due to the fact that some improvement of the road condition at different section are made in the zone such as, adding speed reducing facilities, upgrading in to different road class i.e. to asphalt or maintenance, special treatments at some hazardous place such as posting guide post,

placing hazardous sign and adding the speed brake on the travel lane in order to control those severed accident. This trend agrees with different research in different world class in which they are concluded that most ROR crashes occurred on rural road network and its result is highly severed (Cejun Liu, Tony Jianqiang Ye).



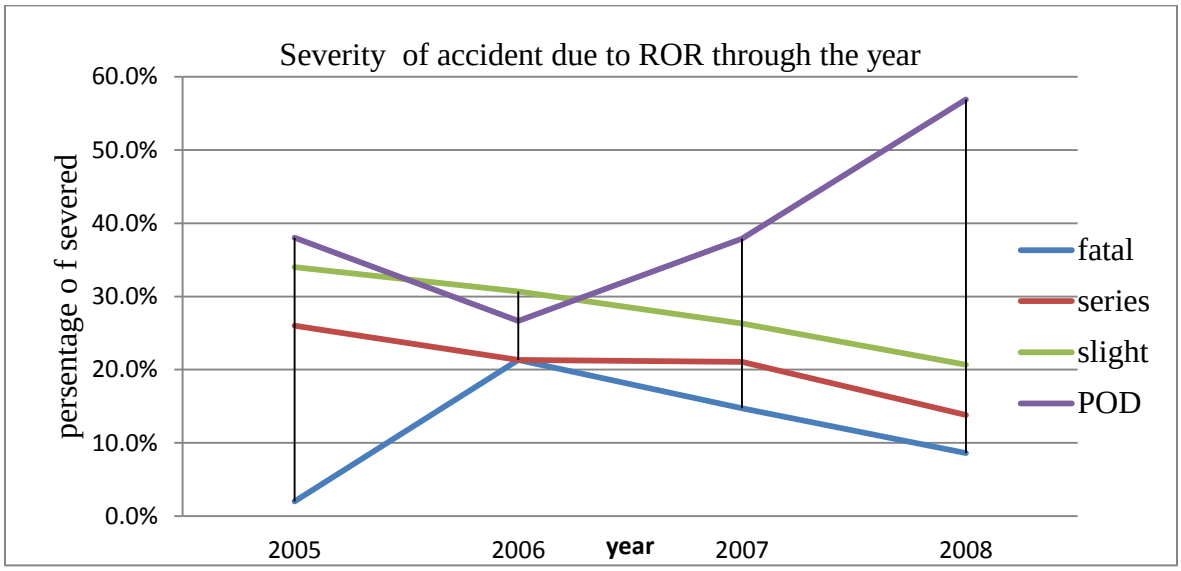
Data Source: East Wallega Police Office; compiled by author

Figure: 4.1 Trend Analyses of ROR and NROR Crashes

To investigate run-off-the road crash severity, the percentage of different injury crashes to that of total ROR crashes in the crash data base is presented in Figure: 4.2 below. The result from the figure shows that the percentage of fatal accident extremely increasing during the beginning of the investigation period and picked in (2006) and considerably decreasing after this year, while severity due to series and slight injuries is picked during the beginning period of the year and slightly decreasing throughout the consecutives year and in similar way the accident due to POD is decreasing from the beginning of the study year up to its subsequent year and highly increasing from (2006) to (2008).

This may result due to the involvement commercial vehicles are mostly predominant in an accident due to ROR crash around the road network under consideration in such way that they are a means of supplying all the material used in any public and privet life around the coverage of the area, and in contrast the traffic volume or AADT of commercials vehicle are continuously increasing due the grant national Dam under construction required construction material has been supplied by this vehicle cat-agree and recently due to technological innovation different row

material needed for some fabrics supplying was done by this vehicle categories which was observed from discussion of transport facilitating party from the area.



Data Source: East Wallega Police Office; compiled by author

Figure: 4.2. shows the trend of different catagree of accident severity in percentage

4.4. Characteristics and Comparison of ROR and NROR Crashes

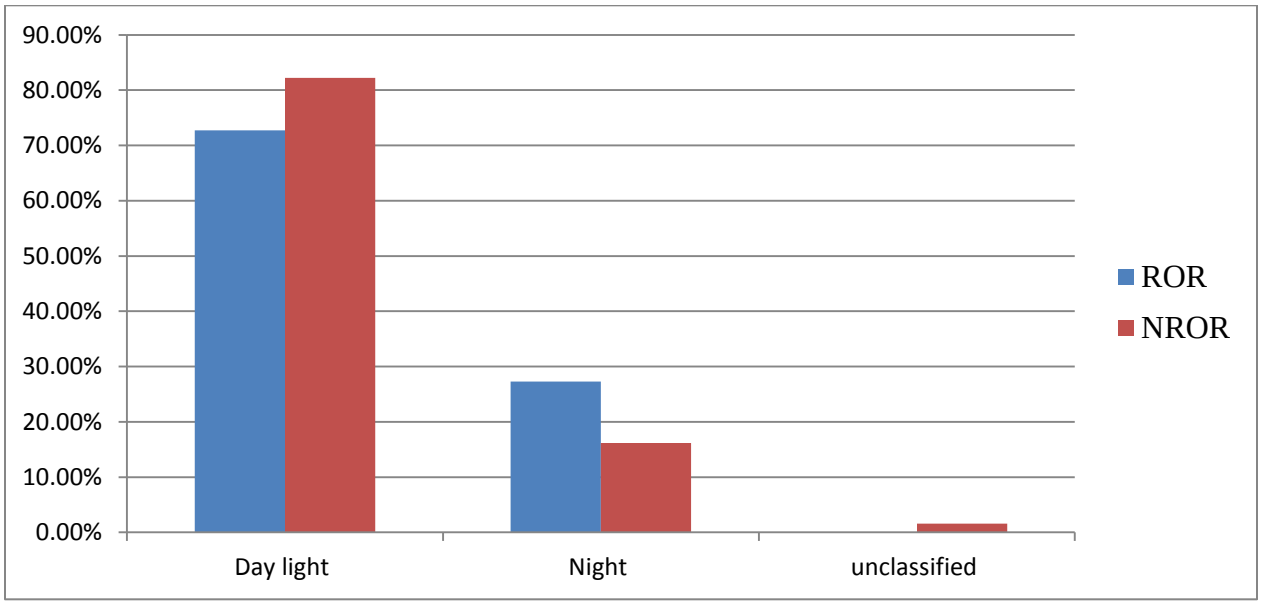
In order to study this, traffic crash data for the period of 2005-2008 was divided into crashes which were involved ROR and those which did not involve ROR crashes which are categorized under NROR. Percentages in each sub-category were calculated by taking the total number of ROR or NROR crashes as the base value. In this section, several variables are discussed such as the influence of environment, time of occurrence of crashes, roadway, and vehicle-related factors, which have strong association with ROR and NROR crashes.

Based on studies mentioned in the literature review subdivision, different variables considered in this study are; weather and light conditions as environment-related factors; time of the day to find the critical time of occurrences of crashes; road surface type as roadway-related factors; and vehicle body type and vehicle classification as vehicle-related factors and driver age, the way they are acting during the crash happened, types of collision and their severity, different types of contributing factor for the crash has been discussed in detail from the finding based on the accident crash data. All the factors that are considered in this study are compared between ROR and NROR crashes. For the ease of comparison, percentages in each sub-category are calculated by taking the total number of ROR or NROR crashes as the base value as explained above.

Light Condition.

Could visibility due to natural lighting be an issue in the occurrence of ROR crashes? To answer this question, frequency analysis was considered for two lighting conditions from the crash data collected: i.e. nighttime and daytime. Even though the existence of light is very important for the reduction of accident due to different traffic crash categories significantly, the result from this analysis shows that almost most of the accident due to ROR and NROR occurred during the day light than nighttime in each consecutive year of analysis considered for the study period.

Figure: 4.3 below shows the percentage frequency distributions of all the category of vehicles involved in road departure (ROR) and NROR crashes by lighting conditions. It is observed from figure that the percentages of both ROR and NROR crashes occurring during daylight are much higher than those of nighttime hours. But when light condition is considered in ROR/NROR crash scenarios, it has been found that ROR crashes are more likely than NROR crashes to occur during nighttime. The result confirm that Dark conditions, even if the streets lights are present (but not practical in the study area since there is no any lighting system during dark condition), relate to a larger number of ROR crashes in comparison with NROR crashes and in addition to this most of highly severed accident are occurred during the day time which more analogous with research finding by (Cejun Liu et., 2009)



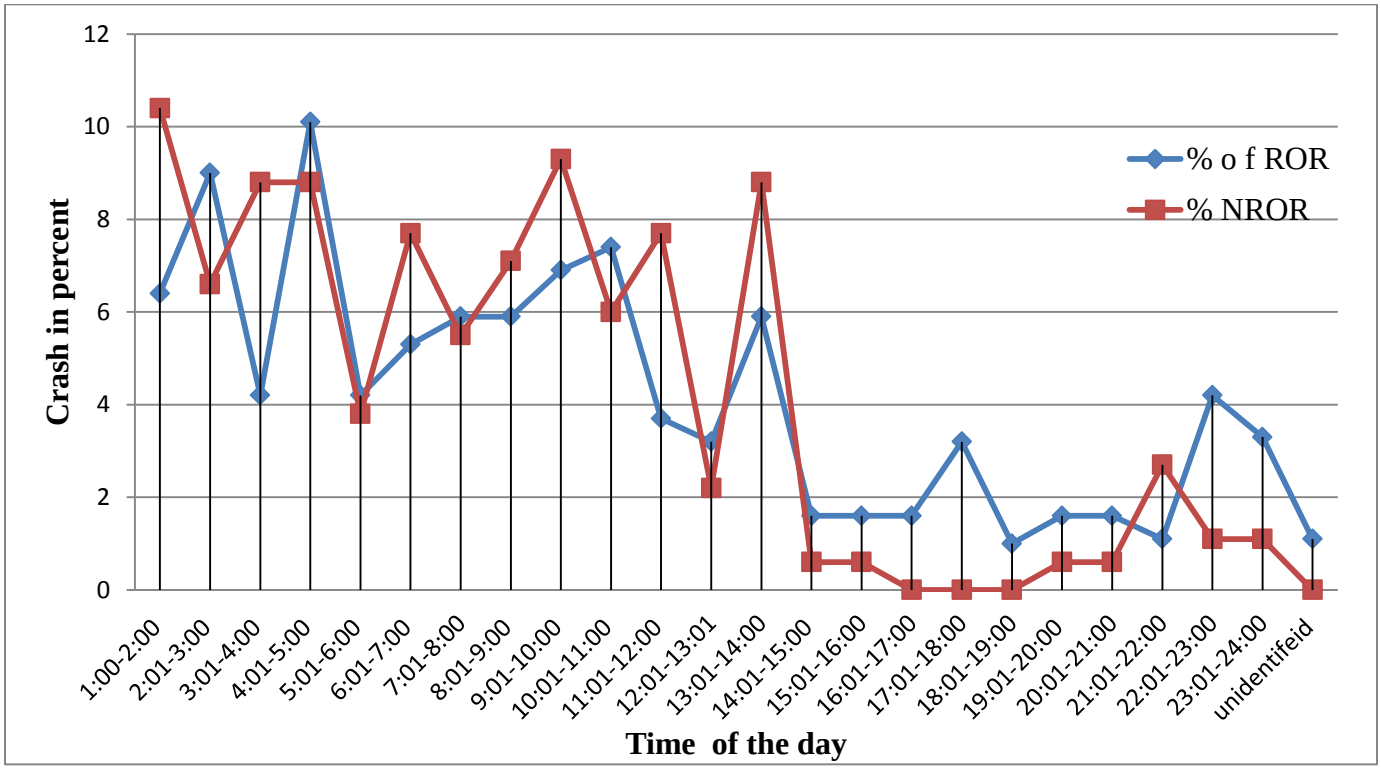
Data Source: East Wallega Police Office; compiled by author

Figure: 4.3. Bar Chart showing accident involved in the zone based on Light Condition

Time of Day

Road traffic accidents vary by hours of a day and in fact with maximum crashes when mobility of pedestrians, passengers, and drivers frequency increases so that result observed also support this views. The figure: 4.4 below shows that the distribution of ROR crashes and NROR crashes based on time of day, according to the result observed from the figure; the percentages of both ROR and NROR crashes are higher during daytime than at night. But the percentage of ROR crashes is higher than the percentage of NROR crashes at night.

