ROAD TRAFFIC ACCIDENT ANALYSIS BASED ON VEHICLE ACCIDENT PERSPECTIVE: A CASE OF ADAMA CITY

Jafer Adem Mohammed

A Thesis Submitted to

The Department of Mechanical Systems and Vehicle Engineering

School of Mechanical, Chemical and Materials Engineering

Presented in Partial Fulfillment of the Requirement for the degree of Master of Science in Automotive Engineering

Office of Graduate Studies

Adama Science and Technology University

December, 2021 G.C

Adama, Ethiopia

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APPROVAL OF BOARD OF EXAMINERS

We, the advisors of the thesis entitled “Road Traffic Accident Analysis Based on Vehicle Accident Perspective: A Case of Adama city” and developed by Jafer Adem, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Major Advisor	Signature	Date
Co-advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by Jafer Adem have read and evaluated the thesis entitled “Road Traffic Accident Analysis Based on Vehicle Accident Perspective: A Case of Adama city” and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Automotive Engineering.

Chairperson	Signature	Date
Internal Examiner	Signature	Date
External Examiner	Signature	Date

Finally, approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

Department Head	Signature	Date
School Dean	Signature	Date
Office of Post Graduate Studies, Dean	Signature	Date

CANDIDATE'S DECLARATION

I hereby declare that this Master Thesis entitled "Road Traffic Accident Analysis Based on Vehicle Accident Perspective: A Case of Adama city" is my original work. That is, it has not been submitted for the award of any degree, diploma or certificate in any other university. All sources of material that are used for this thesis have been duly acknowledged through citation.

Jafer Adem Mohammed	_____	_____
Name of the student	Signature	Date

RECOMMENDATION

We, the advisors of this thesis, hereby certify that we have read the revised version of the thesis entitled “Road Traffic Accident Analysis Based on Vehicle Accident Perspective: A Case of Adama city” prepared under our guidance by JAFER ADEM submitted in partial fulfillment of the requirements for the degree of Mater’s of Science in Automotive Engineering. Therefore, we recommend the submission of revised version of the thesis to the department following the applicable procedures.

_____	_____	_____
Major Advisor	Signature	Date
_____	_____	_____
Co-Advisor	Signature	Date

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ACRONYMS

ACTAO	Adama City Transport Authority Office
ACPC	Adama City Police Commission
EDHS	Ethiopian Demographic and Health Survey
ERA	Ethiopian Rod Authority
ESZTAO	East Shoa Zone Transport Authority Office
FMVSS	Federal Motor Vehicle Safety Standards
GDP	Gross Domestic Product
HO	Head Office
HTVJ	High Traffic Volume Junction
HTVS	High Traffic Volume Straight
LTVJ	Low Traffic Volume Junction
NHTSA	National Highway Traffic Safety Administration
NMVCCS	National Motor Vehicle Crash Causation Survey
ATC	Adama Traffic Complex
PSV	Public Service Vehicles
PTS	Public Transport Service
RTA	Road Traffic Accident
SPSS	Statistical Package for Social Sciences
TRL	Transport Research Laboratory
USDT	United States Department of Transportation
WHO	World Health Organization

ABSTRACT

Road traffic accident is the major cause of human injury, human death, and economic resources loss all over the world. About 1.35 million deaths occur each year worldwide due to road traffic accidents which of about 70 percent of the deaths occur in developing countries. The literature indicated that 23 percent of the deaths involve pedestrians, out of which 35 percent are children. The objective of this study is to assess road traffic accident analysis based on vehicle accident perspective. And also, the researcher targeted to analyze the causes, contributions, determinant factors, and effects of road traffic accident with regards to it's over all linkage with vehicle accidents. This study tried to explore how road traffic accident is a human life threat in the Adama city. The methods followed were purposive and simple descriptive statistics of primary and secondary sources of data such as literatures, reports, policy, and research documents. Based on responses from respondents and documents from responsible offices detailed analysis was done. Thematic, content and comparative data analysis techniques were applied to analyze the data gathered through interviews. To fulfill the objective of the research, the researcher had given attention to collect accident data from different pertinent Transport Authorities in Adama such as Oromia Transport Authority Office, Adama City Transport Authority Office, and Adama Town Traffic Office, Road data, and Field Observations. For better awareness creation in reducing road traffic accident educational implications of the study were also included with respect to global level, country level, regional level, and finally respective TVET level. And also this study was recommended for striving the road traffic safety treats in Adama town. Hence, the result of the study showed the existence of large difference in road traffic accident victims among drivers, passengers, and pedestrians in their sex and age levels. The male drivers, passengers, and pedestrians were the most affected one as compared to females. From day of the week road traffic accidents reached maximum on Tuesday. In conclusion to have accident free road traffic, enhanced and consistent drivers' training, refreshers, and testing, awareness creation on how to use the road to pedestrians and school children, strict employment of law enforcement, for risky overtaking and over loading, constructing side walkways, marking new zebra crossing and remarking the faded ones, and employment of easy accident data recording system for further study and enhancement of road traffic.

***Keywords**: Black Spot, Junction, Road Traffic Accident, Traffic Crash, Traffic.*

CHAPTER ONE
INTRODUCTION

1.1. Background

Rod traffic injuries and death due to road traffic accident in Adama city and around the city are causing a major public crisis on health and socio-economic condition. Each day across the country vehicles and people can react unexpectedly which is a cause for a certain accident claims lives or permanent injuries. Road traffic injuries represent accounts for significant cause of morbidity and mortality around the globe, particularly in developing countries like Ethiopia. There are various causes of vehicle accidents. When an accident occurs, it is not simply to say something went wrong. The analysis of the accident statistics provides clues to many factors that lead to the accidents and to improvements that may be desired. Based on the statistics the traffic engineer must devise ways to reduce the accidents through better planning, design, construction, maintenance, and traffic operation. And also concerned about the regulation and management of traffic to ensure safer travel.

There are a number of different factors that can cause vehicles accidents, road users, vehicles, road conditions, environmental factors, rod design, and other causes. The aim of vehicle accident investigation is to determine the direct, indirect and basic causal factors, and use statistics call up from different vehicle crashes to evaluate other structural elements so as to upgrade road traffic safety.

An incorrectly aligned cause of a motor vehicle crash leads to some triggering factors. However, close accident investigation and accident reconstruction can determine exactly what will happened and also can help to prevent future accidents. This study, deals with the cause and effect of vehicle accident on house holds' life in Adama city to fill the gaps and tried to recommend the way to reduce traffic accidents in Adama city. Poor pre-carrying system and delays in and out of hospitals before getting aids added to the woes of mortality. However, there are no study that determine the types of injury, management and outcome of road traffic accidents and associated factors in this study area.

1.2. Statement of the problem

This study is focused on studying and analyzing the factors contributing to traffic fatalities. Depending on Adama city traffic police office data report, the results of this research is to

study the causes and counter measures of a road traffic accident in the city. Our country has the highest rate of road traffic accident. The fact that, road transport is the main transportation system all in our country. Due to this reason, every day many people are injured or killed on the road in Adama city. Resulting more and more of these causalities have to spend long day in the hospital after sever crashes and more will not be able to live, work, and play as they used to do. The performance, reliability and accuracy of road traffic accident study mostly depend on carrying out inspections in accordance within the traffic laws and insurance standards. If the exact sequential causes of accidents are well known, it will be possible to reduce the accidents in general and investigate the errors in particular. Researches which lack the standard and incomprehensive way of reporting has been carried out. This way of investigation has therefore been causing problems in justifying the exact cause of traffic accidents. As a result, it has been hindering the investigation of future road traffic accidents while causing a great damage to vehicle owners, the insurances and the ensured people, and those who one way or another had involved in the accident. So, by collecting the necessary information, data processing and interpretations were done using Statistical Package for Social Sciences (SPSS) version 20.0 and descriptive methods in the form of table, charts, and graph. P-value 0.05 were considered as statistically significant and undertaken to suggest possible measures and to identify section length and traffic volume influence on the accident.

1.3. Objectives

1.3.1. General objective

The general objective of this thesis is to study the causes and counter measures of a road traffic accident in Adama city.

1.3.2. Specific objectives

The specific objectives of this study are:

- ✓ To identify locations with high number of road traffic accidents (black spot) areas in the Adama city roads by collecting necessary data from East Shoa Zone Transport Authority Office, Adama City Transport Authority Office, Adama City Police Commission, and Adama Traffic Complex;
- ✓ To explore the crash type of road traffic accidents in the identified black spots areas of Adama city major roads;

- ✓ To develop a standard procedure for traffic accident recording systems of Adama City Police Commission;
- ✓ To suggest preventive measures for Black spot areas.

1.4. Significance of the Study

Antecedently, no implication studies were organized to show the mass of road traffic accidents and announced blackspot areas in Adama city administration. As we learned before in the "ACCIDENT ANALIYSIS" course, this study has better essentiality of:

- ➢ Filling the knowledge on the gap created around the issues;
- ➢ Identifying the cause of road traffic accident in the city;
- ➢ Investigating the cause of accident will help to propose preventive measures in terms of design and control;
- ➢ Support the improvement proposals suggested by the traffic engineers;
- ➢ Supporting charter designer, researchers, organizations etc. with adequate, and dependable data to implement possible and appropriate engineering solutions to reduce the road traffic accidents;
- ➢ The research will also give information to those who are interested in conducting research on traffic safety.

Based on this, the researcher identifies and analyze most blackspot areas of the major roads of city and suggests that easily preventive measures for those black spot areas. Accordingly, this study will be used for several institutions such as, (Adama City Police Commission, Adama City Transport Authority Office, Adama Traffic Complex, East Shoa Zone Transport Authority Office, etc.), Adama city populations, and all other populations of (Ethiopians & foreigners) that comes into the city.

1.5. Scope and delimitations of the study

1.5.1. Scope

This study focuses on traffic accident analysis of the empirical research problems related to road traffic accident investigation process involved in accomplishing the various traffic accident investigations carried out in Adama city and the possible implications in terms of reducing (minimizing) the risk as well as fixing the future traffic problems.

1.5.2. Delimitation of the study

This study is limited to reducing the frequency of accident in the city based on vehicle accident perspective and analyzing of accident data by using SPSS, purposive, and descriptive methods in the form of table, charts, and graph. Vehicle speed is not included.

1.6. Limitation of the study

At the time of this study the absence of information related to vehicle speed limit, unavailability of respondents in their proper office work hour, poor data collection methods, some respondents want benefit from the researcher, and other related factors made this study difficult. Also, it was hard and tiresome to convince the respondents about the aim of the study.

Therefore, shortage of time, absence of fully organized data, and limited cooperation of the government offices such as Adama city transport authority office (ACTAO) was the main problems that the researcher had to face.

1.7. Organization of the thesis

This study consists of five chapters. The first chapter is an introduction to the study. It includes: Background of the thesis, Statement of the problem, Objectives of the study, Significance of the study, Scope and delimitations of the study, Limitation of the study, and Organization of the thesis. Chapter two focuses on the literature review based on the previous related works. Chapter three describes materials and methods used to complete this work. Chapter four consists of results and discussion. Chapter five consists of conclusions, recommendations, and future work areas.

CHAPTER TWO

LITERATURE REVIEW

Literature review part mainly includes causes of road traffic accident which occur in different countries with different road conditions, vehicle defects, and lack of awareness of the drivers. It also includes reviewing of previous studies to choose appropriate analysis type on the given data of previous accident occurrence trends around the study area.

2.1. Global accident statistics

The WHO Report on Road Traffic Injuries for 2018 has listed Road accidents as the leading cause of death for the age group 5-29 years and a growing public health concern. To address this growing public health problem, there is a need for evidence-based research and hence the focus on relevant and reliable data on accidents (Lal, 2019).

According to WHO (2016), road traffic injuries caused an estimated 1.35 million deaths worldwide. That is, one person is killed every 25 seconds. Only 28 countries, representing 449 million people (seven percent of the world's population), have adequate laws that address all five risk factors (speed, drunk driving, helmets, seat-belts and child restraints). Over a third of road traffic deaths in low- and middle-income countries are among pedestrians and cyclists. However, less than 35 percent of low- and middle-income countries have policies in place to protect these road users. The average rate was 17.4 per 100,000 people. Low-income countries now have the highest annual road traffic fatality rates, at 24.1 per 100,000, while the rate in high-income countries is lowest, at 9.2 per 100,000.

WHO (2004). Discussed that road traffic accident is the leading cause of deaths especially for the people whose age is 15-29, while, it is the second leading health problem for children whose age is 4 to 5 and it is the third cause next to HIV/AIDS and tuberculosis for the people who are found between the age of 30 to 40.

More than 1.2 million people die each year on the world’s roads, making road traffic injuries a leading cause of death globally. Most of these deaths are in low- and middle-income countries where rapid economic growth has been accompanied by increased motorization and road traffic injuries. As well as being a public health problem, road traffic injuries are a development issue: low- and middle-income countries lose approximately 5% of GDP as a result of road traffic crashes. Globally an estimated 3% of GDP is lost to road traffic deaths

and injuries. Ninety percent of road traffic deaths occur in low- and middle-income countries, and while these countries also account for 82% of the world's population, they nevertheless bear a disproportionate number of deaths relative to their level of motorization, as they account for only 54% of the world's registered vehicles and for comparisons between the continents Africa has the highest contribution to road traffic accident which is 26.6 % fatality deaths per 100,000 populations (WHO, 2015).

The magnitude of road traffic accidents and fatalities in India is frightening. Road safety is a major issue that needs special consideration as there is one death reported every 3.7 min on the streets of India (World Health Organization 2013). Growth in the road network, a surge in motorization and the rising population in the country contribute toward the increasing number of road accidents, road accident injuries and road accident fatalities. As the study conducted by Society of Emergency Medicines India (SEMI) shows that the road network in India, the numbers of registered motor vehicles in the country and the country's population have increased at a compound annual growth rate (CAGR) of 3.4 %, 9.9 % and 1.6 % respectively, during the decade 2001–2012. During the same period, the number of road accidents in the country increased at a CAGR of 2.1 %. (Society of Emergency Medicines India 2013).

The number of annual road traffic deaths has reached 1.35 million. Road traffic injuries are the leading killer of people aged 5-29 years. The burden is disproportionately borne by pedestrians, cyclists and motorcyclists, in particular those living in developing countries. The report suggests that the price paid for mobility is too high, especially because proven measures exist. Drastic action was needed to put these measures in place to meet any future global target that might be set and save lives (WHO, Statistics of Road Traffic Accidents in Europe and North America, 2017)

WHO (2016). Reported that the distribution of road traffic deaths by type of road user data by country.

Table 2.1. The distribution of road traffic deaths by type of road user data by country

	Estimated number of road traffic deaths	Estimated road traffic death rate (per 100,000 population)	
Country	2013	2016	2013
Ethiopia	23 837 [18 528 - 29 146]	26.7	25.3
Eritrea	1 527 [1 249 - 1 805]	25.3	24.1
Ghana	6 789 [5 877 - 7 701]	24.9	26.2
Mozambique	8 173 [6 502 - 9 843]	30.1	31.6
Saudi Arabia	7 898 [7 002 - 8 795]	28.8	27.4
Zimbabwe	3 985 [3 319 - 4 652]	34.7	28.2
Paraguay	1 408	22.7	20.7
Nigeria	35 641 [27 949 - 43 332]	21.4	20.5

Source: WHO Last updated: 2019

World report on road traffic injury prevention (2004), emphasizes the role of public health in the prevention of road traffic injuries and covers the fundamental concepts and prerequisites of road traffic injury prevention, the intensity and impact of road traffic injuries, key determinants and risk factors, intervention strategies, and recommendations.