The difference between two types of crashes is the highest between midnight and late morning, in addition to this; the finding reveals that nighttime driving apparently results in more ROR crashes relative to NROR crashes. In general reflection from the result shows that hourly distribution is closely related to people's lifestyles and travel habits which is consistence with the study done by (Liu et., 2009, Najm et al. 2003)



Data Source: East Wallega Police Office; compiled by author

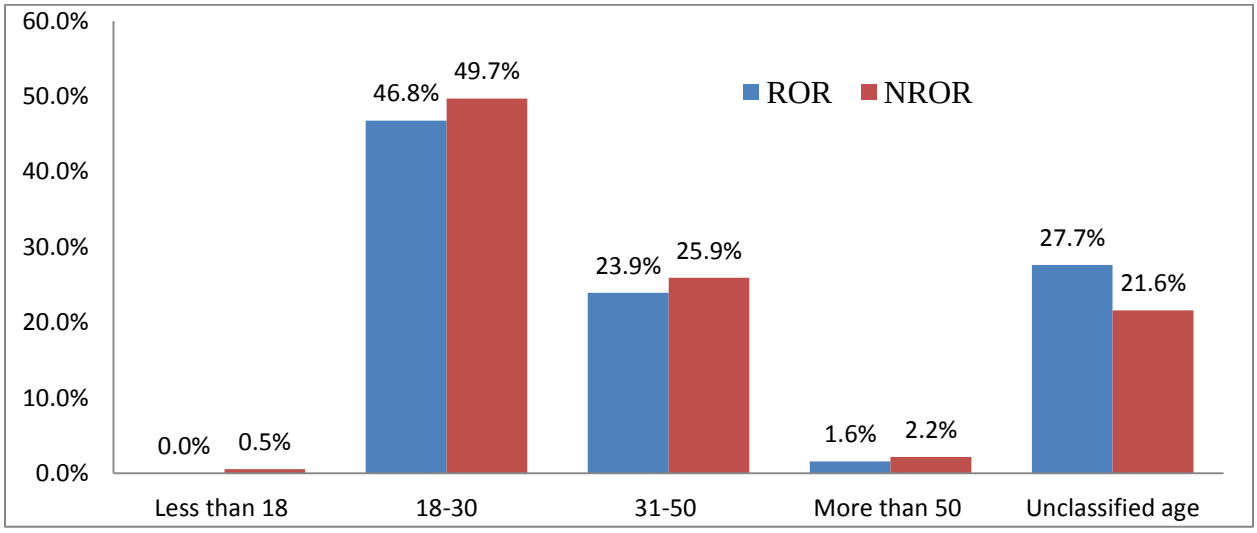
Figure: 4.4. Bar chart showing accident density involved in the zone with in the time of the day

Driver Age

In this study, like similar investigations done elsewhere, almost all of the drivers that caused crashes were male. This preponderance of males in collisions might be due to greater

involvement of males compared to females in professional driving activities simply by observing the statistical demographics driver licensing in the overall part of the country. For accurate observation of accidents it is important to find out which age of people are mostly involved in accidents since most of the time, the major contributing factor in the majority of traffic accidents in developing country was the comportment of the drivers; and hence, worldwide studies such as those of the national road safety studies, world health organization (WHO) show that about 80-90% of the road traffic accidents are attributed to the fault of the driver in developing country, and majority of them are male drivers cited in (Bitew, 2002).

With regard to age, citation in different literature shows that; it has been found that the young drivers are most likely to inflict more traffic accidents than the old ones and the result from this finding also support this argument. One can observe from the figure: 4.5 below, the younger those are in the 18-30-age group cause about 46.8% of ROR and 49.7 % NROR and this may be also due to the fact that instruct the dominancy of young age drivers coverage are there throughout the road network in the country at national level.



Data Source: East Wallega Police Office; compiled by author

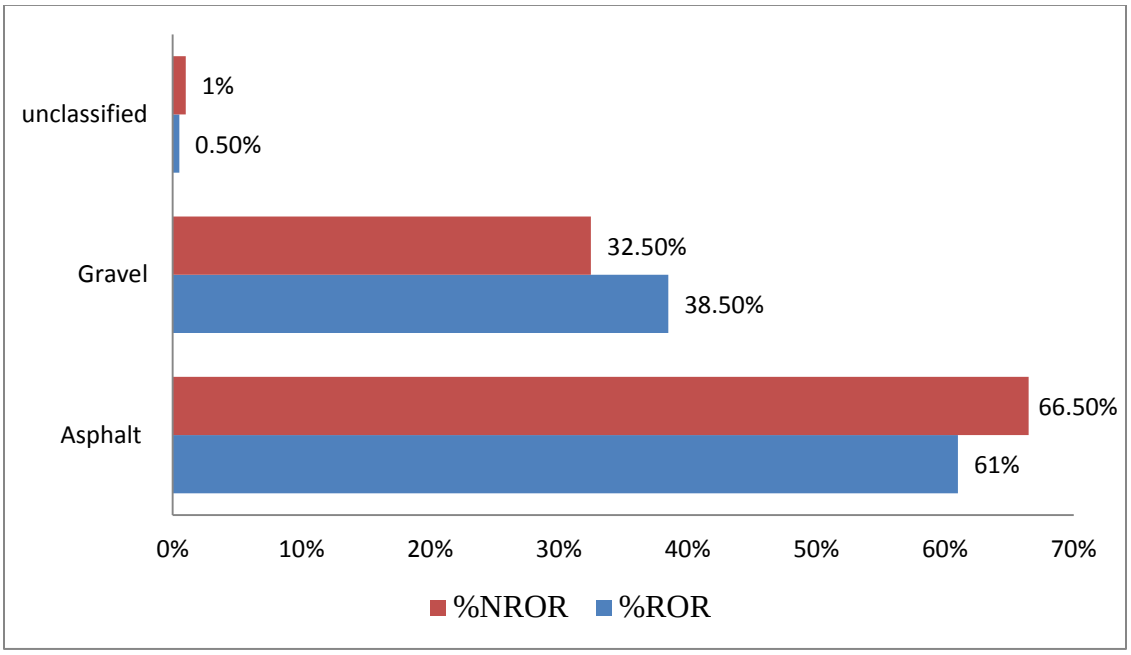
Figure: 4 .5. Bar chart showing percentage of driver age involved in the crash

Road Surface categories;

In this segment major dissimilarities are found between ROR and NROR crashes based on road surface type. The bar chart of road surface type shows that almost most of accident are occurred on asphalt pavement surface; while in terms of ROR and NROR crashes the result shows that among two major types of roads that are being deliberated (asphalt, and gravel), the percentage

of crashes is higher for ROR crashes than for NROR crashes when the road surface type is gravel.

An in different way higher percentage of NROR crashes compared with ROR crashes occur on asphalt road. Unclassified types of roads are categorized as others in this study, and it is found that this category also exhibits a larger percentage of NROR crashes than ROR crashes. This suggests most of the roads around rural area covered by earth or gravel roads are relatively more common for the occurrence of ROR crashes compared with NROR crashes as per the result observed from analysis data; whereas Asphalt road surfaces are more common for NROR crashes to occur relative to ROR crashes and this will agree with the research finding by Niranga et al., 2014)



Data Source: East Wallega Police Office; compiled by author

Figure: 4.6. Bar chart showing road type in relation with accident percentage

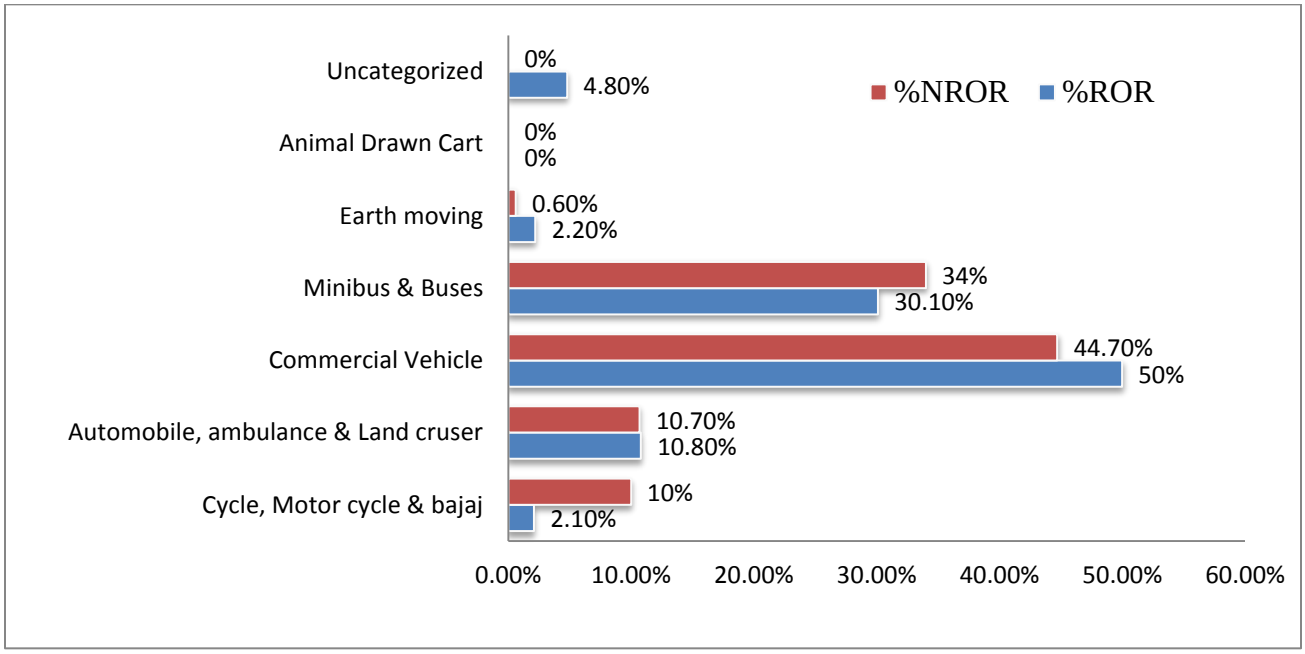
Vehicle characteristics

Traffic crash records contain very little information to describe the characteristics of vehicles involved in road accident crash, especially run-off-road crashes in developing country i.e. in Ethiopia (Girma, 2000). But data of vehicle character was the most useful for any research encompassing in the involvement of traffic crash in different type of vehicle categories and to accomplish those detached; it is needed complete information relating to the vehicle type and

registration status especially for policy maker. In most of the studies there was question like, which modes of transport are involved in run-off-road crashes most frequently?

To answer this question rate of recurrence analysis has been carried out from the registered vehicle involved in the crash on the crash data base and the result figure-out in figure: 4.7 below shows that the percentage frequency distributions of different categories of vehicles involved in single-vehicle or ROR and NROR crashes; the result shows that commercial vehicle are more likely to be involved in ROR crashes as compared to other vehicle types.

For instance, commercial vehicles (50%) were the most predominant vehicle type involved in run off road crashes (ROR), and followed by buss and minibus (30.1%) which was consistence with the research done by (Abdullah, 2014, SWOV 2013) which state that in terms of vehicle cata-gree in transport, commercials vehicle are mostly involved on the rural road run-off- the road crashes.



Data Source: East Wallega Police Office; compiled by author

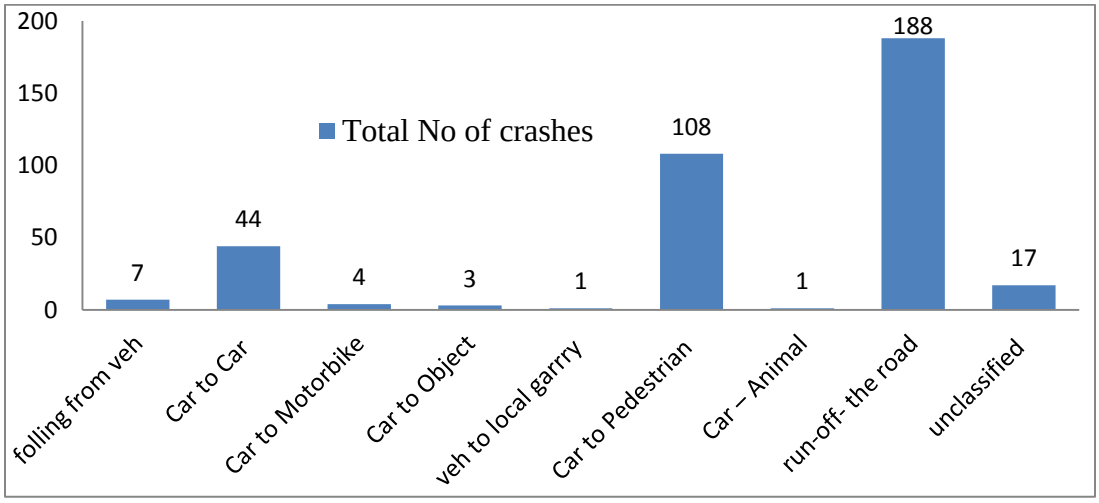
Figure: 4.7. Bar Chart Showing Percent of Vehicle Type involved in the crash

Collision type

This is important for any research concerning traffic safety; meanwhile; collision type is a good indication for crash contributing factors and also significant for cataloging of the crash type which is one bull's eye of this research objective which is identification the dominant type of collision along the road in transport specifically on rural roads: - collisions like vehicle to

vehicle, falling from vehicle, vehicle with animal, collision with fixed object, overturning or road departure or ROR and collision with pedestrian etc. Not only this, collision type identification is important for proposing what type of remedial action should reduce accident at different road location in such way that when accident concentrations was observed at specific road location or on section of the road in danger.

Basically from collision type observed at different period when an accident resulted justify that what method of improvement needed at different special place related with more traffic accident; and according to the result from the figure: 4.8 below, it is conclude that run-off-the road crash is the dominant type of the crash followed by car with pedestrian collision in the rural area.



Data Source: East Wallega Police Office; compiled by author

Figure: 4.8. Bar chart showing collision type with percentage total crash

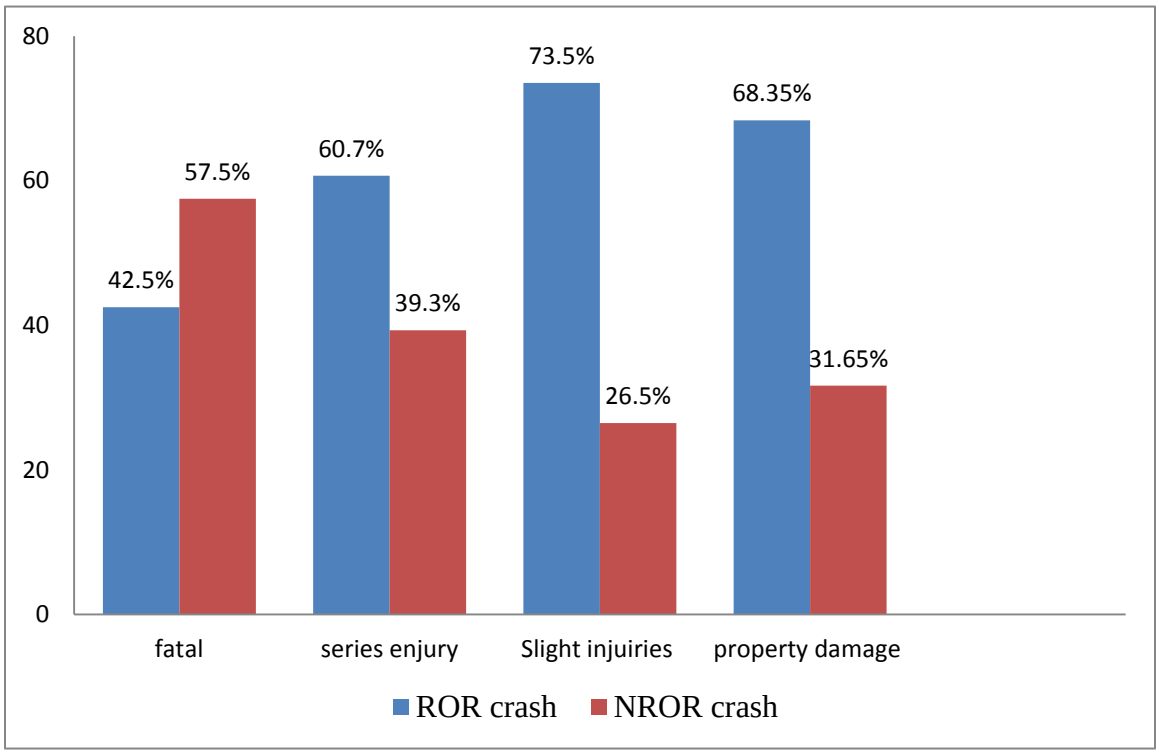
Severity of the crash

In common for traffic safety, Run-off- the road crashes have always been a serious safety concern around the world as they account for a large number of fatal crashes and fatalities each year once such type of traffic accident happened and in this respect; researchers have identified ROR crash as an important leading cause of traffic fatalities on rural highways (Johnston et al., 2006).

From crash data under consideration a total of 374 road crash accident has been observed between study period and out of this about 188 are Run-off-roadway accidents and about 185 are Non-Run-off–the road crash accident was reported during the period were used in this severity study; and considering the number of severity of each category involved in the crash, severity

separation in to different class should follows the systematic classification system in practice in the country.

For comparison the number of observed accident severity has been changed in to percentage, thus based on the result from the analysis graph: 4.9 shown below; for the two categories ROR and NROR crash, about 42.5 % of the fatal is due to ROR and about 57.5% of fatal is due to NROR. In the same proportion, it is observed from the figure: 4.9 that the percentage severity of serious and slight injuries, property damage due to ROR mostly higher than that of NROR and its values are indicated on the figure below. In drawing conclusion from severity result; possible explanation was desired about the trend of vehicle involvement in the crash and this is due the fact that when vehicle run out from the road the occurrence of highly severed accident are more common which is supported by different research cited in the literature review and as it observed from the figure the distribution of accident severity follows type vehicle involved in run-off-the road crash stated in above section or page.

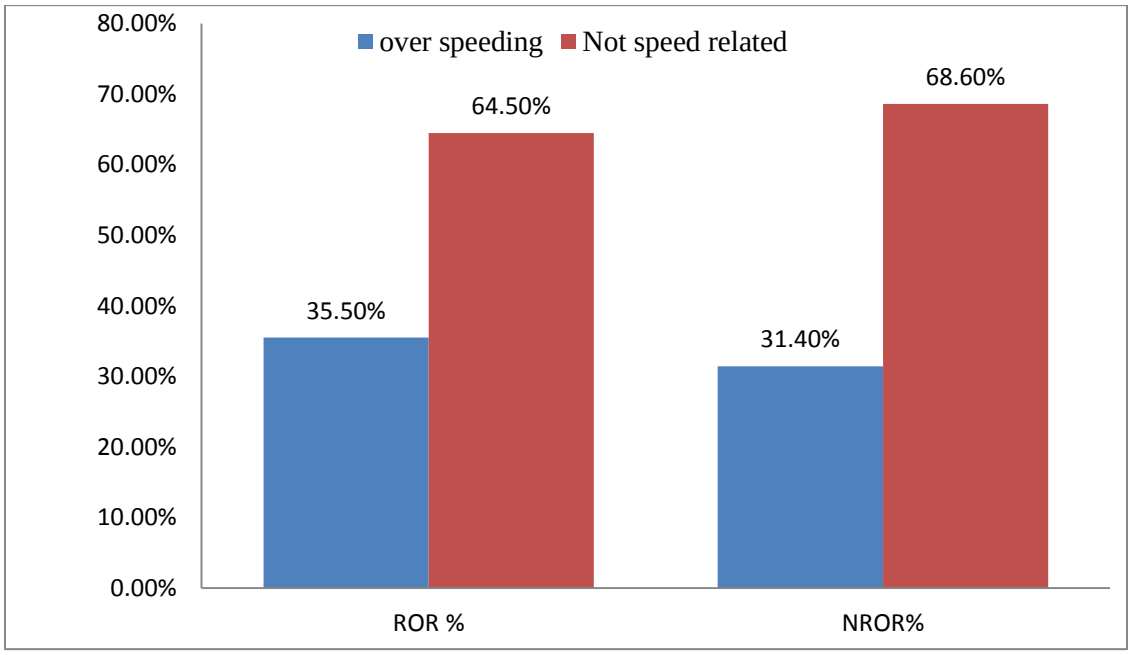


Data Source: East Wallega Police Office; compiled by author

Figure: 4.9. Bar chart showing severity accident due to ROR and NROR crash in percent

Out of many contributing factor involved in the crash and in relation with the above the two categories of the crash type, accident has been observed based on whether the contributing factor is only due to only the speed related and plotted figure: 4.10 below shows percent of crash types in relation to speeding only and the record due to this was based on the judgment of traffic officers who attended the crash scenes to determine whether speed was a contributing factor and reported that crash was due to speeding related. Taking the above statement in consideration the result from figure below reveals that for crashes where speeding was an issue, ROR crashes were more frequent making up of 35.5% percent of such crashes and that of NROR was 31.4% and this will be presented in in detail in analysis by model presented in section below.