(Lagarde, 2007). He compared the selected African countries with recent available data on road mortality and number of vehicles in use in the table below. When comparing death per 10,000 vehicles, the contrast appears even more-stark, with 1.7 deaths per 10,000 vehicles in high-income countries across the world and more than 50 in low-income African countries. And he concluded that:

- In Africa, driving a car is still considered a privilege, an enviable option, not a risky task with inherent responsibilities;
- Unfortunately, Africa has other burning public health priorities;
- Documented success stories in road safety are needed to demonstrate that road traffic accidents need not be inevitable and unpredictable but, avoidable etc.

Table 2.2. Traffic fatality indicators in Africa

Region	Income Level	Country	Year	Vehicles in Use	People Killed in Road Traffic Accidents	Deaths per 100,000 Population	Deaths per 10,000 Vehicles
Sub-Saharan Africa	Low-income	Ethiopia	2002	121,179	1,628	2,3	134.3
	Low-income	Rwanda	2000	26,554	401	4.5	151.0
	Lower middle-income	Swaziland	2001	85,446	255	22.8	29.8
	Upper middle-income	South Africa	2002	6,549,901	12,198	26.8	18.6

Source: World Road Statistics 2006. International Road Federation.

(Gebremeskel, 2014). Studied on RTAs in Addis Ababa (Akaki Kaliti sub-city roads), to identify black spot areas by using accident (frequency methods, rate method, density method), quality control method, and accident severity method. On his study the result achieved and concluded that:

- The road traffic accident trends in Akaki-Kaliti sub-city in terms of days of a weak revealed were a slight difference except on Sunday;

- His study implied that the existence of large difference traffic accident victims among drivers, pedestrians' significant growth of the severity of the accident from 2003-2005 in all days of a week there
- , and passengers with respect to ages and sex;
- His study also identifies collision types mostly occurred in the sub-city, and hence, collisions like rear end, sideswipe, head on, broadside, and collisions with pedestrians were the most frequent collisions in the sub-city in the 2010/11-2012/13;
- As a result, the trend in serious accidents, slight accident, and property damage dramatically increased in all collision types except collision with animal, fall from vehicles, collision with roadside parked vehicles, and collision with roadside objects.

(Wordofa, 2017). Studied to assess the burden of road traffic accident and its determinants among drivers of Adama town. The total of 374 respondents: 22 Taxi driver, 128 Private car or automobile car driver, and 224 Bajaj drivers were selected by systematic random sampling technique. Then by using a face-to-face interview and SPSS version 21model analysis, and he used the logistic regression to assess the association between the study variables at a statistically significant level of ($p<0.05$). Then he achieved that the magnitude of road traffic accident among drivers during the 12 months period were 211 (56.4%). And he gives the reasons related to the driver's behavior, the vehicle status, and the pedestrians or the road were the leading perceived causes of road traffic accident during his study period. Also recommended to the regional and Adama town transport authority and police authority to develop strategy that helps to improve the understanding of the community on safe use of roads. And Adama town transport and police authority should enforce the existing laws and adopt proven road safety interventions for risk driver's identification mechanisms like alcohol breath test and the like.

(Tulu, 2013), the aim of their paper is to synthesize the causes and contributing factors that typify influences on pedestrian crash risk in developing countries. The road traffic accident crashes in Ethiopia by using descriptive analysis. Pedestrian behavior in developing countries is fundamentally different in comparison to developed countries, and influenced by a variety of less well understood contributing factors, leading to difficulty in modelling and predicting pedestrian crash, risk and in turn identifying effective safety counter measures.

They conclude by articulating a critical research path moving forward, with the aim to achieve an improved understanding of developing country pedestrian crash risk, and an ultimate goal of identifying effective pedestrian safety countermeasures suited to the unique challenges faced by transport system managers in developing countries.

(Abdisa, 2018). Studied to identify the major factors determining the number of human deaths per road traffic accident in Oromia Regional states of Ethiopia. By using an appropriate count regression model based on data obtained from the Oromia Police Commission Bureau that have been recorded on daily basis during July 8, 2016 – July 7, 2017. His result showed that 2,712 out of 3,900 of the accidents were not fatal accidents. Also, he concluded that, the Poisson hurdle regression model (HP) was found to be the most appropriate and preferred well-fitting model among the six count models considered for the data, and his descriptive results suggested that there is high variability in the data set. The variance of the number of human deaths per road traffic accident was larger than its mean, suggesting the possibility of over-dispersion. In addition, all formal tests indicated that the data are over dispersed and that there are excess zeros. The Poisson hurdle model provided the most appropriate fit to the dataset.

(Abera, 2019). Discussed about the relation between road traffic accident (RTA) and annual average daily traffic (AADT) with time of a day shows that between 6:01 am-2:00 pm 484 RTA and 5257 AADT, 2:01 pm-10:00 pm 504 RTA and 6923 AADT and between 10:01 pm-6:00 am 149 RTA and 5641 AADT was recorded throughout the study period so that RTAs were depended upon AADT with a time of a day. The total road traffic accidents were nearly equal distribution through the week of the day, the maximum number of the accidents occurred Saturday (178) 15.70% and the minimum was on Wednesday (143) 12.60%. When we see the relation RTA is independent of AADT with the day of the week.

Table 2.3. The relation between RTA and AADT with the day of the week.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
RTAs	153	175	143	165	175	178	148
AADT	18264	18813	18884	19518	19428	19211	17483
RTAs %	13.5%	15.4%	12.6%	14.5%	15.4%	15.7%	13.0%
AADT	13.9%	14.3%	14.3%	14.8%	14.8%	14.6%	13.3%

Source: From Mikiyas (2019)

(Minassie, 2012), on his study in case of north Shoa zone of ANRS, he concluded that Debre-brehan zonal police indicated that 910 accidents which caused 193 losses of lives and over ETB 22,123,133 estimated cost of property damage. And also, the cost of property damages each year can cover approximately 22% of one woredas budget.

2.2. The factor that causes traffic accident

The various causes of road accidents are:

- Road Users: drivers, passengers, and pedestrians.
- Vehicle: Cars consist of hundreds upon hundreds of parts that keep them running safely and smoothly. But with that many parts, it is not uncommon for them to go haywire and malfunction.
- Road Condition: Poorly maintained roadways increase the risk of a popped tire and influence a driver's ability to brake adequately
- Road design: When roads are poorly designed, accidents can happen at any time. Unsuspecting drivers can be affected by flaws in the road from potholes to debris to bumps and get into accidents.

- Environmental factors: slippery roads from rain, snow, or ice affect traction in tires, in turn causing vehicles to slide off the road or hit other objects or vehicles. Fog, water levels, and wind speed may also contribute to weather-related accidents and
- Other causes

(Abdelfatah, 2016). To reduce the causes of traffic accident in Malaysia, he used traffic accident rate methods and he noted that the range of fatality per 100,000 people is very small spanning from approximately 23.2 to 24.6 over a period of ten years. And the following is a list of his conclusions based on the analyses conducted in his paper:

- The fatality rate per 100,000 people is not significantly decreasing, the rate of fatalities per 100,000 registered vehicles does display a reasonable decrease. In addition, the fatality rate based on the number of registered vehicles exhibits a much better correlation than the fatality rates based on the population.
- No significant accident percentage difference exists between months. However, more than one third of the daily accidents (38 percent) occur during the late afternoon and evening (from 4:00- 10:00 pm).
- The percentage of motorcycles involved in traffic accidents is only about 1.3 percent. However, the percentage of motorcycle fatalities ranges from 56 percent to 62 percent. Furthermore, this trend has increased during the study period. It is clear that the majority of fatalities on Malaysian roads are linked to motorcyclists. Accordingly, there is a need for strategies to reduce the use and improve the safety of motorcycles.
- The motorcycle fatality rate is about 1.3 to 1.8 times the rate of other vehicles.
- Traffic rules and regulations are not regularly enforced in Malaysia, as the percentage of summonses compounded by the police from 2009-2013 was only 35 percent.
- Dangerous turning and speeding are the most common causes of accidents.
- Head injuries (at 54 percent) are the most common type of injury linked to traffic fatalities. The traffic-accident reports do not provide accurate data regarding the causes of accidents, as the cause “not at fault” is reported for between 60 percent and 80 percent of all accidents.

- The majority of the motorcyclist fatalities (52 percent) occurred within the 16-30 age group.

Studied from the American and British reports; accidents occurred 57% due to driver factor, 27% due to combined roadway and driver factor, 6% combined vehicles and deriver factor ,3% a combination of the road, drivers, vehicles ,2% vehicle factor ,1% combined of vehicle and road user factor (Ruman K, 1985).

2.2.1. Vehicles

Defective vehicle parts such as tyres, brakes and lights can lead to tragic accidents by affecting the driver's ability to maintain control of his vehicle. Safety products designed for vehicles such as warning lights that don't work properly may also cause serious accidents, inspection and maintenance of (tyres, lights, and braking systems) is crucial to ensure the safety of drivers and other road users.

(Deme, 2016). Conducted that to identify the major causes of road traffic accident specifically focusing on Addis-Adama expressway, to project causes of traffic accident on the expressway and propose possible counter measures, and to provide empirical evidence on the feasibility of an existing solution to a problem. Both descriptive and inferential statistical analyses were used to identify causes of road accident and he concluded that traffic accident was higher on working days (Monday to Friday) of the week mostly between 6:01 to 12:00 AM local time. Unethical behavior of drivers, over speed, sight distances, phone usage during driving, drug usage etc. were the main causes of all crash accidents. Days of the week, collision types, types of vehicles and plate number region highly determine the accident.

The trends of fatalities due to car accidents in Spain starting the period from 1987 to 2011, focusing on the effect of gender and age on fatality rates. They noted that the fatality rate was reduced over the study period, with the highest reduction in the fatality rate occurring in the 15-34 age group (about 90 percent reduction). They noted further that the fatality rate among women was much lower than among men (Inmaculada Melchor, 2015)

Although automobile safety has improved considerably over the last several decades, vehicle defects still cause car accidents. Vehicle factors were the critical reason for 44,000 of the 2.2 million accidents reviewed in the National Motor Vehicle Crash Causation Survey, according to the National Highway Traffic Safety Administration (NHTSA). Automobile and automotive

parts manufacturers are required to comply with Federal Motor Vehicle Safety Standards and Regulations issued by NHTSA. Millions of vehicles and auto parts have been recalled by NHTSA for failure to meet those standards. Some examples of safety-related defects listed by NHTSA include:

- ✓ Accelerators that stick or break;
- ✓ Electrical system problems that cause fires or loss of lights;
- ✓ Fuel system components susceptible to crash damage that leak and cause fires;
- ✓ Steering components that break and cause loss of vehicle control;
- ✓ Wheels that crack or break, causing loss of control of the vehicle;
- ✓ an airbag deploys unexpectedly;
- ✓ Tires or other critical vehicle components that break, fall apart or separate from the vehicle, causing potential for loss of control of the vehicle and injury to people in or out of the vehicle, etc.

The main causes of traffic accident occur due to the defects such as failure of brakes, steering system, and tyre burst lighting system. According to the TRL conducted from 1968 to 1969, on the spot investigation of 274 accidents, vehicle defects were found to have contributed to 18% of the accidents. University for the United States Department of Transportation in 1973, Vehicle defects were the contributor to 5% of defect related accidents and contributed to 13% of defect-related accidents when considered in correlation with either the human factor or the environment. Moreover, braking systems were identified as the major cause followed by tyres and wheels.

While vehicle design can have considerable influence on crash injuries, its contribution to crashes, through vehicle defects, is generally around 3% in high-income countries, about 5% in Kenya (4) and 3% in South Africa. Though periodic vehicle inspections have not been found useful in reducing injury crashes, inspections and checks for overloading and safety related maintenance for larger commercial vehicles and buses could be important for vehicles more than 12 years old.

2.2.2. Drivers

The first model to identify the statistically significant variables. Conducted to provide people with better choices and make life and travel easier and the movement of AVs were the focus

area of their research, by using in three phases that can be compared to a human ability to sense, decide, and act in a given scenario. In phase one, all of these instruments collect data from the environment and are an augmented representation of the human's visual and cognitive system. In phase two, the instrument and the instruments combine information and via advanced computing and algorithms, from a plan of action much as the human brain operates cognitively. Their result showed that a new set of pavement markings can be used as one of the options for the movement of AVs in the work zone. And they concluded that AVs are set to revolutionize the transportation systems and have a big expectation for a transportation engineer in improving mobility, level of services, cost saving, and safety. The result is intuitively reasonable (Prashant Singh, 2020).

2.2.3. Road condition

Traffic accidents have a great dependent on road characteristics. Improper standards of road construction and maintenance have a relationship with RTAs. The road can bring immeasurable change in the accident. Using properly designed standard construction of the road with the correct specification, vertical alignment, sight distance, supper elevation, carriageway width, width condition, shoulder, road signs, road markings, junctions' designs, pavement surfaces, narrow bridges and culverts, median, width, street lighting and length of road (Geremew, 2018)

2.2.4. Road design

Defective geometric design like inadequate sight distance, inadequate width of shoulders, improper curve design, improper traffic control devices and improper lighting.

2.2.4.1. Horizontal alignments

2.2.4.1.1. Curve radius

The past studies showed that most of accidents often occur at curves. (Yulong, 2011-2015), reviewed from the study of Shenda Freeway that accident rate and curve radius have a close relationship. This means, the radius of the road increases, as accident rate reduces, and the curves with the same or similar radius are safer than with different radius. A small radius, which is inserted into long and straight line, is dangerous, and the study conclude that modification of horizontal alignment is one of the effective countermeasures for highway accidents.

The causes of road accidents on black spot section, by using three methods of ranking of accident-prone sites his result indicated that the density of accident per kilometer were found to be a function of access points in the towns. And also, narrow bridge, inadequate sight distance, insufficient illumination, road curvature, and faded road markings are usually the major causes of accidents (Segni, 2007).

(Gebissa, 2019). Investigate their paper for twofold aims, first to develop an excel program referring to the governing values of geometric design manual of Ethiopia in order to identify and quantify inconsistent geometric design on Mettu-Gore Road and secondly, to assess the geometry characteristics of police-reported hotspot zones of the road. Then they achieved that the road geometric parameters such as; radius of a curve, super elevation, gradient, and sight distance are the most significant factors affecting road safety on Mettu-Gore Road. Finally, they concluded that:

- Road sections that combine inadequate sight distance, high gradient, and sharp curves bend with insufficient super elevation would have produce higher safety problems.
- The effect of road geometry and route selection on road safety, the safety solutions were considered to minimize the high frequency and severity of accidents at the police reported blackspots for the most ranked areas.

2.2.4.1.2. Deflection angle

The angle at a point on the earth between the direction of a plumb line (the vertical) and the perpendicular (the normal) to the reference spheroid; this difference seldom exceeds 30 seconds of arc 2.2.4.2. Vertical alignments

2.2.4.2.1. Grade

Steeper grades increase the accident rates, and the accident rate in mountainous terrain is higher than in flat terrain. And also summarized that the effects of vertical road alignment on accident are excessive speed, differential speed between vehicles and visibility difficulty for diver on crust curve (Makrajep, 1999).