While most of the crash with speed factor was related to NROR crash and their comparative result has been shown on this figure.



Data Source: East Wallega Police Office; compiled by author

Figure: 4.10. Bar chart showing only speed as factor for crash comprises

4.5. Contributory Causes for Run –off the road and Non-Run-off the road Crashes

A number of risk factors have been identified that contributed to traffic crashes and resulting with human casualties and property loss from the crash data report and site investigation. To identify the detail contributing factor for the crash by model it was stressed on the narration written by traffic police and the summary of the reports may lack detail information about the crash parameter in some of the crash and so that it was decided to collect additional sample

information about the crash pattern around the area and those identified factor listed below has been gathered by site observation using purposive sampling method and the sampling depends on the information gathered from the crash data and it was done by capturing a photo, video recording of existing road feature around the area and those investigation has been done in-line with traffic police. Though, based on this the following factor has been identified as contributing factor and the details how they are identified are discussed in the discussion section.

- Fatigue, sleeping
- Night driving
- Carelessness
- In experienced
- Emotionality and distraction
- Influenced by alcohol, chat, cigarette smoking
- Live animal on the travel lane and thus need special attention since it is frequently resulted accident due to saving the life of this animal in most of the time
- Over speeding , too fast for conditioning
- Improper following ,improper passing and turning problem
- Licensing state of driver i.e. most of driver who is causing accident frequently are driver trained in the new curriculum and most of them has no approved license.
- Road deterioration throughout the road network
- Restricted road width, no shoulder, no barrier at fill station, no sign post at very hazardous place.
- Site obstruction due to different roadside object
- Transportation law i.e. it gives superiority to the driver and the owner of the vehicle
- Pedestrian and passenger problem using the road since most of the population coverage throughout the country has no knowledge about the traffic safety
- Over loading and due to this most of the vehicles loaded material are bulging in one direction and loss their horizontal center of gravity
- Vehicle defect such that most of the vehicle using the road network are the vehicle destroyed from higher cities in our country and they are poor in quality, most of them has age of minimum greater than 10 or 20 as an average

- Luck of public knowledge how they use the road in transport i.e. once the road has been constructed they directly start giving service without introducing the public basic safety rule how they use and protect them self's from traffic accident
- Driver cannot use the safety practitioners and is not expected for the passenger etc.

According to the recommendation from traffic officer and from the purposive sampling, reporting the main cause for the accident is very difficult since most of the report they are providing is not immediately when the crash has been occurred and the location of the accident may far from the built up area in such way that the concentration of traffic police mostly around the built up area and there is a gap of information, and in some case the crash is also not reported.

In various circumstance each crash might have more than one contributory factor leading to the event, on the other hand the crash data records format in the country does not has fit for those all contributing factor recording or script multiple factor, so that traffic officer who is recording those factor write only single parameter that he observe during the crash occurrence or simply not specify/outline the crash was due to which factor, in other word crash recording outlet sheet doesn't have separate place for each parameter resulting to the crash i.e. vehicle, road, environment, and driver factor causing to the crash and on little crash record more than one contributing factor has been written on the same line but its representatives to all crash is neglected.

4.5.1. Statistical Analysis Result and Discussion of the Result

The following section shows method used for the analysis and how to identify the contributing factor for the crash occurrence in general and the likelihood of contributory factors occurring in Run-off-the road (ROR) crashes as specific when compared to factors Non-Run-off-the road crash (NROR) since study of the factors contributing to crashes is important in order to improve the overall safety of the transportation system.

The equation that has been described in the method has been used and the interpretation of each formula has been formally shown in the sample calculation below and the final output of the model is likelihood ratio which represent that factor was related with one of the two class of the thesis objective or factor more related with ROR or NROR, and by calculating the probability of each contributing factor for the two type of crash and likelihood ratio has been determined,

where in the case if the probability of the factor in the likelihood is greater than or equal to one it indicates the factor was more predominant in ROR crashes than NROR crashes.

The sample calculation has been shown below as an example by taking the crash occurred due to speeding and the same step has been followed for the other contributing factor and overall result has been displayed in the tabular form and aspects in the tables 4.6, 4.7, 4.8 describes that follows belong to categories of driver-related, vehicle-related, road and its environment crash related concerns. The likelihood ratios are recorded in proceeding value of predominance in each category.

$$P(ROR/CC) = \frac{\text{Number of ROR crashes due to excessive speeding}}{\text{Number of all ROR and NROR crashes due to excessive speeding}}$$

- Referring table 4.4 and the value for each parameter was applied as follows

$$\frac{66}{66+50} = 0.568965517$$

This is Probability that the crash was an ROR crash, given that speed was specific contributory causes for the crash in the crash data reported factor causing to the crash. As it observed from the equations result, out of many factor contributing to the ROR crash, the exposure proportion of the speed in the crash is almost close to 57% when direct observational consideration from the raw data and the result shows that speed is the most significant factor contributing to crash at this stage, but the result was judged based on the value likelihood ratio.

$$P(ROR) = \frac{\text{Number of ROR crashes}}{\text{Number of all ROR and NROR crashes}}$$

$$\frac{188}{188+185} = 0.504021448$$

This may shows that the overall probability of a ROR crash in terms of total crash observed in the study area and the result shows that about more than 50% of the crash recorded during the study period are ROR.

$$P(CC) = \frac{\text{Number of Crash Due to excessive Speeding}}{\text{Number of all ROR and NROR}}$$

$$\frac{116}{188+185} = 0.310991957$$

Those shows that the overall probability of the speed is causative factor out of factor reported causing to the crash and the observed result shows that in terms different factor contributing to the total crash about 31.1% was due to speed related.

$$P(CC/ROR) = \frac{P(ROR/CC)\,P(CC)}{P(ROR)}$$

$$\frac{0.568965517 \times 0.310991957}{0.504021448} = 0.35106383$$

Here the result observed in the above parameter has been interpreted in this result and this shows that probability of the speed is factor causes being reported as a contributory cause for a particular ROR crash and this was a function of different parameter stated above. Hence the significance value of this parameter is important in factor identifying in the likelihood ratio since the numerical value of the likelihood ratio depend on this parameter and the result of this observation predict sensitivity of the parameter under consideration to the defined crash type in this case to the ROR crash.

Similar with the above parameter referring table 4.4 functional contributing factor of each specific factor for NROR was calculated and displayed bellows

$$P(NROR/CC) = \frac{\text{Number of NROR crashes due to excessive speeding}}{\text{Number of all ROR and NROR crashes due to excessive speeding}}$$

$$\frac{50}{66+50} = 0.431034483$$

This is Probability that the crash was an NROR crash, given that speed was specific contributory causes for the crash in the crash data reported factor causing the crash. As it observed from the equation result out of many factor contributing to the NROR crash the coverage proportion speed in the crash is almost close to 43.1% when considered directly from the raw data and the result shows that speed is the significant factor contributing to crash.

$$P(NROR) = \frac{\text{Number of NROR crashes}}{\text{Number of all ROR and NROR crashes}}$$

$$\frac{185}{188+185} = 0.495978552$$

This may shows that the overall probability of a NROR crash in terms of total crash observed in the study area and the result shows that about more than 49.6% of the crash recorded during the study period are NROR.

$$P(CC) = \frac{\text{Number of all Crash due to excessive Speeding}}{\text{Number of all ROR and NROR}}$$

$$\frac{116}{188+185} = 0.310991957$$

Those shows that the overall probability of the speed is causative factor out of factor reported causing to the total crash and the observed result shows that in terms different factor contributing to the total crash about 31.1% was due to speed related.

$$P(CC/NROR) = \frac{P(NROR/CC)\,P(CC)}{P(NROR}$$

$$\frac{0.431034483 \times 0.310991957}{0.495978552} = 0.27027027$$

Similarly this is a probability of speed is factor causing being reported as contributory cause for particular NROR crash and the significance of this parameter will reduce the sensitivity of the factor contributing to ROR crash such that in the likelihood ratio as numerical value of P (CC/NROR) increases the result of likelihood ratio decrease so that sensitivity of the factor identified to be contributing factor for ROR will reduce.

Finally the likelihood ratio was calculated based on the calculated value of each specific parameter causing for both ROR and NROR crash, and based on the result comparison was made to judge as a factor for one of the two crash type.

$$\text{Likelihood Ratio} = \frac{P(CC/ROR\ Crash)}{P(CC/NROR\ Crash)}$$

$$\frac{0.35106383}{0.2702702} = 1.29893617 >= 1$$

This shows that speed is the contributing factor for ROR since the value of likelihood ratio is greater than one. The value of the likelihood ratio state that the factor identified has been categorized in to one of the crash type such that if the value of the likelihood ratio is greater than or equal to one stated in the method part factor is contributing factor for ROR crash. Hence with referring above sample calculation, the identified contributing factor has been classified into driver, vehicle, road and its environment and their value has been displayed in separate table: 4.6, 4.7, 4.8 and possible explanations are drowned.

Driver Related Causes

Table 4.1 shows contributing factor of driver-related causes as well as their corresponding likelihood ratios in ROR crashes when compared with NROR crashes. The total number of ROR and NROR crashes occurring between (2005) and (2008) due to driver-related contributory causes are 130 and 142 respectively. The contributory cause is identified by the traffic inspector since the crash was occurred and based on that eight parameter related to the driver has been labeled as the contributing cause for the crash and considered in the method of analysis to identity which of this parameter are more related with run-off-the road crash or more frequent in contributing for the crash.

The results from the analysis indicate that excessive speeding and (fatigue, distraction, sleep) on the same analog appear to have more likelihood of contributing factor to run-off-the road crashes since their likelihood ratios are greater than one. While wrong side driving, too fast for condition and loss distance, improper turning, carelessness, not giving attention, failure to give first, in-experienced, over loading, pedestrian & passenger problem more related with non-run-off-the road crash since their probability of likelihood ratio was less than one. In fact Collisions with oncoming traffic on rural roads were also clearly the most common accidents caused by "distraction/inattentiveness" so that vehicle in collision become run-out from the road and cause most sever type of accident.