(A.F. Iyinama, 2000), studied that the accident rate is highly increasing with increasing of road grades at the point of high slope section. For the low radius horizontal curves, the accident

number is high. The effect of grade type on the accident rate is determined at a highway of 72 km in America Flzer Mountain from 1960 to 1996.

(Sarbaz Othman, 2009), studied that the effects of grades on accident rates and he reported that accident rate on downgrade is slightly higher than upgrades, and upgrades have less effect on accident rate while accidents' rate increases with increasing downgrade.

2.2.4.3. Cross section elements

Cross-section elements is the important elements that will be considered in designing properly in order to decrease road accident. These include: lane width, shoulder width type, and cross section type.

(Sarbaz Othman, 2009), studied that the influence of carriageway width on the accident rate and suggested that the accident rate decreases with increasing lane width greater than 5.8 m, and the carriageway width of 5.8 m has the lowest accident rate on one lane roads.

2.2.4.3.1. Lane Widths

A study that was conducted by (Daniel J. Findley, 2011), found that wide lanes had accident rates 10 to 39% lower than those on narrow lanes. The study showed that heavy vehicles overtaking other heavy vehicles remain centered in their lanes only when lanes were 12 feet (3.6 m) wide or wider. Studying the effects of lane width on trucks. Another study conducted by DeLuca (1985), in Miami-Dade, showed that a significant increase in sideswipe crashes with the decrease in lane width.

On the other hand, the study conducted by (Hauer, 2000), attempted to show the link between lane width and safety. Accordingly, the first link is that the wider the lane, the larger will be the average separation between vehicles moving in adjacent lanes. This may provide a wider buffer to absorb the small random deviations of vehicles from their intended path. The second link between safety and lane width is that a wider lane may provide more room for correction in near accident circumstances.

2.2.4.3.2. Shoulders

(A.F. Iyinama, 2000), they were tested the relationship between accident rate and shoulder width and they showed that, as the width of a shoulder is increased, the number of accidents is decreased. With respect to type of shoulder, the Chrisro et al. (1999) reviewed from the

various studies that accident rates become high on roads with a wider lane and paved shoulder than on wide lane with a gravel shoulder with 2 to 2.1m wide.

2.2.4.3.3. Medians

National Association of Australian State Road Authorities (1988) reported that a Victorian study where 42 km of 2-lane highway was replaced with a 4-lane divided highway, with a 30 % crash reduction. And also reported an Adelaide study, which compared crash rates for 4-lane roads having wide medians, narrow medians, and painted narrow medians with 4-lane roads without medians. Compared with the undivided roads, the others reduced the crash rate by 30% in narrow painted median, 48% in narrow raised median, and 54% in wide median.

2.2.4.4. Sight distance

(Neuman TR, 1983), in their study of stopping sight distance was found that different geometric conditions were associated with hazards. These were divided into the following three groups:

- Minor hazards: tangent horizontal alignment, mild horizontal curvature (>600 m radius), mild downgrade (< 3 per cent);
- Significant hazards: low-volume intersections, intermediate horizontal curvature (300-600 m radius), moderate downgrade (3-5 per cent), structures;
- Major hazards: high volume intersections, Y-intersections, sharp curvature (< 300m radius), steep downgrade (>5 per cent), narrow bridge, narrowed pavement, freeway lane drop, exit or entrance downstream along freeway.

2.3. Black spot treatment

(Segni, 2007). By using three methods of ranking of accident-prone sites his result indicated that the density of accident per kilometer were found to be a function of access points in the towns. Additionally, he explained that the treatment of black spots using low-cost engineering measures is a mechanism that used to measures to reduce accidents at dangerous spots. The most popular low-cost engineering measures incorporate: rumble strip, traffic signs and road markings, road light and roundabouts. And also, narrow bridge, inadequate sight distance, insufficient illumination, road curvature, and faded road markings are usually the major causes of accidents.

(Dorte, 2002), explained that this work may be divided into three phases. These phases will be further described in the following sections.

1. Targeting hot spots on the road network.

2. Prioritizing the hot spots to treat with safety improving measures.

3. Before and after studies of the effect of treatment.

2.4. Summary of related research

Analysis to reduce the causes and counter measures of a road traffic accident. Most of the literature cited in this work mainly focused on traffic accident reduction. Most of deaths are in low and middle-income countries where rapid economic growth has been accompanied by increased motorization and road traffic injuries. The work uniquely proves the possibility of traffic accident reduction for simultaneous improvement from their point of view. Traffic accidents have a great dependent on road users, defective vehicle parts such as (tyres, brakes and lights can lead to tragic accidents by affecting the driver's ability to maintain control of his vehicle), poorly maintained roadways, environmental factors, and other related issues. The goal is to investigate the magnitude of road traffic accidents and black spot areas. And then to give implementable engineering solutions. This, in turn, the economy of the country and social structure of the population, respectively.

2.5. Research gap

A number of researchers have studied on the effect of road traffic accident. Most of them concluded that the road traffic accidents were highly affecting the economically active citizens i.e., youths and young adult groups, which in turn, negatively affects the economy of the country and social structure of the population. Even though the accident is happening in our day-to-day activities. But still now no one is done on the investigation of vehicle accident in the Adama city. So, in order to reduce (minimize) this accident, the researcher would like to investigate to fill this gap by using deep investigation on causes of accident, types of accident, safety measure, and other related to vehicle accident investigation.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Study design

The main purpose of the study was to study the causes and counter measures of a road traffic accident in Adama city. The study design included both purposive and descriptive type. Since in situations where two strategies might be considered attractive, it is possible to use multiple strategies in a given study. Therefore, descriptive with document analysis was applied.

3.2. Study area

The area for the study were conducted in Adama city major roads, vehicles, drivers, and road users. Adama (Oromic: Adaamaa or Hadaamaa; Amharic: አዳማ), also known as Nazret or Nazreth (ናዝሬት), is a city in central Ethiopia. Adama forms a Special Zone of Oromia and is surrounded by East Shoa Zone. It is located at an elevation of 1712 meters, 99 km southeast of Addis Ababa. The city sits between the base of an escarpment to the west, and the Great Rift Valley to the east.

Latitude / Longitude: 8.541° or 8° 32' 27.7" N / 39.2705° or 39° 16' 14" E

Figure 3.1. Photo: Partial views of Adama City on Map

3.3. Data sources

The main sources of data that used for this study were obtained from primary and secondary sources. Different methods were used to collect primary data. Those are included: field observations of vehicle flows, road situation, and attitudinal surveys. Whereas, secondary data were collected from Adama city police commission, Oromia transport authority drivers and technicians training and competence assurance center, and from Adama city transport Authority Office.

3.4. Data collection

For the purpose of analyzing of safety problems and suggesting countermeasures, information is needed on crashes or accidents, and it is desired to relate crashes to exposure. Some measure of traffic volumes is also necessary; therefore, the necessary reliable data that were collected are accident data, road data, traffic data, and field observations.

3.4.1. Road accident data

To enable systematic analysis of the road crash problem at any location, the following information about each crash is required (Howie, 1989).

- Where crashes occur: location by map co-ordinates, road name, road classification, and road layout and type of traffic control?
- When crashes occur: by year, month, and day of month, day of week and time of day?
- Who was involved: people, vehicles, animals, and roadside objects?
- What was the result of the crash: fatal, personal injury, or property damage?
- What were the environmental conditions: light condition, weather and pavement surface condition? and
- How (or why) did the crash occur?

Therefore, road accident data were collected from Adama City Police Commission record compiled by traffic police officers and from Adama City Transport Authority data that were recorded during 2008-2012. From these, the collected data include;

- Involvement (pedestrian, animal and other objects) presented on Appendix A.4 to A.6;
- Nature of the accident (Rollover, head on collision, rear-end collision…) presented on Appendix B.8;

- Classification of the accident (fatal, serious injury, light injury, property damage only) presented on Appendix A.7;
- Years, day of the week, time (presented on Fig. 4.17);
- Location name and classification of the road & intersection (presented on Tab. 4.15 or Fig. 4.16);
- Location type of the area that is nearest for (school, factory, religious, recreation, office complex, hospital, residential area, open area, pedestrian crossing, narrow bridge culvert, and others) presented on Appendix B.7;
- Light conditions (day light, dark hour with good, street, dark hour with poor street light, dark hour with no street light) presented on Appendix B.3;
- Roadway surface condition (dry, wet, slush, …) presented on Appendix B.1; and
- Vehicle involved (Taxi, Automobile, Cart, etc.…) presented on Appendix B.9.

3.4.2. Road data

The road data were collected from Adama City Road Authority and field observation includes;

- Road way (land use, surface condition, etc.);
- Road character (uphill, downhill, straight and level, sight distance (m), etc.); and
- Traffic control (Guide sign, Lighting, Marking, etc.).

3.4.3. Traffic data

To enable the estimation of exposure, full information on traffic flow is required. Two-way annual average daily traffic (AADT) is normally the best that were obtained (Sanderson, et al., 1985) unless hourly flows are available from either special collections or can be extracted from traffic signal detector inputs. They are noted that if AADT volumes are unavailable, estimates will often suffice since the calculation of exposure is not sensitive to minor estimation errors. Similarly, if count data are not available for every year, interpolation between years is acceptable. Thus, fieldwork was undertaken to count for the traffic flow and traffic composition in addition was collected past traffic data on Average Annual Daily Traffic from Ethiopian Road Authority.

3.5. Methods of data processing and analysis

After collecting all the necessary information, data processing and interpretations were done using Statistical Package for Social Sciences (SPSS) version 20.0 and descriptive methods in the form of table, charts, graph, Accident Frequency Method, and Accident Level Methods. P-value below 0.05 (95% confidence interval) was considered as statistically significant and was undertaken to suggest possible measures and to identify section length that traffic volume influence on the accident.

For the identification of black spots, there is a wide range of methodologies available ranging from simple models based on actual accident count to advanced statistical models based to estimates. For this study, the common methods that the researcher used to identify black spots are:

- Accident severity method (McMillen, 1999, Layton, 1996). The concept of this method is that the number of fatal and/or injury accidents at a location or section of highway are given a greater weight than property damage- only accidents.
- Accident frequency method (Layton, 1996; McMillen, 1999). The frequency method ranks locations by the number of accidents. The location with the highest number of accidents is ranked first, followed by the location with the second highest number of accidents, and so on. This method does not take into account the differing amounts of traffic at each location. Therefore, the frequency method tends to rank high volume locations as high accident locations, even if those locations have a relatively low number of accidents for the traffic volume. Many agencies use the frequency method to select a group of high-accident locations, and then use some other method to rank the locations in order of priority.

3.5.1. Ranking of sites

To prioritize those black spot areas, the ratios of accident costs by degree of severity were established by transport research laboratory (TRL) (Gito Sugiyanto, 2017). The weight given for fatal accident, serious injury, slight injury, and property damages are 5, 3, 2, and 1 respectively.

$$P = \frac{1*W+2*X+3*Y+5*Z}{D} \quad (3.1)$$

Where:

P = priority value; W = Total number of property damages;

X = Total number of slight injuries; Y = Total number of serious injuries;

Z = Total number of deadly injuries; D = Total number of distances of the black spot section in kilometer.

Accident Frequency Method

This method was used to determine the number of accidents occurred in a year for each kilometer, so that the result will present which segment has the highest or lowest part of the accident rate (black spot). The equation for calculating accident rate by accident frequency method (Accident Frequency Method) is:

$$AF = \frac{A}{L*T} \quad (3.2)$$

Where:

AF = accident frequency (accident/km/year);

A = total of accident;

L = segment length/road (km);

T = period (year).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Major factors contributing to road traffic accidents in Adama City

This section focuses on the identification and analysis of the main factors contributing to the problem of road traffic accidents particularly focusing on driver, pedestrian, and passenger's sex and age casualties in Adama in general and Adama city major roads in particular.

4.1.1. Drivers Factors by Sex and Age

4.1.1.1. Drivers factors by sex

Most of the time, the major contributing factors in the majority of traffic accidents is the behavior of the drivers; hence, worldwide studies such as those of the OECD showed that about 80-90% of the road traffic accidents are attributed to the fault of the drivers, and majority of them are male drivers (Bitew, 2002). Similarly, the analysis results in Table 4.1 below confirm that about 99.7% of the driver errors are caused by male drivers, and only female drivers caused by the remaining 0.3% of road traffic accidents during 2008-2012 in Adama City Administration. Moreover, from the 99.7% of road accidents caused by male drivers, about 28.4%, 29.85%, and 41.45% represented fatalities, serious injuries, and slight injures respectively in the city. Correspondingly, the female drivers' road traffic accident casualties were minimal, i.e., only about 0.3% of serious accidents were reported respectively in the year between 2008 and 2012, with no fatalities and no slight injury. In agreement to the data collected from the Adama City transport offices and Adama City Police Commission. It showed that driving license holders are about 78799 (92%) male and 6155 (8%) female up to 2012.

Table 4.1. Cross tabulation of drivers' sex with accident level in ACA

Sex of driver *Accident level Cross tabulation

			Accident Level			Total
			Death	Serious Injury	Light Injury	
Sex of Drivers	Male	Count	98	103	143	344
		% of total	28.4%	29.85%	41.45%	9
	Female	Count	0	1	0	1
		% of total	0.0%	0.3%	00%	0.3%
Total		Count	98	104	143	345
		% of total	28.4%	30.15%	41.45%	100%

Data Source: Adama city traffic police commission (ACTPC)

Therefore, with the above analysis of the Chi-Square test result shows that statistically significant difference between male and female drivers for causing road traffic accidents in the City. It shows the significant effects between male and females (Figure 4.1).

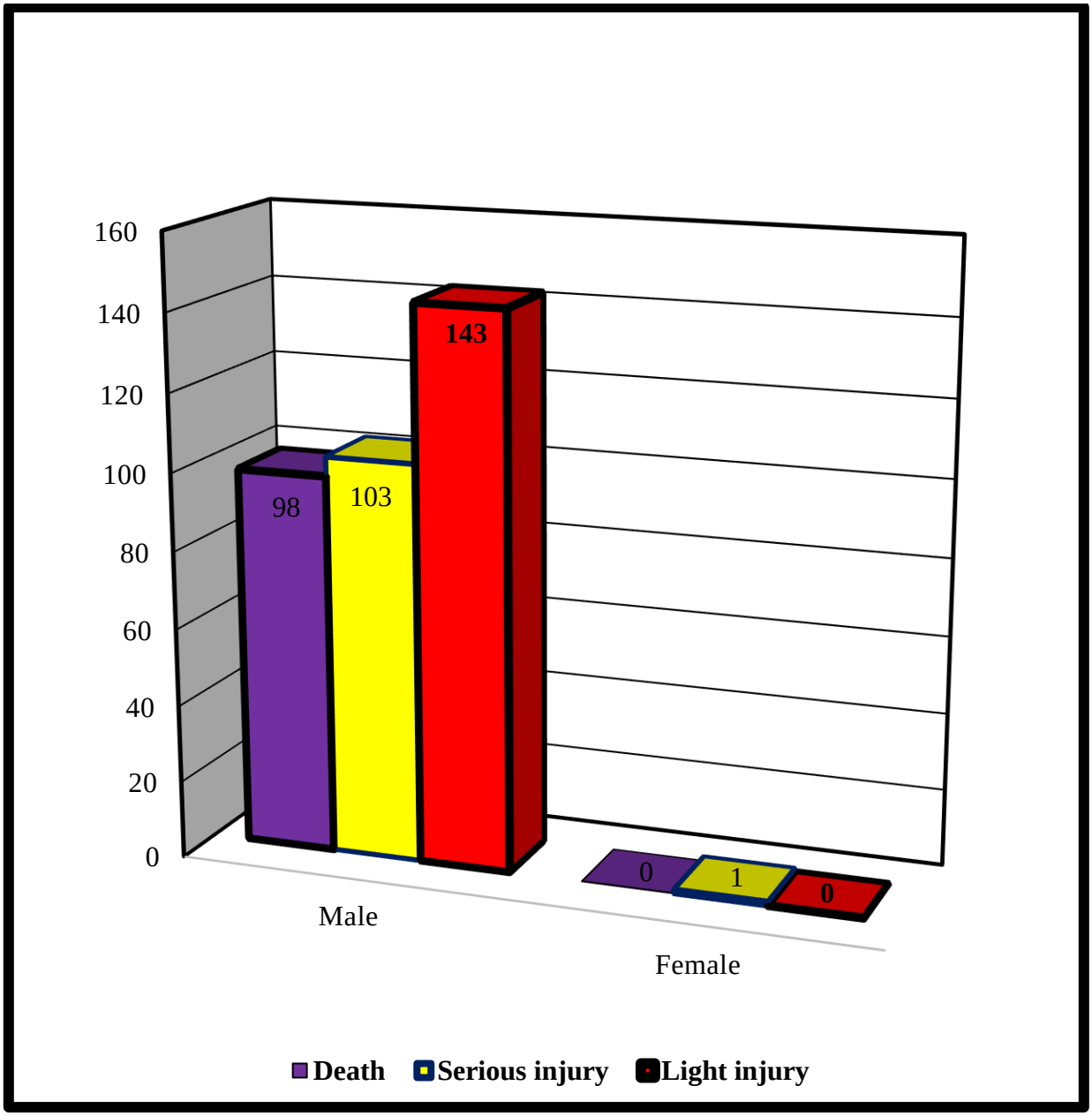


Figure 4.1. Comparison of RTA casualties (sufferer) in Adama City Administration by their Sex

4.1.1.2. Drivers factors by age

Table 4.2 and Table 4.3 elaborate the age distribution of the drivers and its associated effects on the levels of Road Traffic Accidents in Adama. Accordingly, about 3.46%, 31.87%, 44.62%, and 19.99% of the reported driver casualties have an age of < 18, 18-30, 31-50, and >50 years, respectively. When drivers' accident victims were compared by their age category, those drivers with an age of less than 18 years old are the lesser affected age category since

acquiring driving license considers at minimum of 18 years. In contrary, drivers with an age greater than 18 years, but less or equal to 50 years were the most affected drivers in RTAs in all categories of RTA classifications. For instance, 7.82% and 13.33% of the drivers with ages of 18-30 and 31-50 years respectively were found in death report. Generally, the current study concluded that the number of drivers who suffered in deaths, serious injuries and light injuries have decreased as the age of drivers becomes above 50 years old as shown in Table 4.3.

Table 4.2. Chi-Square test results by age group of the drivers and frequency of accident (2008-2012)

Age Group of The Driver	Observed Frequency	Expected Frequency	Degree of freedom	Critical X^2	$\frac{\sum(O-E)^2}{E}$
<18	12	86.25	3	7.81	117.852
18-30	110	86.25			
31-50	149	86.25			
>50	74	86.25			
Total	345				
			Significant figure	.05	.000

The Chi^2 value is 117.852. The p-value is < .00001. The result is significant at p < .05.

Table 4.3. Chi-square test results for independent test drivers' casualties by age with accident level in Adama City Administration (2008-2012).

Drivers causality			Accident level			Total
			death	Serious injury	Light injury	
Age categorized	<18	Count	4	7	1	12
		%	1.16%	2.02%	0.28%	3.46%
	18-30	Count	27	33	50	110
		%	7.82%	9.56%	14.49%	31.87%
	31-50	Count	46	34	74	149
		%	13.33%	9.85%	21.44%	44.62%
	>50	Count	21	30	18	74
		%	6.08%	8.69%	5.21%	19.98%
Total		Count	98	104	143	345
		%	28.4057%	30.1449%	41.4492%	100%
Chi-square test		Value	20.09			
		Sig.	.012			

The magnitude of drivers' sufferers in RTAs including death, serious injury, and light injury reached maximum level between 31-50 years see Figure 4.2, and then after it start declining for the three mentioned accident types and levels. It means, the study result emphasizes that as the age of the drivers' increases, the road traffic accident also increases. In addition, graphical sketch in both death, serious injury, and light injury road traffic accidents associates with similar drivers' age category to begin risk reductions. It is possible that aged drivers have more experience and probably not much more responsibility than youth for details (Figure 4.2).

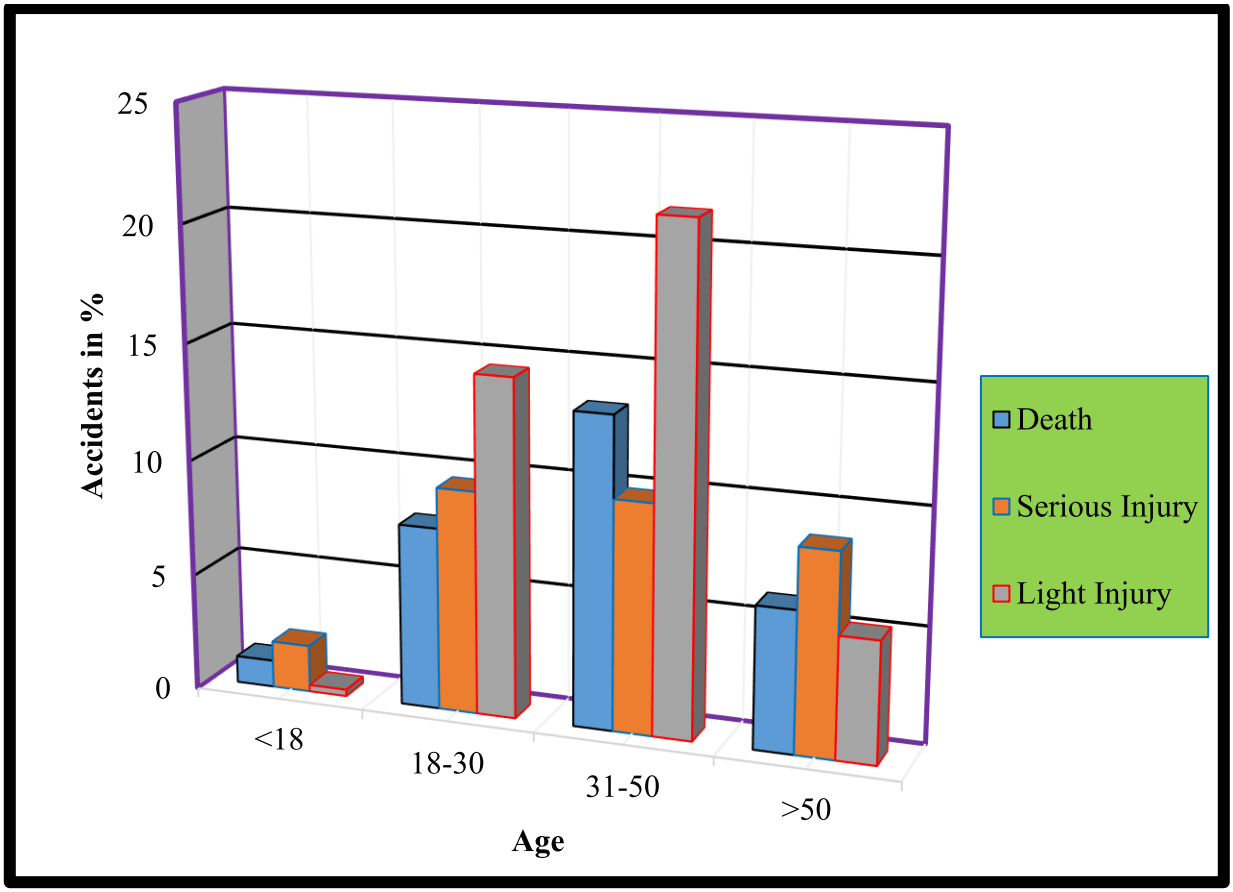


Figure 4.2. Comparison of accident types by drivers age (2008-2012) in Adama City Administration

Besides the above figure, the results of the analysis on the number of drivers victimized by road traffic accidents, 2008-2012, has shown the occurrence of very high fatalities in 2008, followed by 2009 and 2012, respectively. Whereas, the magnitude of the occurrences of serious accidents in the city was very significant in year 2008 and 2009, respectively. Similarly, light injuries were significant in year 2008 and 2012 respectively (see figure for details).

Generally, the trends of victimized drivers' sufferers from RTAs had shown decrements for two years from 2008 - 2009 and 2009 – 2010, then increased from 2010 - 2011 and 2011 – 2012, the highest percentages of drivers those were involved in accidents were between the ages of 31 and 50.

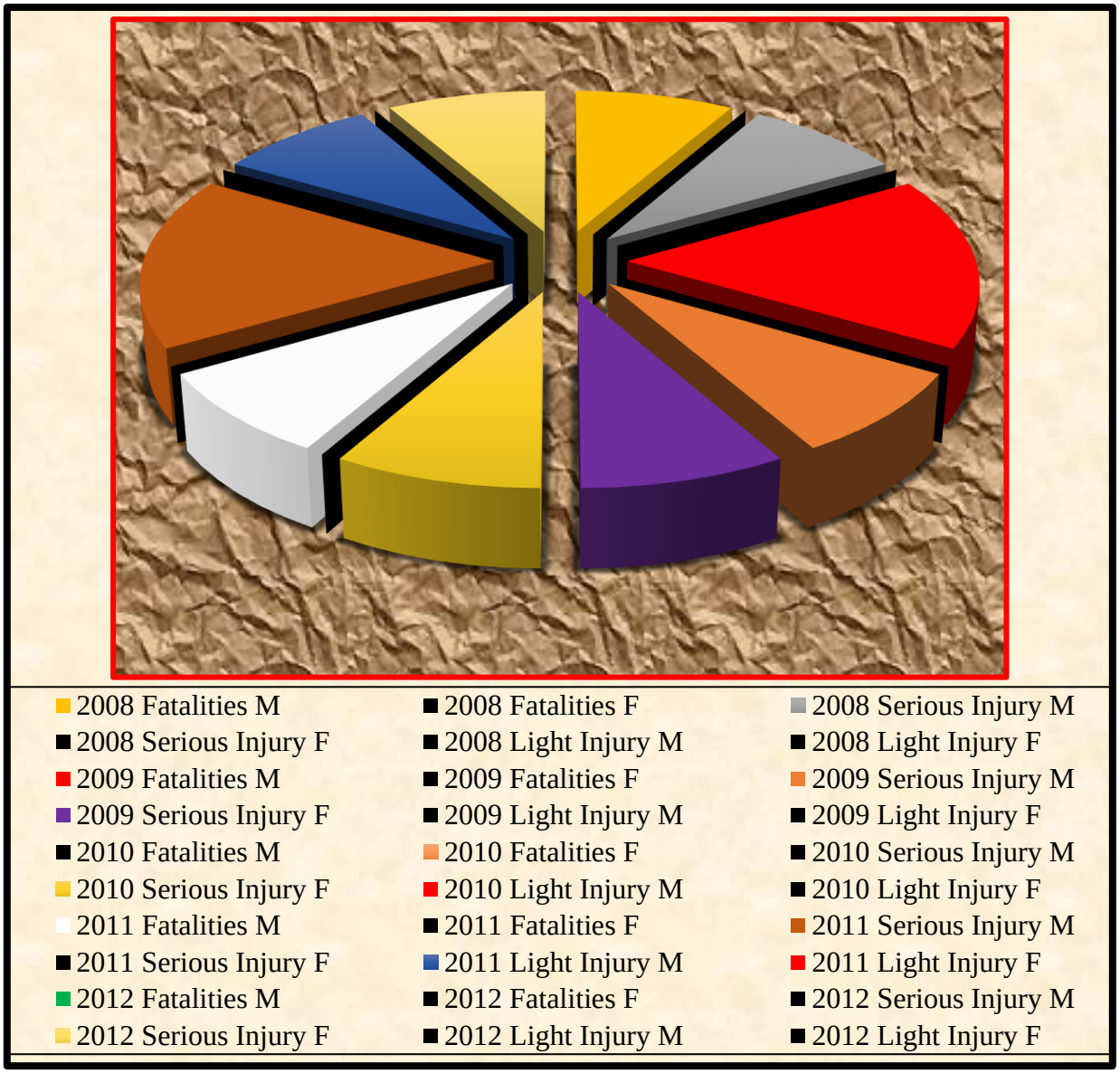
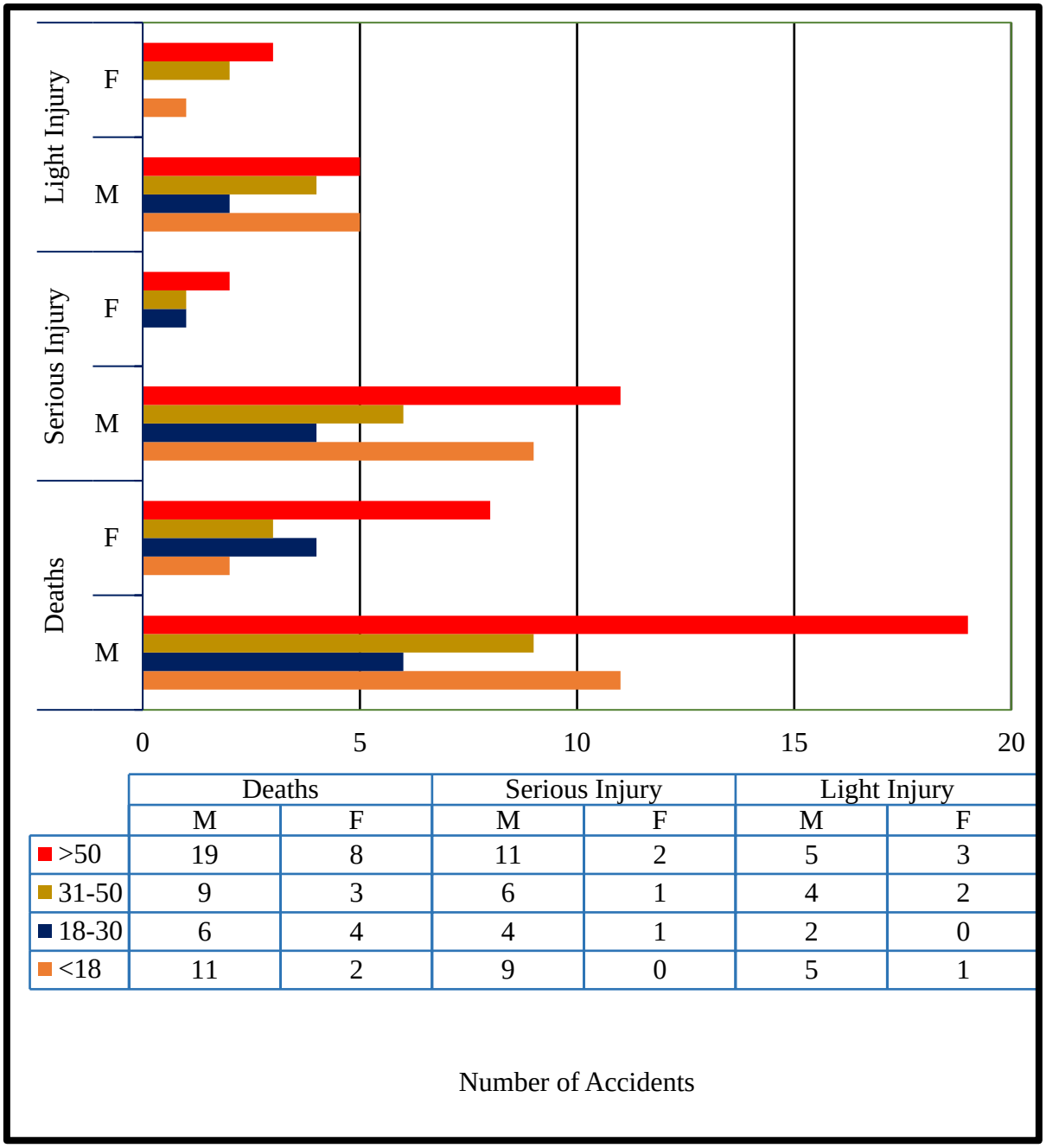


Figure 4.3. Drivers' casualties during 2008-2012 in Adama City administration

4.1.2. Passenger victims in Adama city

Passengers are those of the other victims of road traffic accidents in Adama City Administration (Figure 4.4). Accordingly, the passengers whose age is above 50 are the major affected groups by road traffic accidents in the city during 2008-2012 followed by passengers whose age is less than 18 in the same years. In contrast, passengers with an age of between 18 and 30 are the smallest sufferers of road traffic accidents from 2008 up to 2012.