From the site investigation information, not only factor listed in this section as driving behavior or factor causing for the occurrence of the crash, since most of them does not tested in our country they are left, specifically most of driver driving large truck vehicle will drive with impaired, usage of alcohol while they are driving and before/mid driving, exposed to chewing chat, smoking cigarette, mobile usage, over loading or improper loading due to this vehicle center of gravity can deflect in to one side position and bulging or shifting into single direction

and resulted with run-off in the bulging direction on the curved road section and more super elevated direction of the road.

In similar way overloading in different vehicle that of differ from the large truck also result with very series accident as per the recommendation of inspection service at different position, especially during winter season due to insufficient public and privet transportation service while this is a problem, the density of the movement of the people and material at different location was increasing during this period and the same is true in summer season most of the road around the area of the study worn out and is difficult for vehicle to transport and is very difficult to predict the problem which consistent with the finding by (Shahnewaz, 2013).

In contrast from the result of this studies analysis by the model, even if over loading is not likelihood of contributing factor for Run-off-the road crash observed from the table 4.1, vehicle speeding and overloading condition are the common factors in the rural road that may affect the stability of vehicles which is observed from site investigation, such that when vehicle is in motion, it undergoes continuous jerking and vibration effect from the potholes and rough road surface. So that if the loading is loosely fastened and is of high height, bulging and shifting of load occurs. Due to this, the horizontal component of Center of Gravity of loaded vehicle gradually shifts towards the direction of roadway slope that makes a vehicle more prone to overturn.

Practically as it is stated in the literature review, the volume of traffic increases, the speed of vehicles drops and the main kind of accident becomes a nose-tail collision so that run-off the road crash would reduce due to the traveling speed of the vehicle is reduced which is observed in some part of built up area and more discussed in black spot section of this research. In the same manner as the volume of traffic grows the increase of opposing vehicles increases, intervals for passing vehicles are less available, the accidents due to improper passing become frequent, and the frequency of accidents grows approximately in direct proportion to the average volume of traffic volume and in the same way the accident due to speeding would reduce which reduce the occurrence of run-off-the road crash. More importantly carrying out flexible publicity education or campaigning help the drivers understand the distribution of traffic accidents on rural road, drivers' traffic safety awareness and strength the safety education of fatigue driving, driving during night and safe driving at rainy and snowy day and improve traffic safety and legal awareness of rural drivers would reduce the accidents. For the administration party, the

investigation and punishment should be enhanced especially in the aspects of alcohol, speeding and illegal overtaking, stop, turning around, since most of the accident was due to those factor, even if they are not listed in the crash etc.

To put it briefly based on the data presented on the table 4.6, driver-related factors were the most common type of contributory cause involved in both type of the crashes. As per recommendation from different discussion with traffic officials during site investigation, drivers are responsible for the occurrence of more/less collision because they can prevent collisions by adjusting themselves to the existing situation i.e. if the road is inconvenient, they should drive slowly and carefully, they should keep the required distance while following another car and adjusts themselves according to the current road environment which is consistence with different journal published by WHO at different time cited in the literature on this research.

Table: 4.6. Contributing factor verses total number of crash and ROR crash based on driver factor (DF)

contributing factor verses total no of crash &ROR crash based on driver factor(DF)						
No	Driver Factors (DF)	Number of ROR Crash	Number of NROR Crash	Conditional Probability of this DF Given a ROR Crash	Conditional Probability of this DF Given a NROR Crash	Likelihood Ratio
1	Excessive/violating speeding	66	50	0.35106383	0.27027027	1.29893617
2	Wrong Side Driving , Too Fast For Condition & Loss Distance ,Improper Turning	1	5	0.000275128	0.027027027	0.010179751
3	Carelessness, not giving attention	43	69	0.228723404	0.372972973	0.61324391
4	Failure to give first	1	7	0.005319149	0.037837838	0.140577508
5	In-experienced	0	2	0	0.010810811	0
6	Fatigue, distraction, sleep	18	4	0.095744681	0.021621622	4.428191489
7	Over loading	1	0	0.005319149	0	#DIV/0!
8	Pedestrian & passenger problem	0	5	0	0.027027027	0

Source: Study work.

Vehicle related

Vehicle related factors were the next most important contributory causes of both run–off and non-run-off the road crashes. With this intention, a comparable way vehicle-related contributory factor between Run –off the road and Non-Run-off the road has been recognized from the list of those contributing factor and their likelihood ratio in the analysis was shown in the Table 4.7. As most of the vehicles involved in the crash are commercials and minibus and busses; Tire Blow Out, and brake are out of control has been identified as the most factors contributing to Run –off-the road, since their likelihood ratio are greater than one and the rest such as Motor Problem, strapping has been seen as factor for Non-Run-off the road crashes based on the value of their likelihood ratio resulted on the table.

But this is not only the vehicle defective factor causing the crash for truly speaking the reason is that since traffic inspector who is reporting the crash is not proffitional with vehicle inspection of the vehicle involved in the crash and the inspection proffitional team service provider also aspect the problem some days later the crash has been occurred and most of vehicle using route section are poor in quality so that overall the current vehicle defective identification are very difficult which was one of the limitation of data observed in this research and sometime once inspections team seen the vehicle defective contributing to the crash; their inspection result has been left in their office doesn't report to respective parties i.e. to the traffic police office since most of the time data used for research was taken from this office.

These introduce insufficient data in factor for vehicle related and moreover, poor vehicle technical inspections and poor enforcement of traffic safety rules in the country could aggravate the problem. As the amount of commercials vehicle and passenger vehicle travel is dramatically increasing with the growing rate of freight transport and people movement from place to place which in turn requires continued attention in order to find ways of reducing truck and passenger crash risk accordingly, it is important for the safety community to identify the characteristics and contributory factors related to vehicle involved fatal crashes. In contrast these factors, recorded as vehicle-related factors, are subjective with respect to police officers present at crash sites. As officers are not professional vehicle inspectors, these records might not be absolutely precise

Table: - 4.7. Contributing Factor Verses Total Number of Crash and ROR Crash Based on VF

Contributing Factor Verses Total Number Of Crash And ROR Crash Based on Vehicle Factor						
No	Vehicle Factors (VF)	Number of ROR Crash	Number of NROR Crash	Conditional Probability of this VF given A ROR Crash	Conditional Probability of this VF given a NROR Crash	Likelihood Ratio
1	Motor Problem	0	1	0	0.005405405	0
2	Tire Blow Out or Tire failure	6	2	0.031914894	0.010810811	2.95212766
3	Brake are out of control	17	3	0.090425532	0.016216216	5.576241135
4	Strapping	3	4	0.015957447	0.021621622	0.738031915

Road and its environment factor

After driver and vehicle-related causes, road and its environmental factors were the most important type of contributory cause related to the crashes in these studies. Environmental and road-related causes responsible for ROR and NROR crashes are summarized in table 4.8. Analysis from the table showed that among different road and its environment-related causes; rain, rutting, pothole, obstructions was identified as road and its environment since they are written on the line of crash recorded contributing factor, but it was difficult to categorize this parameter in to one of crash type contributing factor since the probability of NROR was almost zero and it was difficult to determine likelihood ratio.

The (#Div/0!) parameter written in the table 4.8 under the columns of likelihood ratio shows that it is difficult to determine the value of those factor likelihood ratio since conditional probability of this road and environmental factor (RF) given a NROR crash is almost zero or in other word it difficult to divide number to zero and this was due to poor data collection quality.

This is due to the fact that crash record received has luck of information regarding the road and its environment which consistence with cited in the literature review such that data collection system in developing country doesn't dictates detail road geometric factor resulting traffic accident and this one is problem identified in the crash data registering and the rest of factor that are not stated clearly categorized under unidentified factor and unidentified associated factor was

found to have the lowest or less than one likelihood ratios, which indicates that they significantly contribute to NROR crashes.

Table: 4.8. Contributing factor verses total number of crash and ROR crash probability distribution based on road and its environment factor

Contributing factor vs total number of crash & ROR crash probability distribution based on road & its env't factor						
NO	Road and environmental factor	Number of ROR Crash	Number of NROR Crash	Conditional Probability of This RF Given a ROR Crash	Conditional Probability of this RF Given a NROR Crash	Likelihood Ratio
1	Rain	2	0	0.010638298	0	#Div/0!
2	Rut, Hole	2	0	0.010638298	0	#Div/0!
3	Obstruction	2	0	0.010638298	0	#Div/0!
4	Un Identified	24	36	0.127659574	0.167567568	0.7618394

4.6. Analysis for black spot identification

The main objective of this investigation part is to identify the probable road section/location accident black spot on the considered road stretch. Four years accident data (secondary crash data) in above from the east Wallega zones collected were used in this data analysis and the top ranked nine accident black spots road section from Nekamte town to different section with their road network were identified using Weighted Severity Index Method (Si) by assigning scores based on the number and severity of accidents in that particular section of the road.

Based on this evidence the result observed has been manipulated in the tabular form and the detail sample calculation followed in the method has been shown below. In this studies since accident severity was considered for identification of black spot, the whole section of the road network accident resulted severity has been estimated to calculate average severity value, which is important for determination of critical severity value (Qc) with specified percent confidence interval and with some deviation from the mean, where these values was important for judging to call section whether is black spot or not. If a certain road section shows higher values than or equal to the critical ones considering all of the parameters, the section is considered to be a black spot.

Analysis were start by estimating the total accident severity resulted in the entire road network and is estimated from the crash data base and the result was displayed as follow.

ΣFatal (F) =160, ΣInjuries (I) =570, ΣPOD =158,

This is the total number accident severity in the whole section of the road network in study area, and following this the severity value for whole section (Si) has been calculated by;

ΣSi =(9 x 160 +3 x 570+158) =3308, and **ΣAi = 374**

Once the accident severity value for the whole section (**ΣSi)** are estimated and knowing the total number of accident (**Ai**) occurred on the whole section, the average severity value (**Qave)** for the entire section in the road network was estimated according to the equation listed in the method,

$$Qave = \Sigma Si/\Sigma Ai = 8.845,$$

Meanwhile, average severity value was estimated it was possible to write the critical severity value (**Qc**) in the function form and pass to find the other unknown parameter in the equation

$$Qc = 8.845 + K_{\alpha}\sigma$$

Following the equation using at 90 percent confidence interval and its' value was determined from a normal distribution which take value of ($K_{\alpha} = 1.645$) and standard deviation from the mean has been evaluated by calculating the severity value for each section (**Qi**) and applying equation in combination with average severity value for the whole section and the number of section considered as below, and it was done using excel software which is displayed in the tabular form, consequently only the value has been written on the page.