	Deaths		Serious Injury		Light Injury	
	M	F	M	F	M	F
>50	19	8	11	2	5	3
31-50	9	3	6	1	4	2
18-30	6	4	4	1	2	0
<18	11	2	9	0	5	1

Figure 4.4. Passengers Victims during 2008-2012 in Adama City Administration

Generally, as the analysis of the study confirmed that there are more number of male passengers' victims than the female counterparts at all accident levels and types between 2008 and 2012 in the City.

Table 4.4. Chi-square test result of Age of passenger victims and frequency of accident

Age group of the passenger	Observed Frequency	Expected Frequency	D.f.	Critical X^2	$\frac{\sum(O-E)^2}{E}$
<18	28	29.5	3	9.35	17.659
18-30	17	29.5			
31-50	25	29.5			
>50	48	29.5			
Total	118				
			S.f	.025	.000

Table 4.4 shows a calculated χ 2 - value of 17.659 for 3 D.f. Moreover, a critical χ 2 - value of 6.35 at 0.025 alpha levels since the calculated χ 2 - values is greater than the critical χ 2 - value. The null hypothesis independency between the accident and age of the passengers is rejected at p value < 0.025. There is a statistically significant difference and it is evident that the accident is highly related with passengers' age.

Table 4.5. Cross tabulation of passenger victims with Accident type in Adama City Administration

Age-group * Accident level Cross tabulation

			Accident level			Total
			Death	Serious injury	Light injury	
Age-Group	<18	Count	13	9	6	28
		%	11%	7.627%	5.08%	23.728%
	18-30	Count	10	5	2	17
		%	8.4745%	4.2372%	1.6949%	14.4067%
	31-50	Count	12	7	6	25
		%	10.1694%	5.9322%	5.0847%	21.1864%
	>50	Count	27	13	8	48
		%	22.8813%	11%	6.7796%	40.6779%
Total		Count	62	34	22	118
		%	52.5424%	28.8135%	18.6441%	100.00%

Data Source: Adama city traffic police commission (ACTPC)

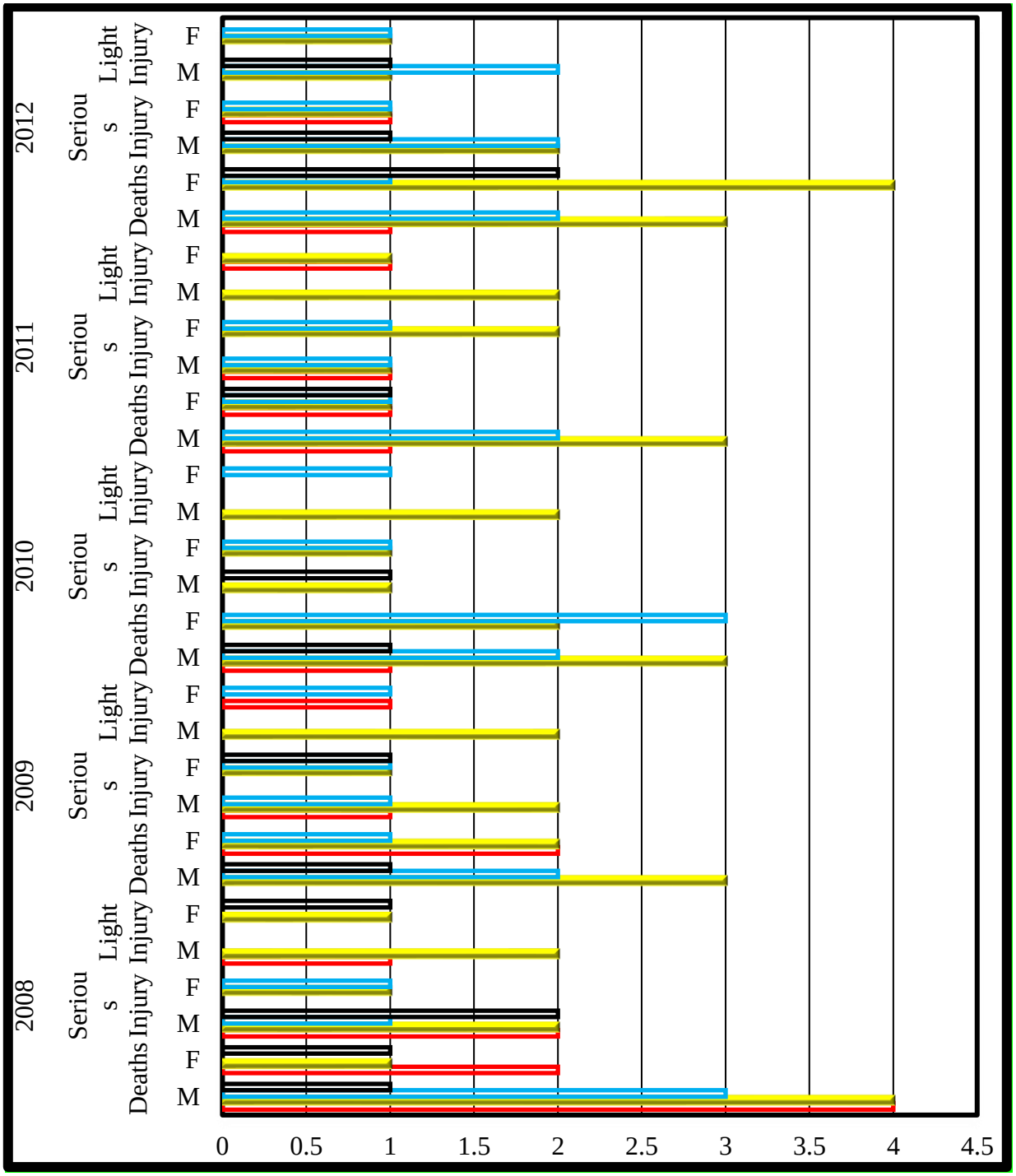
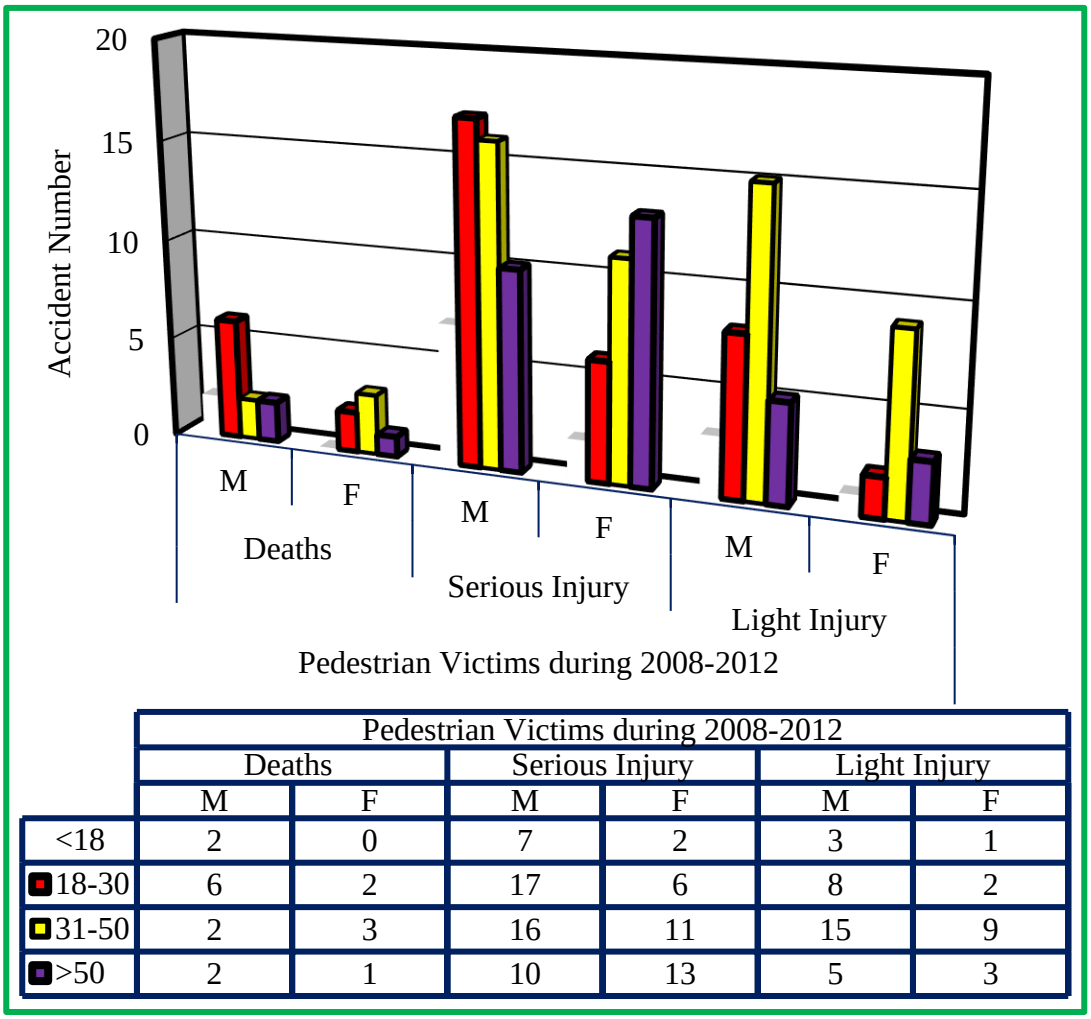


Figure 4.5. Passengers' casualties in Adama City Administration by individual Year, age group, and sex

4.1.3. Pedestrian casualties

Like drivers and passengers, traffic accident is highly affecting the population of developing countries population from which pedestrian are the second most affected. Accordingly, this

study showed that the majority of the death reports are on the male pedestrians is within the age group of 18-30 years. Similarly, high death reports of female pedestrians with an age group of 31-50 and which are followed by age 18-30 years, respectively. These confirms that most of road traffic accidents were highly affecting the economically active citizens i.e., youths and young adult groups. This, in turn, negatively affects the economy of the country and social structure of the population in the city. Figure 4.6 shows pedestrian casualties in Adama.



	Pedestrian Victims during 2008-2012					
	Deaths		Serious Injury		Light Injury	
	M	F	M	F	M	F
<18	2	0	7	2	3	1
18-30	6	2	17	6	8	2
31-50	2	3	16	11	15	9
>50	2	1	10	13	5	3

Figure 4.6. Pedestrian casualties in Adama City Administration

Moreover, the serious injuries highly affect the male pedestrians those whose age is between 18-30 years old than any other age categories. From the light injures perspectives, pedestrians those whose age is between 31-50 were affected more as compared to the others. The general

observation was that males were more involved in road accidents because they travel more in their daily duties when compared with many females who usually stay at home doing domestic duties.

Table 4.6. Chi-square test result of age of pedestrian victims and observed frequency of accident

Age of the Pedestrian	Observed Frequency	Expected Frequency	D.f.	Critical X^2	$\frac{\sum(O-E)^2}{E}$
<18	15	36.5	3	7.81	23.81
18-30	41	36.5			
31-50	56	36.5			
>50	34	36.5			
Total	146				
			S.f	.05	.000

Since p-value = 0.000 ≤ 0.05, we can reject the null hypothesis Chi-square = 23.81 > 7.81 = critical Chi-Square value.

Therefore, Table 4.6, shows the null hypothesis of an independency between the age of pedestrians and distribution of accident is rejected at p-value.

Table 4.7. Chi-square test and cross tabulation result of age of pedestrian victims and level of accident

Age-group * Accident level Cross tabulation

			Accident level			Total
			death	Serious injury	Light injury	
Age-Group	<18	Count	2	9	4	15
		%	1.3698%	6.1643%	2.7397%	10.2739%
	18-30	Count	8	23	10	41
		%	5.4794%	15.7534%	6.8493%	28.0821%
	31-50	Count	5	27	24	56
		%	3.4246%	18.4931%	16.4383%	38.3561%
	>50	Count	3	23	8	34
		%	2.0547%	15.7534%	5.4794%	23.2876%
Total		Count	18	82	46	146
		%	12.3287%	56.1643%	31.5068%	100.00%
Chi-square test		Value	7.807146926			
		S.f	0.25			

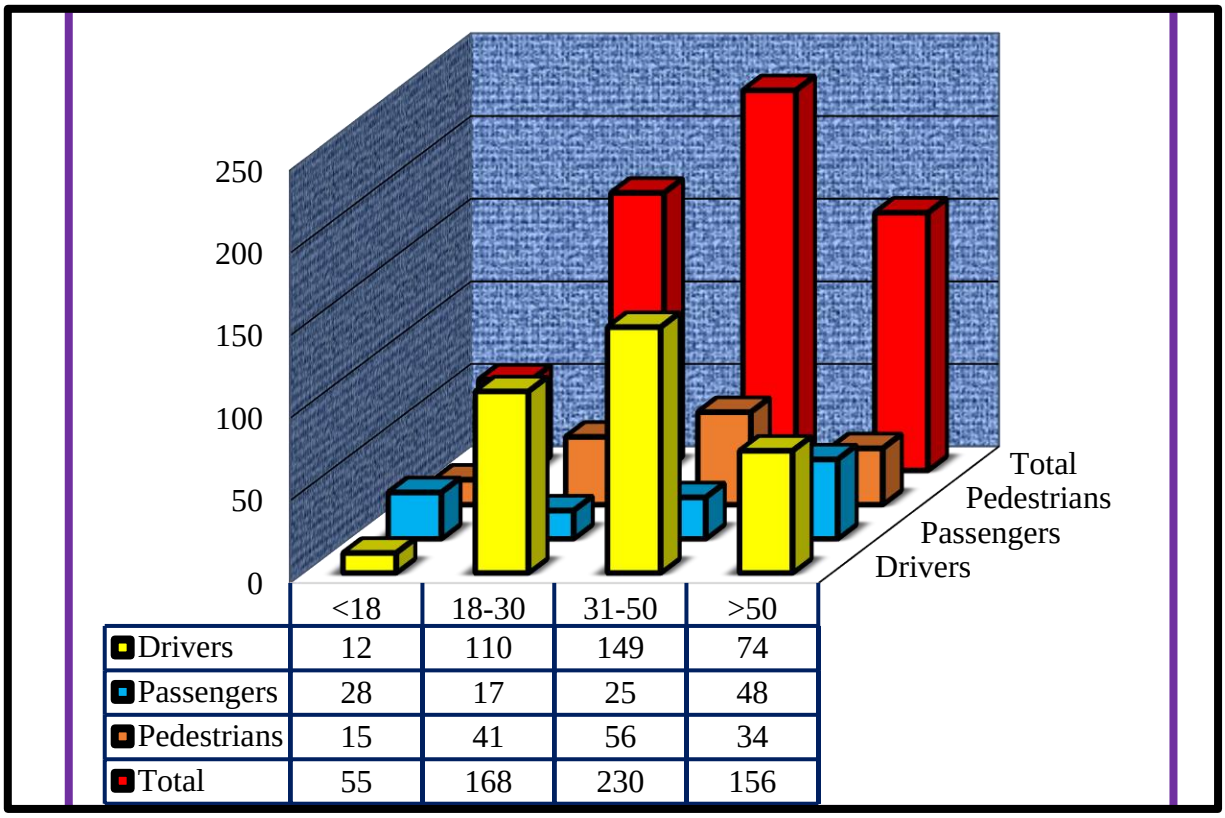
The above descriptive statistics of Figure 4.6 and Table 4.8, the Chi-square test result endorse the presence of significant difference on the level of accidents based the given age category of the Pedestrian at p (0.25) and chi-square value of 7.807. These confirm that economically active citizens are highly affected by traffic accidents.

Table 4.8. Chi-square test result of sex of pedestrian victims and accident level

			Accident Level			Total
			Death	Serious Injury	Light Injury	
Sex of causality	Male	Count	12	50	31	93
		% of Total	8.2191%	34.2465%	21.2328%	63.6986%
	Female	Count	6	32	15	53
		% of Total	4.1095%	21.9178%	10.2739%	36.3013%
Total		Count	18	82	46	146
		% of Total	12.3287%	56.1643%	31.5068%	100.00%
Chi-Square Tests		Value	0.6028			
		Sig.	0.73979			

The result of the above table confirmed that there is large difference of accident causality between two sexes (male and females). And accident level of pedestrians' victims in road traffic accidents of the City at probability level of p (0.739) and with Chi-Square value of 0.602.

Summarized Road User Casualties in Adama City Administration by Individual Age Group



	<18	18-30	31-50	>50
Drivers	12	110	149	74
Passengers	28	17	25	48
Pedestrians	15	41	56	34
Total	55	168	230	156

Figure 4.7. Drivers, pedestrians, and passengers casualties in Adama City Administration

The above Figure 4.7. Showed that the distribution of road traffic accident victims by the age group. The findings shows that pedestrians are the second vulnerable to traffic accident in Adama. Drivers aged 31-50 and 18-30 account for the highest percentages of accident victims than those groups who's aged are <18 and >50. Generally, the magnitude of the road accident victims (drivers, pedestrians, and passengers) within the age group of 31-50 in RTAs who have age are the most affected during 2008-2012, and followed by age group of 18-30 in the same period. In contrary, road users whose age is less than 18 were the least victims of road traffic accidents during 2008 to 2012 in Adama City Administration.

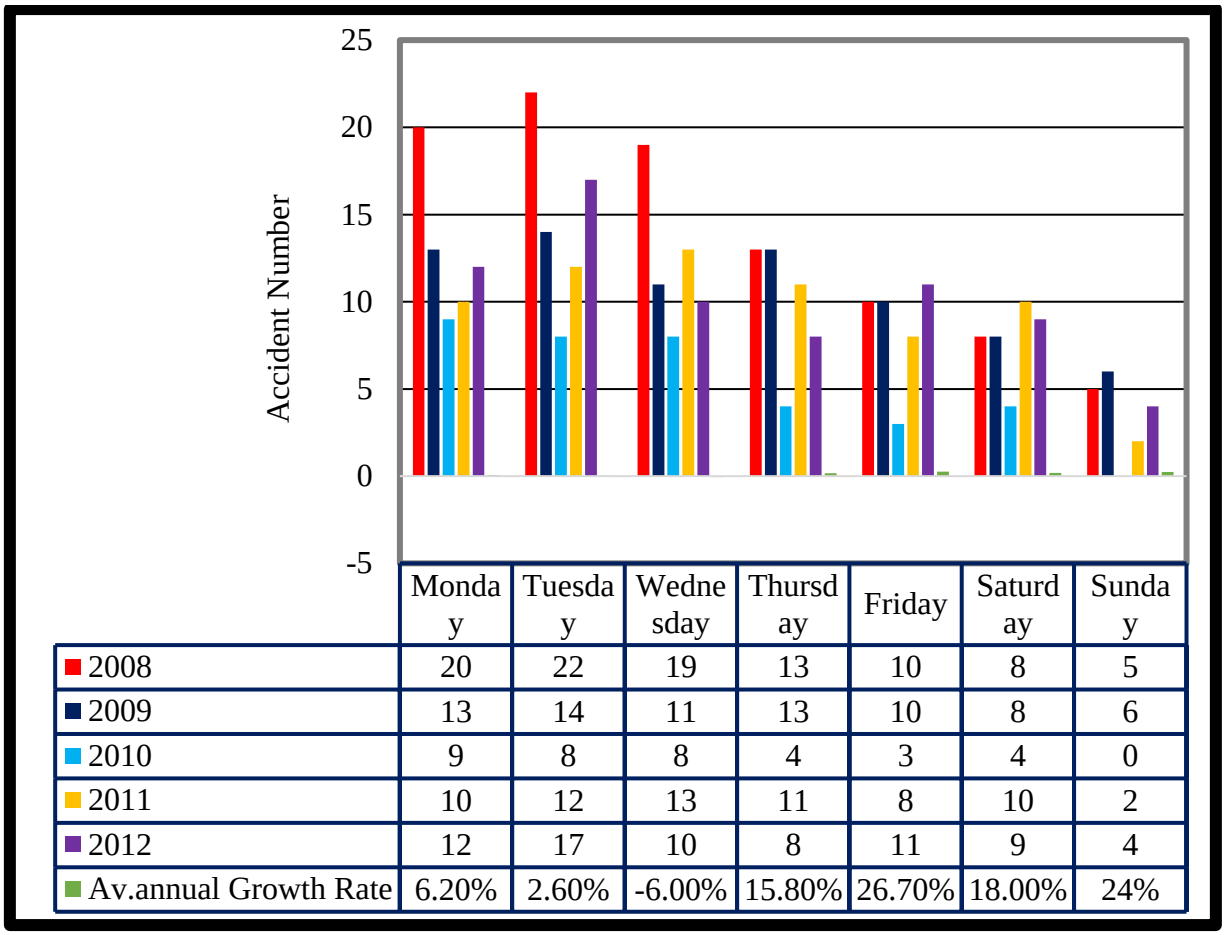
4.1.4. Road traffic accidents on major roads of Adama city

In this section the researcher discusses RTAs by day of a week, time of the accident occurred, collision type, land use, accident by road lane type, accident by road character, accident by

road junction type, accident by vehicle type, type of vehicle defect, by light condition, and road way surface condition.

4.1.5. RTAs by day of a week in Adama city major roads

Analysis of road traffic accidents in the city by day of a week refers growth of the severity of the accidents from 2008 to 2012. In 2008, Tuesday, Monday, and Wednesday were the highest number of accidents with 22, 20, and 19 data reports, respectively. Consequently, in 2009, the highest accident crashes occurred on Tuesday, Monday, and Thursday with report data of 14, 13, and 13, respectively. In 2012, significant accidents were recorded in all days of the week, except on Sunday. Since, there were significant report of 17, 12, and 11 accidents on Tuesday, Monday, and Friday, respectively. Sunday had relatively small accident number were recorded. Generally, the analysis confirms that higher accidents occurred in the City from Monday to Saturday, especially on Tuesday, Monday, Wednesday, Thursday, and Friday.



	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2008	20	22	19	13	10	8	5
2009	13	14	11	13	10	8	6
2010	9	8	8	4	3	4	0
2011	10	12	13	11	8	10	2
2012	12	17	10	8	11	9	4
Av.annual Growth Rate	6.20%	2.60%	-6.00%	15.80%	26.70%	18.00%	24%

Figure 4.8. Distribution of accidents by day of a week (2008-20012)

Table 4.9. Calculation of Chi-Square

Days of the week	Observed frequency	Expected frequency	D.f.	Critical X^2	$\frac{\sum(O-E)^2}{E}$
Weekdays	289	172.5	1	3.84	157.359
Weekends	56	172.5			
Total	345				
			S.f	.05	.000

Table 4.9, indicates that the calculated χ 2 statistics for 1 degree of freedom is 157.36. Additionally, it indicates that the significant value (0.000) is less than the critical p-value of 0.05.

This suggests that the null hypothesis is rejected. The alternate hypothesis is that accidents occurred on weekdays have significant difference when compared with weekends. Overall 289 (83.7 %) of accidents occurred on weekdays with significant difference when compared with weekends (p-value< 0.05).

4.1.6. RTA's on major roads by hour of a day in Adama city

Road traffic accidents vary by hours of a day; with maximum crashes when mobility of passengers, pedestrians, and drivers' frequency increases. Accordingly, accident reports in the city by crash have three basic scenarios named by the researcher as plateau stage, maximum stage, and decreasing stages. In the first categories, 6:00AM-12:00PM accident rates more or less have similar features from 2008 to 20012. After the plateau stage especially after 6:00 am, RTAs tremendously increased and reached maximum at 10:00 am in both 2008 and 2009, 2010, 2011, and 2012 at 11:00 am. Decreasing trends of crashes per hour began with, slight decrease from 13:00 to 18:00 in the same way in the five years, and acutely decreases after 18: 00 (6 pm) and reaches plateau levels at 24:00 (12 pm) (see Figure 4.9). Hence, the accidents were highly associated with the number and time of movements of pedestrians, passengers, drivers, and vehicles.

Table 4.10. Calculation for Chi-Square accident distributed over the hours of the day.

Hours	Observed frequency	Expected frequency	D.f.	Critical X^2	$\frac{\sum(O-E)^2}{E}$
12:00AM-6:00AM	114	86.25	3	7.81	142.13
6:00AM-12:00PM	161	86.25			
12:00PM-6:00PM	53	86.25			
6:00PM-12:00AM	17	86.25			
Total	345	S.f		.05	.000

Table 4.10, shows that calculated χ 2- value of 142.13 for 3 D.f. and a critical χ2- value of 7.81 at 0.05 alpha level. Since the calculated χ2- value is greater than the critical χ2- value, the null hypothesis, i.e., accidents are uniformly distributed over the hours of the day, is rejected. Thus, it indicates that accidents are not uniformly distributed over the hours of the day. More than 41% of the accidents occurred during day time (6 AM to 6 PM). These times coincide with the period when people are more active and mobile. The peak time was between 12 AM to 6 AM (37%; Table 4.10). These hours are the busiest as there is heavy rush of commuters from schools, offices, factories, business places, etc. Between 6 AM to 12 PM, also a high number of RTAs i.e., 15% were observed (see Table 4.10). During this period, the roads are opened for heavy vehicular movements.

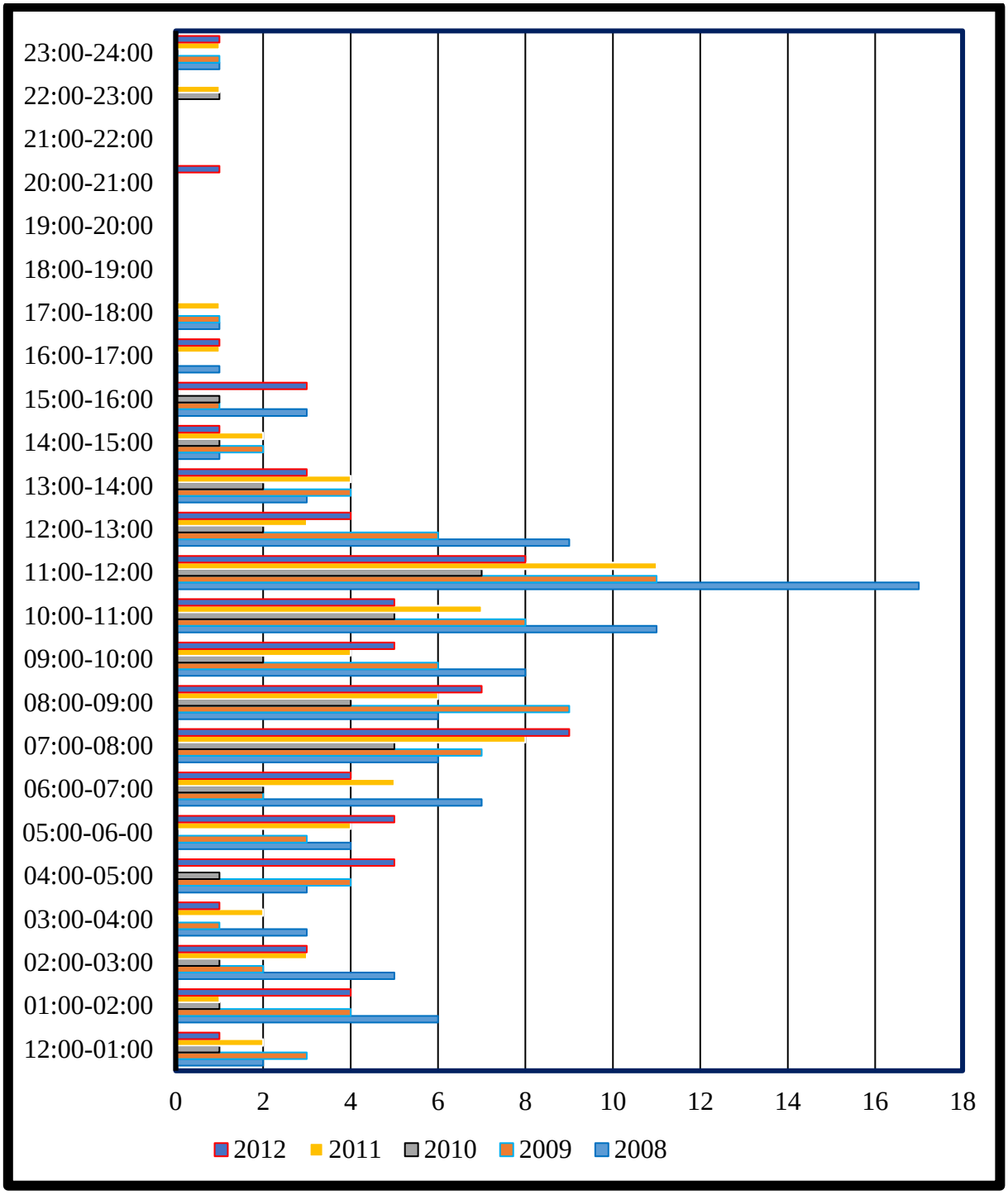


Figure 4.9. Number of crashes / by hour of a day for major roads of the city during 2008-2012

4.1.7. RTA's by land use in Adama city major roads

Land uses of the Sub-City are divided into Market Areas, School Area, Industrial Area, Church Areas, Recreation Area, Hospital Area, Urban Residential and Other types of land uses in order to examine the accident extents in each area. Accordingly, as the collected data

confirmed that land uses like Agricultural area and rural village Area haven't recorded accident reports in all the five selected years. Whereas, CBD (Central Business District) and market areas have highest accident reports. 24 in 2008, 21 in 2009, 10 in 2010, 16 in 2011, and 18 in 2012 respectively. Similarly, in market areas, there were accident reports of 20, 15, 12, 15, and 16 in 2008, 2009, 2010, 2011, and 2012 respectively. The remaining selected land uses have medium level of accident reports, and hence the study confirmed that the presence of significant difference in exhibiting road traffic accidents in the city.