In order to calculate the severity value for each section (**Qi**) it was followed that of the whole section severity value estimation method and the road network under consideration has been classified in to nine road section so that the number of section considered in the study was nine (n=9) and based on this estimated deviation from the mean has been calculated as follows,

$$\sigma = \frac{1}{9-1} \text{ x } (\Sigma(Qi - 8.845) \text{ ^2) ^0.5} = 2.134$$

Finally, hereafter it is obtained the value for each parameter and the required parameter for critical severity value estimation are $K\alpha = 1.645$ which is confidence level at 90% and this means that there is a 10 % risk that a road section is considered a black spot when in fact it is not. And the σ **=2.134**

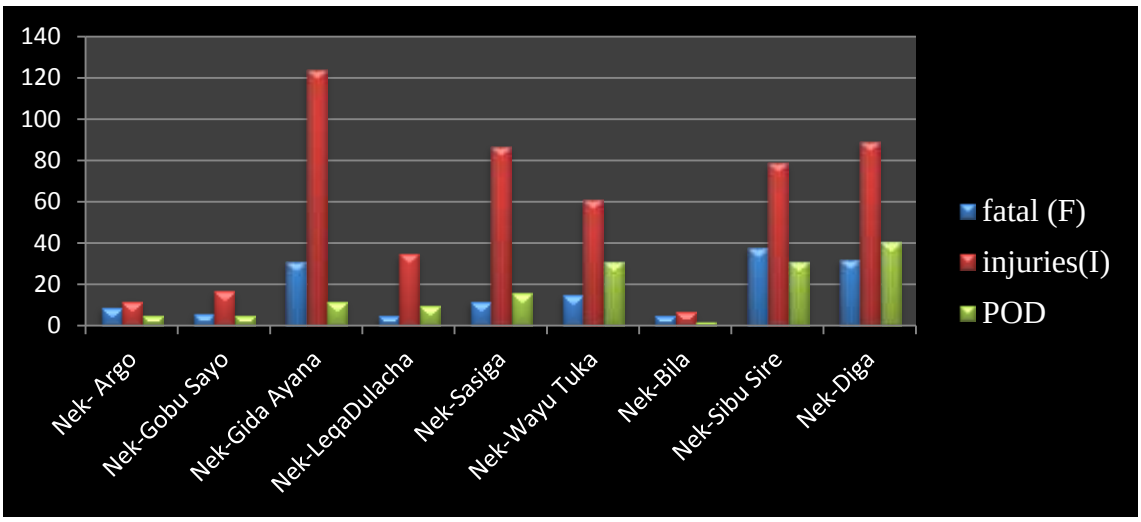
has been calculated based on the relative severity value for each section and average severity value for the entire section (**Qave = 8.845**); then, critical severity value has been estimated as follows;

Qc = 8.845 +1.645 x 2.134 = 12.35543

Based on the result estimated on critical relative severity value and the relative severity value for each section which was shown in the table 4.9, comparison was made in order to identify the sectional black spot in the road network and their result of comparison has been done by excel software displayed in the table 4.10

4.6.1 Computational Black Spot Result of the Road along the District in the Zone

Based on the severity value observed in road section considered for identification of black spot; their resulted injuries severity has been evaluated from the extracted crash data and the result of accident severity occurred on each road section was displayed on the graph of figure 4.11 below and as it is observed from the result of accident severity distribution, most of road section of the sampled areas has similar distribution of accident due to the road characteristic, traffic volume, roadside characteristics and different type of vehicle class transporting on the roadway have similar features and in parallel way accident distribution follows traffic volume flowing on the road and functional importance of the road since most of the accident has been registered on nekamte to (Diga, sasiga Sibu sire, Gidda Ayana, Wayu Tuka) which are the main route connecting East Wallega Zone to different zone bounding the zone and the result is presented as follows:



Data Source: East Wallega Police Office.

Fig 4:11 Top Road Section or district Spots based on accident severity

Subsequently, this section of the paper will present black spots identified based on an accident severity method, in such ways that concentration of the accidents on a particular stretch or segment/location is not a mere chance but due to combination of several parameters such as a result of traffic flow characteristics, roadside factor, nearness of crash area to hospital, road geometry, road user behavior, safety method used etc. which increase or decrease the severity of an accident make the road section very disaster. Consequently in this study road network is classified in to road section/segment/district and considered as black spots, i.e. sites are generally assessed in terms of their degree of hazard or probability of being associated with a crash.

In the table 4.9, road network has been classified into different section/district and their cross-ponding accident occurred on them are described in terms of severity encountered in the research and based on the number of accident severity and weighting factor, severity value was estimated and the road section has been ranked according to severity value registered on them and the result has been displayed bellow's table.

Table 4.9: Top Ranked Accident Spots of Road Section in the East Wallega Road Network

No	Section/disrict Name	Number accident occurred on the section	Accident severity resulted on section			**Si**	**Rank**	**Qi**	**σ^2**
		Ai	Fatal F	Injuries I	POD	9F+3I+POD		Si/Ai	(1/9-1)(Qi- Qave)^2
1	Nek-Gida Ayana	49	31	124	12	663	1	13.53	21.95496211
2	Nek-Sibu Sire	62	38	79	31	610	2	9.839	0.987458923
3	Nek-Diga	85	32	89	41	596	3	7.012	3.360751644
4	Nek- Sasiga	41	12	87	16	385	4	9.39	0.297290913
5	Nek-Wayu Tuka	47	15	61	31	349	5	7.426	2.014889645
6	Nek-Lqa dulacha	23	5	35	10	160	6	6.957	3.566350142
7	Nek- Argo	13	9	12	5	122	7	9.385	0.291184763
8	Nek-Gobu Sayo	15	6	17	5	110	8	7.333	2.285136111
9	Nek-Bila	9	5	7	2	68	9	7.556	1.662666975

Source: Study work result

Sum of σ^2 = 4.55258640

.

σ=2.134

In Consistent with the evidence from the past research on the study area (Gashaw, 2016) and driver communication, traffic police discussion during site observation and from the result of crash data analysis the roadside environments are some common properties of the accident prone locations around the area and some specific location having more brought to the accident frequently are identified. These include vegetation along the roadside which limits the visibility of drivers (on Digga road section; Katta Fola, Qajela are some of specific site, on Gobbu sayyo sction; Qejjo Michael, on Gida Ayana section; Guto gidda; Bellam-Sorg, kiramu area, around Andode mountain), and absence of guard rails (on Diga section Dhaga Kaba, Qajela hazardous location, on Wayyu tuka road section; Gulliso, Hadiyya-Mino and on Sibbu-sire road section; laga gindo, Jalalle). Besides the geometric and environmental behavior of the accident prone areas there are causes for the existence of road traffic accidents.

From site observation, in addition to the above listed factor causing traffic accident at the special location stated in the above or the most common causes of crashes is, road surface condition (such as road deterioration as an example on Digga district; special place called as Katta Fola road site; not only this in many part of the road under study accident happened at different time has been characterized by over speed, ignoring warning posts sign since they are posted on certain road section under investigation, restricted traffic lane width or lane width are very narrow, traffic congestions and parking along the roadside in built up area are some of problem observed during the site observation, as per former research done evidence on the area and recommendation of traffic inspector observing the crash environment during the accident happening. These causes alone couldn't result with road accidents. But they are interrelated with other factor i.e. human error, road geometry and environments factor.

For instance, as an illustration in considering the road accident happened in Katta Fola road site; speed, deterioration of the road and existence of vegetation which obstruct site of driver has a great contribution. The crash and its pattern are shown in the following figure 4.12; this photo has been captured by traffic officer immediately when the accident has been happened and confirmed with site investigation result.

Figure: 4.12. Road traffic accident at Kata Fola and its pattern

Conversely, for the accident happened on Wayyu tuka road section at special place called Gulliso has been characterized by, slope, speed, luck of road side barrier, the alignment of the bridge and its width resulted in a head-on collision between vehicles was the factor the accident happened as per traffic inspector observation during the crash occurrence and confirmed with site observation photo displayed below. In similar way the accident happened at this place has been characterized at different time by different parties and confirmed with the above parameter listed, and the pattern of accident is shown in the following figure 4.13.

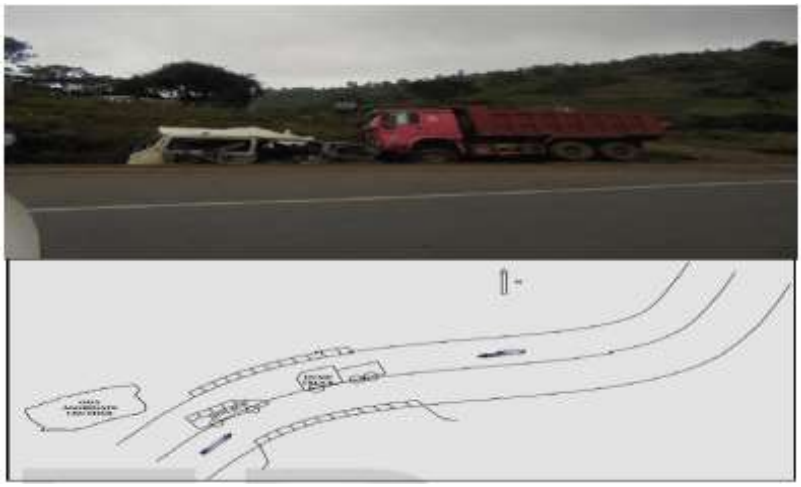


Figure: 4.13. Road traffic accident at Gulliso and its pattern

In line with the results from the analysis table the road has been ranked according to their severity of an accident resulted on them and specific road section is considered dangerous when

its severity value is greater than or equal to critical severity value. Based on that Nekemte - Gida Ayana section/district fall under black spot criteria; since relative severity value of this road section is greater than the critical severity value. This is due to the fact that the road geometry along Gida Ayana districts is partly straight and flat where drivers move faster and are subjected to severe accidents, some part of the location of the road is curved following the mountain with densely vegetation cover which is expected to be driver driving along this area exposed to accident and subsequently it was difficult to see vehicle oncoming in opposite direction and its surface is gravel type.

Not only this is factor for the road possess in the black spot, as the road connect Nekamt cities to Bahirdar cities and its location is covered with commercials agricultural type of product, commercials type of vehicle are using the road section, with intention of this most the passenger use vehicle transporting the product within the two cities for their movement due to transportation problem and little traffic enforcement which is observed from the discussion with traffic police and contact with some driver for detail information during site observation. Most of the road geometry along Diga, Wayu Tuka, Sibu Sire district or road sections are sloppy coupled with both horizontal and vertical curves. Therefore drivers are expected be active and should have to remain alert to save life and property from traffic accidents along this portion of road.

Thus, this portion of road was the safest side in this studies when compared with Gida Ayanaa road section and it is observed that accident-prone sections have a close relationship with traffic volume due to the fact that on Diga, Wayu Tuka, Sibu Sire district/road section have more traffic movement than Gida Ayanaa road section since this rout connect the zone with capital Addis Ababa and confirming to this from the literature, with the traffic volume decreasing, the spacing of vehicles increases, so drivers can choose the speed according to their own habits without the interference from the vehicles traveling in the same direction. In contrast, drivers are more careful when the number of vehicles is larger with the traffic volume increasing, which lead to the decrease of traffic accidents and make the road safer which analogous with study by (Getu, 2007, Girma, 2000).

The result described in the table 4.10 below shows that classification of the road section in terms of cited criteria in the studies such that, in order to identify weather road section is black spot or not data has been arranged according to the criteria stated in method and their result has been compiled by excel software based on the value of relative severity value (Qi) and critical severity

value (Qc) and finally simple programing is developed which categorize the result as follows in the table.4.10.