Table 4.11. Accidents by land use

Land Use	Adama city					2008 to 2012
	2008	2009	2010	2011	2012	
School Area	11	9	2	7	6	35
Industrial Area	4	3	2	5	6	20
Church area	5	2	1	3	3	14
Market area	20	15	12	15	16	78
Recreation area	5	5	1	3	3	17
Hospital area	14	11	5	8	8	46
CBD	24	21	10	16	18	89
Urban residential	11	8	3	7	7	36
Other	3	1	0	2	4	10
Total	97	75	36	66	71	345

Data Source: Adama city traffic police commission (ACTPC)

4.1.8. RTA's by Collision Type in Adama City major roads

The collision type is a good indication for crash contributing factors. Collisions like rear end, head on, broad side, and collision with roadside parked vehicles are the most dominant type of collisions which frequently occurred in the city with values of 15, 11, 4, 12, 12; 17, 10, 4, 8, 8; 10, 8, 6, 9, 12; and 9, 11, 4, 7 in the 2008, 2009, 2010, 2011, and 2012, respectively. Whereas, collision types like Roll over, unknown, collision with animals, and fall from vehicles have very low number of accident reports. The remaining head on collisions also have relatively medium accident rates.

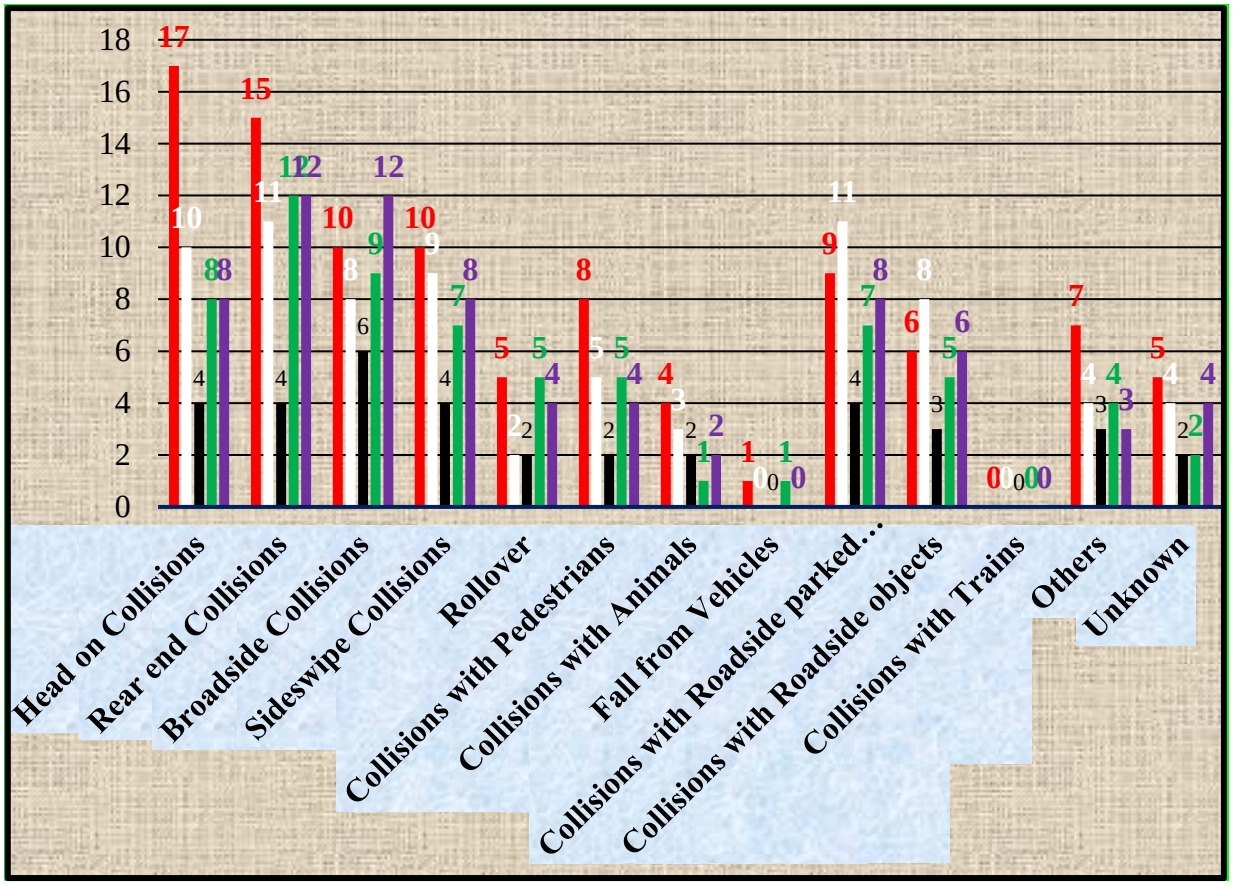


Figure 4.10. RTAs by collision type

4.1.9. RTA's by road junction in Adama City major roads

There are categorizes different types of road junction including midblock, Y-junction, T-junction, roundabout, and four-leg junction. In this regard, unspecified junction has relatively the highest accident rates recorded as compared to the other junctions. Midblock junction had relatively small accident number were recorded in the city.

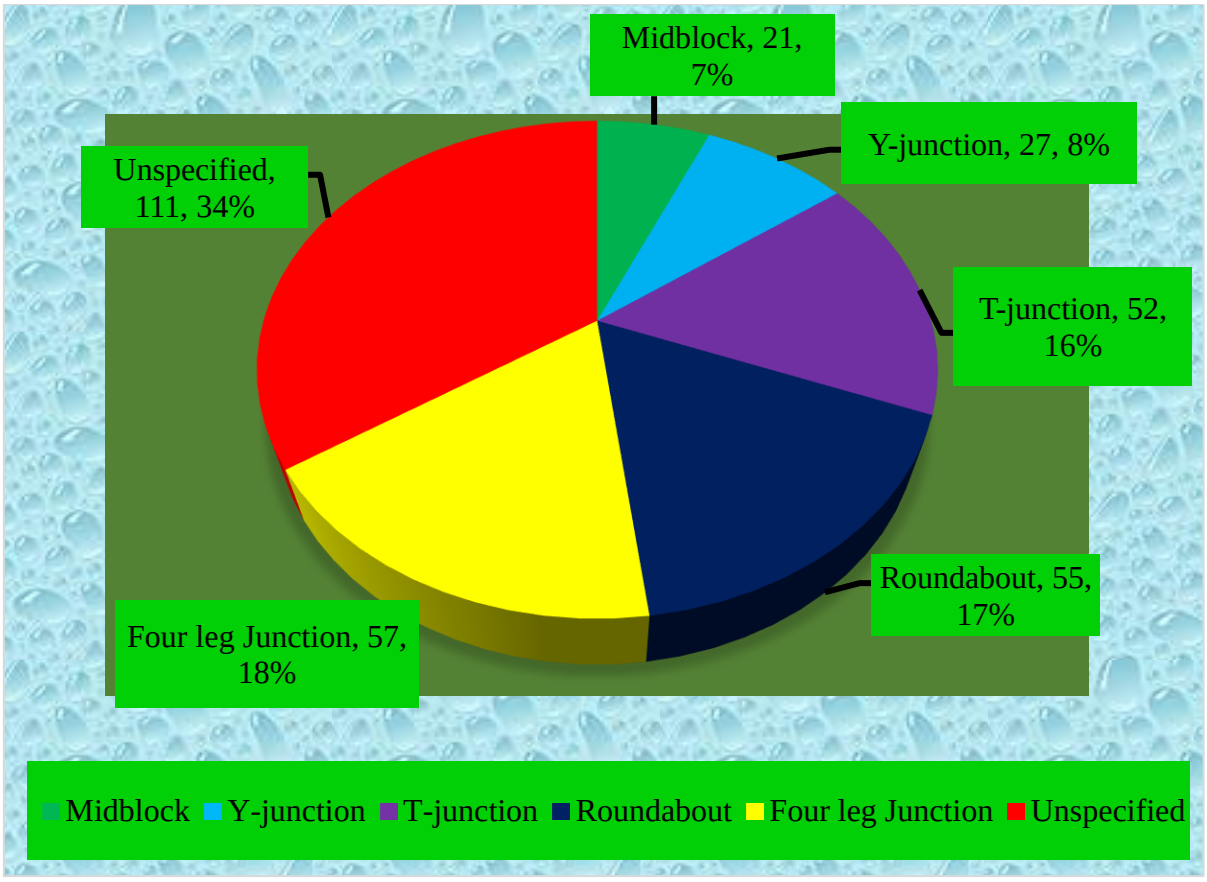
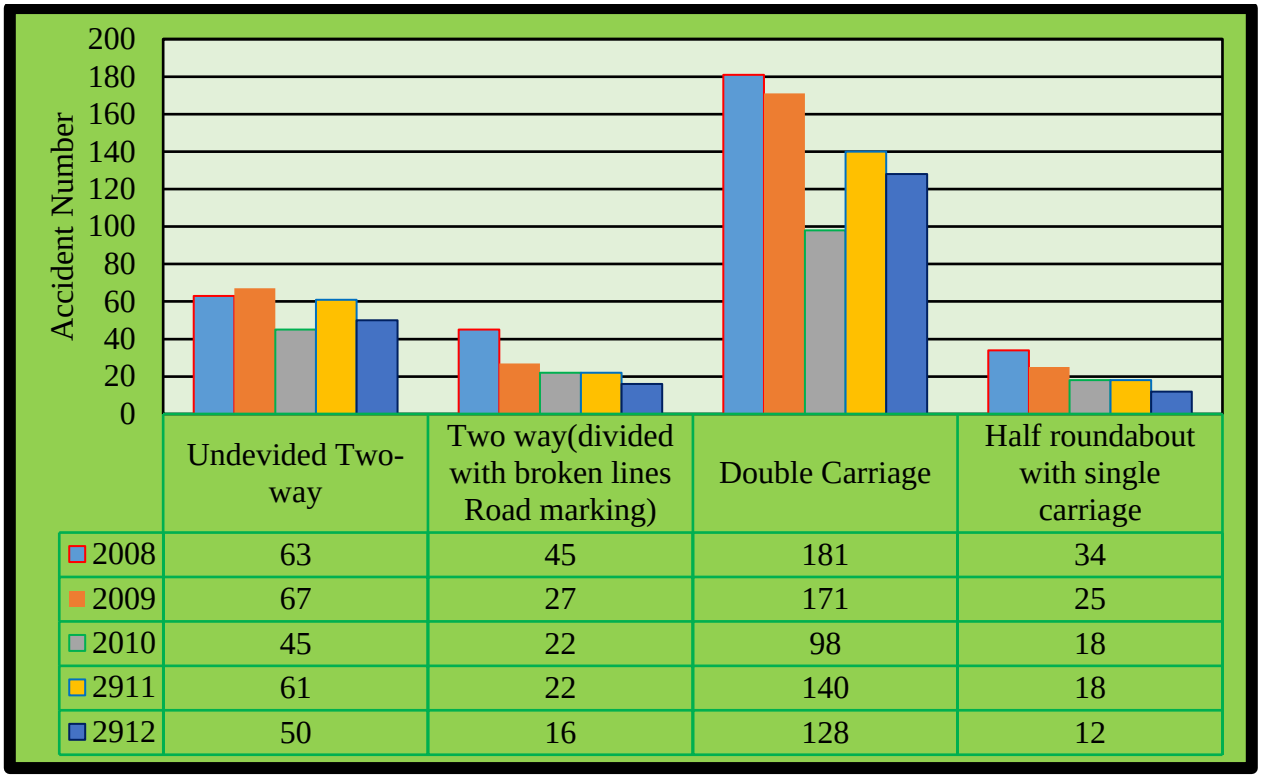


Figure 4.11. RTAs by junction type in the Sub-City (2008-2012)

4.1.10. RTA's by Road Lane in Adama city major roads

Road lane type and quality have crucial importance in reducing road traffic accidents. In this regard, the analysis of the data illustrated in Figure 4.12 shows the presence of significant difference in exhibiting road traffic accidents within lanes and between years. Accordingly, the highest frequency of accidents was associated with double carriage way with total accident number of 181, 171, 98, 140, and 128 from 2008 to 2012, respectively followed by undivided two-way lane with total accident number of 63, 67, 45, 61, and 50 in year 2008, 2009, 2010, 2011, and 2012 respectively. The others like two way (divided with broken line road marking) and half roundabout with single carriage have comparatively average accident rates. Thus, the investigation assured that there was dramatic accident reduction in two way (divided with broken line road marking) and half roundabout with single carriage road lanes from year 2008 to 2012. (Figure 4.12 for more details).



	Undevided Two-way	Two way(divided with broken lines Road marking)	Double Carriage	Half roundabout with single carriage
2008	63	45	181	34
2009	67	27	171	25
2010	45	22	98	18
2911	61	22	140	18
2912	50	16	128	12

Figure 4.12. RTAs by Road Lane

4.1.11. RTA's by road character in Adama city major roads.

Road characters have significant impact in the determining for the level of accident extents in a given area. Accordingly, Table below shows that the presence of adequate difference in various road character of the city, i.e., highest accidents rate were recorded in straight and grade road character in the City with numbers of 25, 21, 7, 21, and 23 in 2008, 2009, 2010, 2011, and 2012, respectively. Besides, except in 2010, all the subject road characteristics did not practice significant accident in the city.