Table 4.10: Result showing top of Black spot in the road stretch

No	Section name	Qi	Qc	=IF(Qi>=Qc," black spot", IF(Qi<Qc," not black spot"))
1	**Arjo**	**9.3846**	**12.355**	Not Black spot
2	**Gobu Sayo**	**7.3333**	**12.355**	Not Black spot
3	**Gida Ayana**	**13.530**	**12.355**	Black Spot
4	**Leqadulacha**	**6.9565**	**12.355**	Not Black spot
5	**Sasiga**	**9.3902**	**12.355**	Not Black spot
6	**Wayu Tuka**	**7.4255**	**12.355**	Not Black spot
8	**Bila**	**7.5555**	**12.355**	Not Black spot
9	**Sibu Sire**	**9.8387**	**12.355**	Not Black spot
9	**Diga**	**7.0117**	**12.355**	Not Black spot

Source: Study work result.

Accordingly on some the places as the carriageway width is less oncoming vehicle collide each other so that existing travel lane are not sufficient for accommodating huge traffic and width is not satisfying the standards of national highways especially Nekemt-Diga, Nekmte-Sibusire, Nekamte-Gida Ayana desired to modifies since they accommodate huge vehicle volume per day and in similar way surface type of Nekamte-Gida Ayana is gravel upgrading the surface to an asphalt will reduce accident on the road section.

Once the section under consideration in terms of accident severity encountered on them has been identified, the specific location where mostly traffic accident occurred on each section has been identified from the crash data and sampled for detail study. In order to rank and identify the hazardous locations for the sample areas, the priority value of each location was evaluated. These priority values depend on the number of slight injuries, series injuries and number of deaths recorded which is basically explained in the method. The basic formula for the evaluation P-values was indicated by this equation and following that P-value above 15 indicate that the location was hazardous locations/black spot.

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

Based on this equation, the priority values of each specific location on the section are put in the following, table 4.11. As it was observed from table 4.11, only three of the locations have p-values less than 15. These three locations are Ariya Jawwi in Wayyu Tuka district and Dhokonnu in Gobbu Sayyo districts Gutin kela in Gida Ayana district. The other locations have values

greater than the requirement, P-value greater than 15. Thus they are road traffic accident black spots. Out of all locations, Qajela in Digga, laga Gindo in Sibbu Sire, Bellam-Sorga in Gidda Ayana, Katta Fola in Digga and Gulliso in Wayyu Tuka districts are the top five black spot locations in the zone.

Table 4.11 Priority Value (P-Value) of the Road Crash Locations in Sample Area

No	Road section	Location of spot on the section	Fatal (Z)	Series injuries (Y)	Slight injuries (X)	P-value	Rank
1	Nek-Gida Ayana	Bellam-Sorga	12	1	2	65	3
		kiramu	6	2	3	39	6
		Andode mountain	2	3	2	21	9
		Gutin kela	1	2	2	14	13
2	Nek-Diga	Qajela	13	2	15	86	1
		Kata folle	7	4	5	52	4
		argo	2	1	5	18	11
		Ephrem	3	3	5	29	7
3	Nek-Wayu tuka	Hadiyya-Mino Minch	2	1	3	16	12
		Ariya Jawwi	1	2	2	13	14
		Gulliso	9	1	2	50	5
4	Nek-sibu sire	Jalale	3	2	3	24	8
		Laga gindo	8	7	6	67	2
5	Nek-gobu sayo	Qejjo Michael	3	1	2	20	10
		Dhokonnu	2	1	1	14	13

Beside with traffic accident occurred on the location listed on the above table 4.11, the location has been characterized with the feature existing around the road area. Specifically Katta Fola is one of the hazardous location which is located about 3.6km from the center Diga town as shown in the figure 4.14.

The feature of this section is curved with short sight distance and covered with vegetation on the road side. This location of the road surface was observed with damaged pavement leading to lane

change for the drivers which is not allowed near curved road. In the road section, there are no any traffic regulation posts to inform the drivers about the road geometry.

Figure: 4. 14 Road deterioration and vegetation coverage of Katta Fola

The other location found in Diga district is Qajela hazardous section. It is extending from Qajela elementary school to the entrance of Arjo Guddatu town. The general character of road feature around the area includes they are located in mountainous area in their geographical appearance. At the entrance of this area (Qajela Elementary school) there was a traffic warning post which informs about the escarpment of the road as shown in the following figure 4.15.

Figure: 4. 15 Warning posts at Qajela road section

The section with its center at Sire town has two major hazardous locations which are located at Laga Gindo and Jalalle road sections. As it is shown in the figure below 4.13 the location for the accident happening is at the beginning of the horizontal curve after a long stretch down the sloped road. The other characteristic of this location is there is a combination of vertical and horizontal curve with vertical curve before reaching the road accident location. For the regulation

of traffic flow (vehicles) there are two posts available at the beginning of the section (on the way from Addis Ababa). These posts inform the geometry of the road, existence of narrow bridge as illustrate in the following figure 4.16.

Figure: 4. 16 Some Features of Laga Gindo Location and Available Road Traffic Posts

4.7. Identified problem causing Run-off-the road and proposed improvements

This study is of better relevance in this context for mitigating accident problems on rural roads through systematic identification, analysis and measure of accident prone stretches based on accident severity and identification factor resulted in the run-off-the road crash in past/recently. Problem identified from the crash data analysis and site investigation and proposed improvements for those stretches and cases are discussed here.

- No pedestrian facilities provided on Road especially zebra crossing where population densities are expected to be high and side walkway even in some of built up area.
- High on-street parking at/in built up area that road section crossing and the effective carriageway for a smooth movement of traffic are reduced.
- In summer season, rain water spills over the road make a pond and wet due to poor drainage facilities
- Road signage and markings are generally missing to warn the road users in advance at many places on the stretches and existing sign are also destroyed due to non-proper maintenance and faded road markings are usually the major causes of accidents at hazardous area.

- Traffic policemen do not work before morning 2:30 and late night after 11:30 local time; these reduces supervision and delays rescue and provision of first aid to victims and in parallel to this most of the vehicle are over loaded at that time causing an accident.
- Defect of vehicle in transportation such as; poor quality, technical problems of vehicles and old age in their usage so that they are means of increasing accident.
- Poor road structure and surface quality and geographical problem since most of alignment of the road are full of Horizontal curves, steep grades, and vertical curves bring additional challenges to drivers, resulting in increased risk of collisions.

In similar way, system of licenses create big problem, with the issuance of driver's licenses, especially with the issuance of higher grade driver's licenses are issued to new drivers. The old way where licenses for heavier vehicles or higher grade were progressively issued was better since in the old system driver will get the higher driving license after so many trials from the lowest to the higher driving skill and issued based on their talented skill which is supported by data sourced figured below and supportive information about the licensing system in Ethiopia has been cited on this page for more https://addisfortune.net/articles/ethiopia-among-worst-in-traffic-safety/). As it is observed from the graph on the figure 4.14, in terms of driving license, driver trained in the new driving curriculum without phasing approach have more involvement causing ROR crash than the last decade back licensing state in the country or the old one.

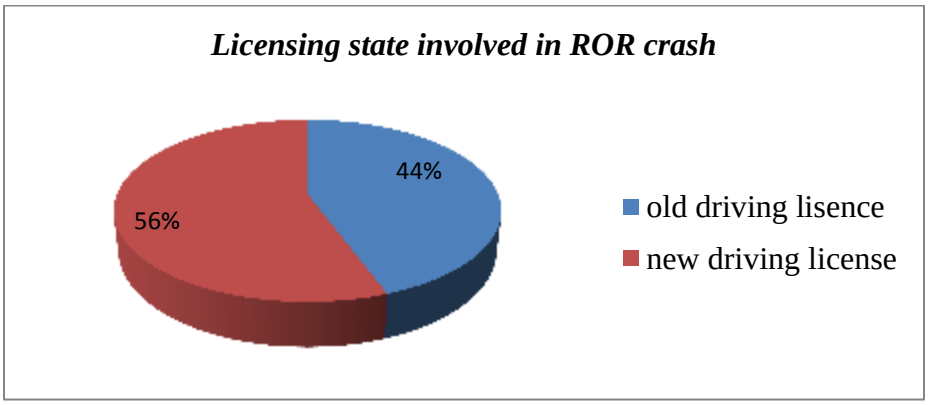


Figure 4.17 Driver licensing state involved in the crash

- Luck of introducing traffic safety rules to public those using the road.

Table 4.11 Systematic and Strategies for reducing run-off-the road crash/accident based on problem identified.

Objectives	Strategies
Keep vehicles from encroaching on the roadside	➢ Install shoulder rumble strips ➢ Install edge line "profile marking," edge line rumble strips, or modified shoulder rumble strips on section with narrow or no paved shoulders ➢ Provide enhanced shoulder or in-lane delineation & marking for sharp curves ➢ Provide improved highway geometry for horizontal curves ➢ Provide enhanced pavement markings ➢ Provide skid-resistant pavement surfaces, apply shoulder treatments ➢ Eliminate shoulder drop-offs ➢ Widen and/or pavement shoulders
Minimize the likelihood of crashing into an object or overturning if the vehicle travels off the shoulder	➢ Design safer slopes and ditches to prevent rollovers ➢ Remove/relocate objects in hazardous locations ➢ Delineate trees or utility poles with retro-reflective tape ➢ Widen the shoulder
Reduce the severity of the crash	➢ Improve design of roadside hardware (e.g., light poles, signs, bridge rails) ➢ Improve design and application of barrier and attenuation systems ➢ Give immediate first aid for those affected by accident
Give attention with driver licensing	➢ Government should have to enforcing licensing part should consider all criteria and improving driver performance.
Proper traffic accident/crash data collection, Road User Information and Campaign	➢ Modifying system of data collection throughout the country. ➢ Include roadside feature affecting vehicle in to crash on the accident/crash data collection. ➢ Increase the efficiency of police traffic working especially at the time recommended in this study to access full data for traffic safety analysis which increase the accuracy of data ➢ Providing appropriate training for Traffic Police Officers especially training conducted by safety practitioner so that multiple apparent causes of accidents were identified in well defined.

For reducing road traffic accident in the East Wallaga zone the following suggestion from this research finding has been drown and effective implementations of this suggestion would make the road in the country in safe way

- Properly defined crash data can identify the key contributing factors to traffic crashes in terms of crash frequency, crash type, and crash severity. Hence for scientific research on crashes, one first needs to have a reliable crash database; but not only in East Wallega in Ethiopia as whole there is no organized crash database maintained for in-depth research on crashes especially accident happened on rural road at regional and zonal level. The absence of such nationwide systematic data impedes the research and analysis of road crashes in the country. To address this issue and to identify the root cause of crashes in the East Wallega zone, it is necessary to fully understand the traffic and crash affecting parameters so that the system of data collection should have to be modernized and is better computer based data filing system is encouraged.
- The driving licensing certification processes in the Zone are poor in quality and not only poor in quality but is also exposed to different aggravating factors. Currently, drivers can directly own the highest possible deriving license level and can drive any type of vehicle (light to heavy vehicles) without any prior experience as a prerequisite. In the same way, the education quality and especially the practical cession given to the candidate drivers in the private training centers is usually below the standard set by the government. Apart from this, corruption is a common practice where the practical examination for the candidate drivers is believed to be exposed for bribe. As a result of this, many trainees who fail the exams can bribe the trainer and get the driving license easily.

  Among alternative solutions, one possible remedy to these problems is designing and implementing phased approach of drivers' licensing program where candidate drivers should own the least driving license first and have some years of experience as prerequisite before they get the next driving license level. This was the drive licensing system used some years back and has been more effective than the current licensing system. This way, drivers own many years of driving experience, more confidence and maturity until they compete for the highest license level to drive heavy trucks and as a supplement to this, automating the licensing process and establishing some central control & authentication mechanisms, such

as using uniform national ID, etc. would help to minimize cheatings. A tight control on the practical cession and examination of the candidate drivers should also be considered.

- Surprisingly, there is no known standard on the age limit for cars (both imported new and used) and for the number of years a vehicle can serve in the country since from sample observation and suggestion from some driver, passenger, traffic police, other stake holder discussion shows that majority vehicle causing an accidents are poor in quality and have old age. Used cars from around the world are imported and operate throughout the country and continue to serve for unlimited number of years. There is no quality control standard in place to check how long vehicles (used or new ones) should serve at different level, if they are prone to accidents, if their carbon dioxide (CO2) emission level is acceptable and when they should completely stop giving service (removed). Definitely, these over served cars have the lion's share on the road traffic accidents. Hence, legal car quality control standards are very necessary in practice for the country.
- From this study outcome, the majority of the victims were males, aged 18–30 years, which is similar with different study at different time and at different place in the country. The dominance of males and younger age groups might be due to their frequent movements from town to town for different businesses. Moreover, younger men are more likely to engage in risky behaviors like running at high speed, infected with different bad driving behavior, violating traffic signs, and passing dangerously so that effective training of this age group driver and encouraging legal penalty free from bribe is importantly reduce accident due to this age group.

Chapter five

Conclusions and Recommendations

5.1. Conclusions

This study identified characteristics of run-off-the road crashes, factors contributing to the occurrence, and factors associated with increased crash severity relating to vehicle, driver, environment, road, and other related factor and compared with those of non-run-off-the road crashes based on Crash data obtained for the year 2005-2008 and the source crash data was a compilation of police-reported crash data at zone level.

- The majority of both crashes in the study were found to have occurred during daylight conditions and under no adverse weather conditions and the results from the up-to-date study show that ROR crashes were more dangerous than NROR crashes because in most cases the percent of crashes that results into higher severity crashes were higher for ROR crashes than NROR crashes.
- Analysis of the factors contributing to the occurrences of Run- off and Non-run-off the road crashes shows that driver and vehicle-related factors were the most dominant type of contributory cause; moreover, speeding, being young age, drivers failing to give first, poor road surface, fatigue, sleep /distraction/ and improper lane change or turning, tire blow out and frame are out of control are contributed to the occurrence of both type of crashes.
- In order to identify factor contributing to the crash Bayesian statistical equation model were used and the model would able to identify some of the most significant factor that lead to cause and increase the severity levels of the crash (i.e., fatal crash, injury crash, and property damage only). The likelihood ratios in the model identified four significant contributing factor for ROR crashes i.e. speeding, (fatigue/distraction, sleep), tire bow out, and frame problem are the most common contributing factor related for the occurrences of ROR crash in the study.
- While wrong side driving, too fast for condition and loss of distance, improper turning, carelessness, not giving attention, failure to give first, in experienced, over loading, pedestrian & passenger problem, motor problem more related contributing factor to NROR crashes and in this study it is difficult to categories road and its environment in to

one of the crash type in the study due to in adequate data relating road and its environmental factor in the crash data obtained.

5.2. Recommendations

High rate of traffic accidents can be significantly reduced through a little attention just by means of educating the people about severity and misery of the accidents and changing the road user behavior through training the drivers, creating awareness about road safety problems and keeping stringent traffic rules and regulations for drivers and educating the pedestrians/ all road user can significantly reduce the accident rate around the rural area. Finally encouraging proper identification of factor causing traffic accident and hazardous area on the road section with model based method should reduce accident frequently occurring at the same location or road section and important for appropriate allocation of resource for improving location/road section having frequent accident.

- More efforts should be made to enforce young drivers obey traffic rules and enforcement of the speed limit using recent technological system.
- Driving public transports (vehicles carrying passengers) at night need to be banned and important controlling mechanisms should be arranged.
- Awareness campaigns on road safety rules should target pedestrians and strengthen the measures taken on pedestrians who don't abide road safety rules.
- The country should have modify and implement road traffic safety policy with current issue concerning agenda.
- Further encouraging large prospective studies are needed to identify the possible factors associated with Road and Traffic Crashes
- The analysis of the study verifies that driver casualties are among the dominant causes of Road Traffic Accidents. The young, and less experienced drivers are responsible for most of the accidents happened due to ROR. Therefore, drivers' training and testing should be standardized; a longer minimum time of driving experience should be imposed before a license is issued to a driver. In addition, there should be additional prerequisite criteria for drivers with regard to their educational background and good behavior, maturity of their age, ample driving experience, free from any addiction like chewing chat, alcoholic

drinks, free from criminal acts as well as offending and frequent violation of traffic regulations.

- Expanding the method of controlling drank driving started at some part of the country to the rural area should reduce significantly the accident.
- Modifying the system of driver licensing with driver experience limit the largest accident coverage of younger driver and reduce overall accident in the country
- Introducing the legal punishment for the owner of animal those using traffic lane would safe both the life of animal and accident occurred due saving the life of animal.
- Increasing the road side feature to be accident resistances in such way that clearing the obstructions near the road and improve surface quality of the road make the smooth movement of the vehicle which reduces an accident.
- Further large prospective studies are needed to identify the possible factors associated with Road and Traffic Crashes
- Take suitable enforcement measures to reduce the speed of vehicles

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Appendix

Table A.1:-Road traffic accident data report of Oromia region, East Wollega zone (2005-2008 E. C)

No	District	Number or Frequency of Road Traffic Accidents Caused				
		Fatal	Series injuries	Slight injuries	POD	Total
1	Argo	6	3	0	4	13
2	Gobu Sayo	6	4	2	3	15
3	Gida Ayana	22	12	7	8	49
4	LeqaDulacha	4	5	7	7	23
5	Sasiga	11	12	11	7	41
6	Wayu Tuka	8	9	11	19	47
7	Bila	5	1	1	2	9
8	Sibu Sire	23	10	8	21	62
9	Diga	27	17	15	26	85

Table A.2:- East Wallega Zone Accident Statistics for Reported road traffic accidents based on Drivers Age group 2005-2008 E, C.

No	Driver Age	Total Number Crash Caused	Severity of Accidents			
			Fatal	Series injuries	Slight injuries	POD
1	Less Than 18	1				1
2	18-30	180	48	44	43	45
3	31-50	93	33	16	12	29
4	More Than 50	8	4	0	1	3
5	Unclassified Age	92	34	21	12	25

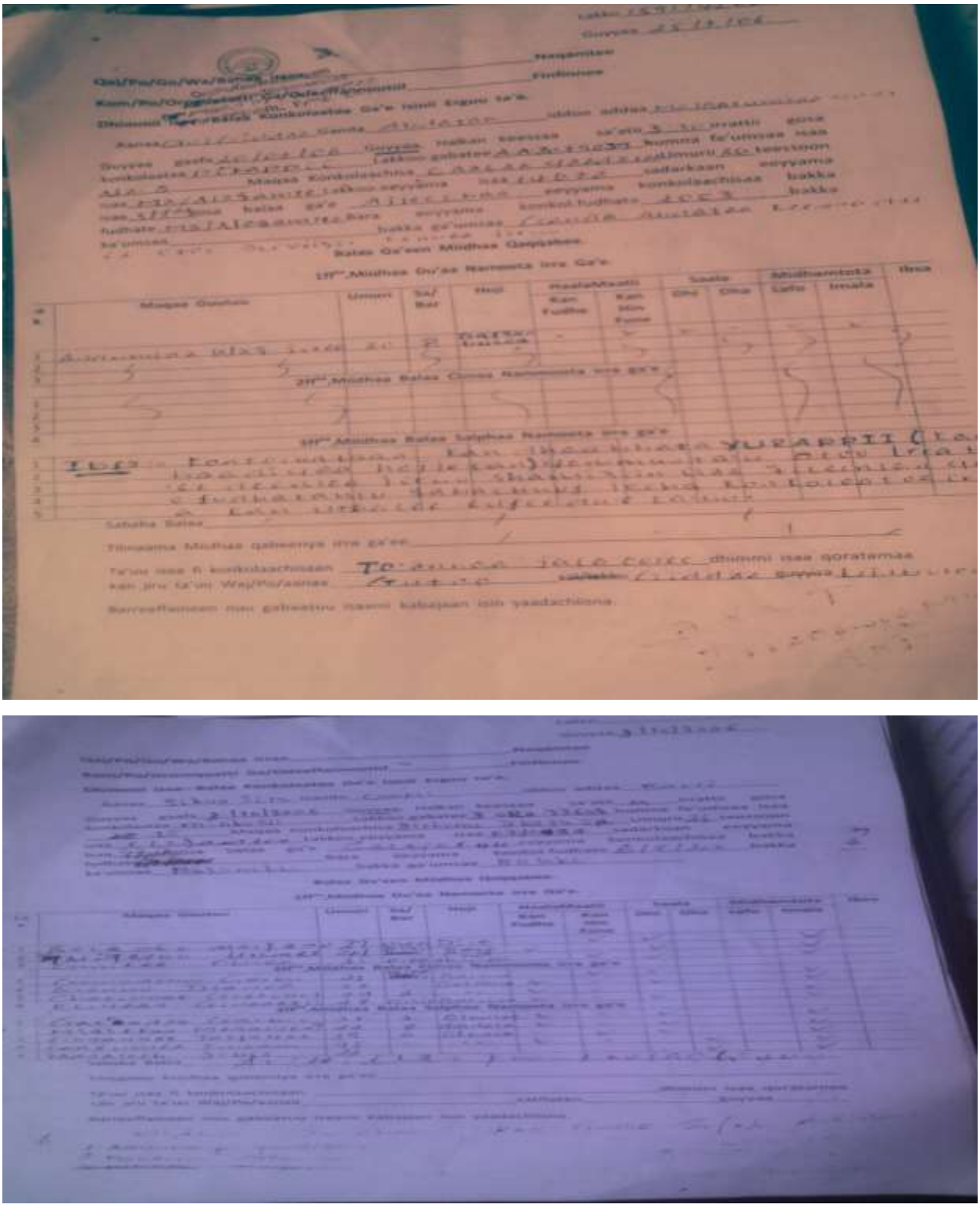

Figure A.1 Sample crash data collection Form obtained from the traffic office of East Wallega Zone