Table 4.12. RTAs by road character

Road character	Number of road accidents in year					Total
	2008	2009	2010	2011	2012	2008 to 2012
Straight and level	23	23	9	18	16	89
Straight and grade	25	21	7	21	23	97
Up hill	9	4	7	7	9	36
Down hill	27	19	10	15	18	89
Unidentified (others)	13	8	3	5	5	34
Total	97	75	36	66	71	345

4.1.12. RTA's by Vehicle type in Adama city major roads

Table 4.13. shows the accidents occurred by different vehicle types; bicycle, motor bicycle, automobile, station wagon, pick up <=10 quintal, truck 11-40 quintal, truck 41-100 quintal, truck with trailer, liquid cargo, taxi, minibus up to 12 seats, bus 13-45 seats, bus>46 seats, earth moving, earth moving with trailer, cart, others and unknown. As the analysis result confirmed that, accident caused by Taxi, Minibus up to 12 seats, truck 11-40 quintal, truck 41-100 quintal, and bus 13-45 seats has the highest accident rates recorded as compared to the other vehicles with accident number of 79, 49, 33, 32, and 30 relatively. On the other hand, Bicycle, others, Earth moving, and Earth moving with trailer has relatively small accident number were recorded with accident number of 3, 3, 2, and 1 in the city during 2008-2012.

4.1.13. RTA's by road way surface condition in Adama city major roads

Road surface condition is a condition were used to investigate the severity of RTAs accidents by road conditions in the city. Accordingly, as shown in figure below, it was revealed that about 68, 51, 27, 44, and 59 of the accidents occurred in 2008, 2009, 2010 2011, and 2012 on dry road surface conditions. Consequently, in unspecified road surface conditions, about 16, 18, 7, 15, and 9 accidents occurred in 2008, 2009, 2010, 2011, and 2012 and in wet road surface conditions, about 13, 6, 2, 7, and 3, respectively. In contrary, no accidents were occurred in slush road surface conditions. Hence, the analysis confirms that almost all of the RTAs happened in dry road surface conditions (Table 4.14).

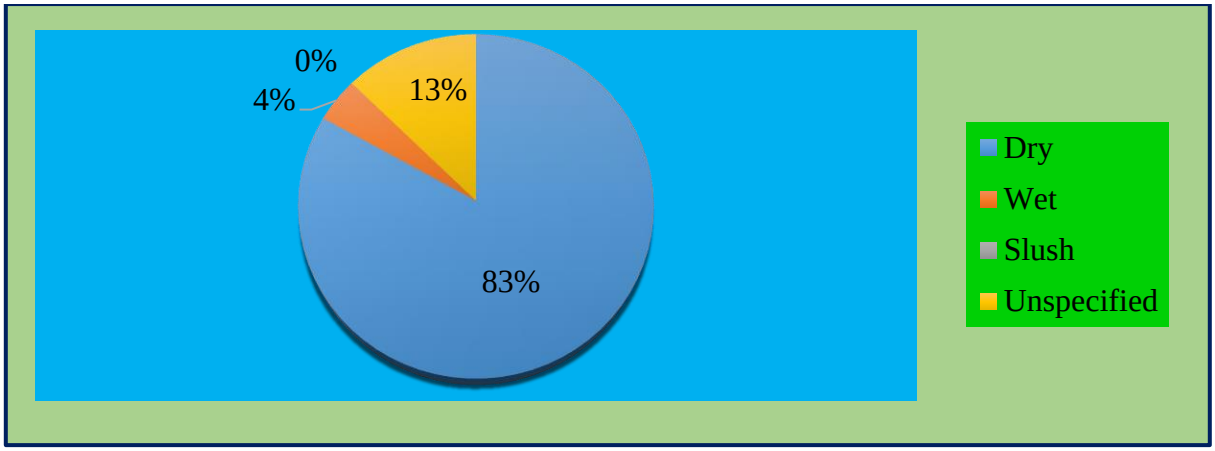


Figure 4.13. RTAS by roadway surface condition in Adama city

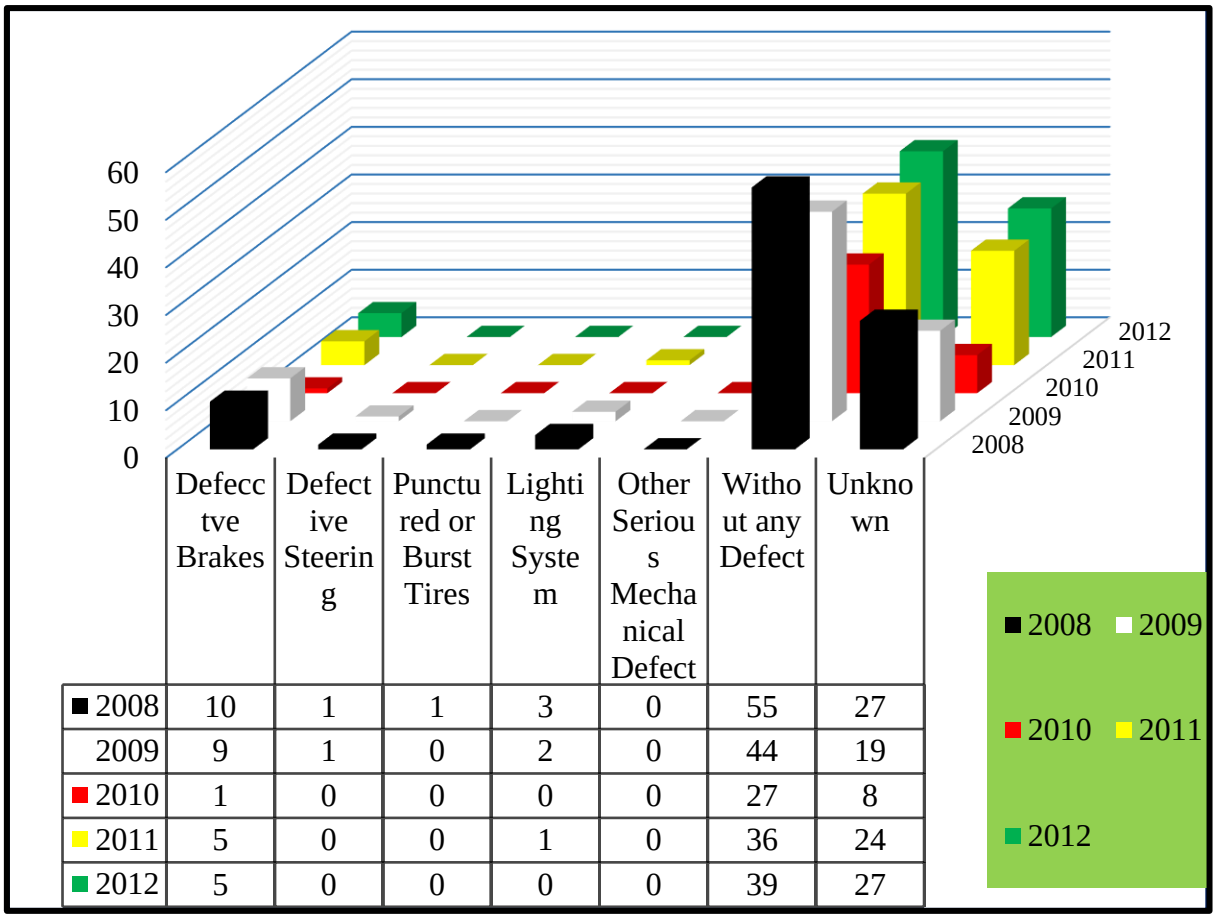
Table 4.13. Calculation of Chi-Square under dry and wet road surface condition 2008-2012 at Adama

Surface condition	Observed frequency	Expected frequency	D.f.	Critical X^2	$\frac{\sum(O-E)^2}{E}$
Dry	249	115	2	5.99	111.5473
Wet	31	115			
Unspecified	65	115			
Total	345				
			S.f	.05	.000

The chi-square statistic is 111.5473. The p-value is < 0.00001. The result is significant at p < .05.

4.1.14. RTA's by type of vehicle defect in Adama city major roads

To investigate the level of RTAs occurred by vehicle defect the indicators were classified with respect to defective steering, defective brakes, burst tyres or punctured, lighting systems, other serious mechanical defect, without any defect and unknown. From the above listed defects of vehicle, significant number of accidents were occurred without any defect and unknown i.e., 55 44, 27, 36, 39; 27, 19, 8, 24, and 27 in 2008, 2009, 2010, 2011, and 2012, respectively. The remaining vehicle defects almost caused insignificant level of road traffic accidents in the city except with the defective brake, which have lower accident rates (Figure 4.14).

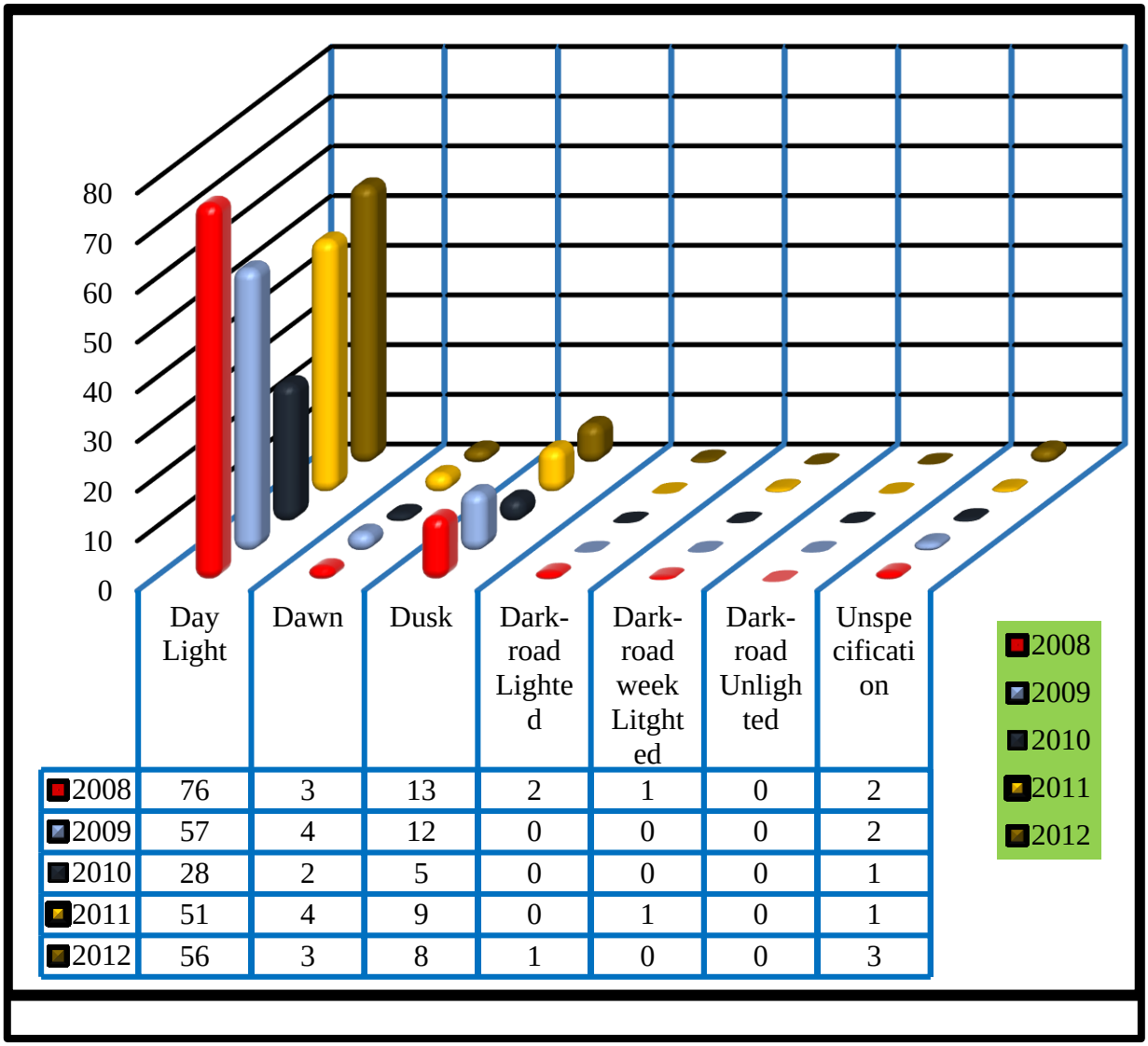


	Defective Brakes	Defective Steering	Punctured or Burst Tires	Lighting System	Other Serious Mechanical Defect	Without any Defect	Unknown
2008	10	1	1	3	0	55	27
2009	9	1	0	2	0	44	19
2010	1	0	0	0	0	27	8
2011	5	0	0	1	0	36	24
2012	5	0	0	0	0	39	27

Figure 4.14. RTAS by type of vehicle defect in the city

4.1.15. RTA's by light condition in Adama city major roads

The existence of light is very important for the reduction of RTAs significantly, the analysis shows that almost all the RTAs, i.e. about 76, 57, 28, 51, 56; 13, 12, 5, 9, and 8 accidents occurred during the day light and dust in 2008, 2009, 2010, 2011, and 2012, respectively. Moreover, as compared to day light and dust, medium accidents were reported in dawn and unspecified road conditions in the city from 2008 to 2012. Accidents those happened in dark-road lighted and dark-road week lighted were relatively very low (Figure 4.15. for the details).



	Day Light	Dawn	Dusk	Dark-road Lighted	Dark-road week Litghted	Dark-road Unlighted	Unspecification
2008	76	3	13	2	1	0	2
2009	57	4	12	0	0	0	2
2010	28	2	5	0	0	0	1
2011	51	4	9	0	1	0	1
2012	56	3	8	1	0	0	3

Figure 4.15. RTAs by light condition in the City

4.2. Spatial distribution of accidents in spot areas in Adama City major roads

The output of this study was to clearly identify the location of major roads of traffic accidents, black spot areas, and then to rank the sites and suggest or recommend (Black spot treatment). To minimize potential vehicle crashes, initially locations and segments of road traffic accident data were identified to ease the computation of black spot areas. Table 4.15 shows that in 2008, all fatalities range between 0 and 9. Highest accidents with value of 9 were recorded at Kella. Regarding medium fatalities, 4 were recorded at Bollo food complex and Amede areas. The highest serious injuries between 7 and 9 occurred at Ayu Hotel, Bollo Food complex, Post

Office Roundabout, Aba Geda Roundabout, Kella, and Warka with numbers of 9, 9, 8, 7, 7, and 7 respectively.

Spatial areas that have less serious injuries between 1and 2 were happened at East Shoa Zone office, Hany, and Kuriftu Hotel. The 2008 slight injury report was classified in two groups, i.e., with the value of 0-4 and 5-8. Accordingly, areas like Muger, Kuriftu Hotel, Aba Geda Roundabout, Amede, East Shoa Zone, Hany, and Tikur Abay have recorded light injuries between 0-4. In Contrary, 5-8 light injuries were recorded in General Tadesse Birru Roundabout, Warka, Post Office Roundabout, Ayu Hotel, Bollo Food Complex, and Kella. Furthermore, the property damage in 2008 was reported with minimum and maximum values of 2 and 21 at spots of East Shoa Zone, General Tadesse Birru Roundabout, and Kella respectively (Table 4.15).

In 2008 and 2009, no fatal accidents were reported at the Kuriftu Hotel, East Shoa Zone, and General Tadesse Birru Roundabout. RTAs by Spatial Distribution with Accident Spot are shown in appendix B (Tab. B.12).

Generally, the summary report in Figure 4.16. Showed that, at the identified spot sections 2008-2012 highest accidents were exhibited at Bollo Food Complex, Tikur Abay, Warka, and Post Office Roundabout areas with the value of 76, 64, 63, and 61, respectively. Whereas, between the same years, comparably low aggregated road traffic accidents were reported at East Shoa Zone, Kuriftu Hotel, and General Tadesse Birru Roundabout with the values of 16, 18, and 19, respectively.

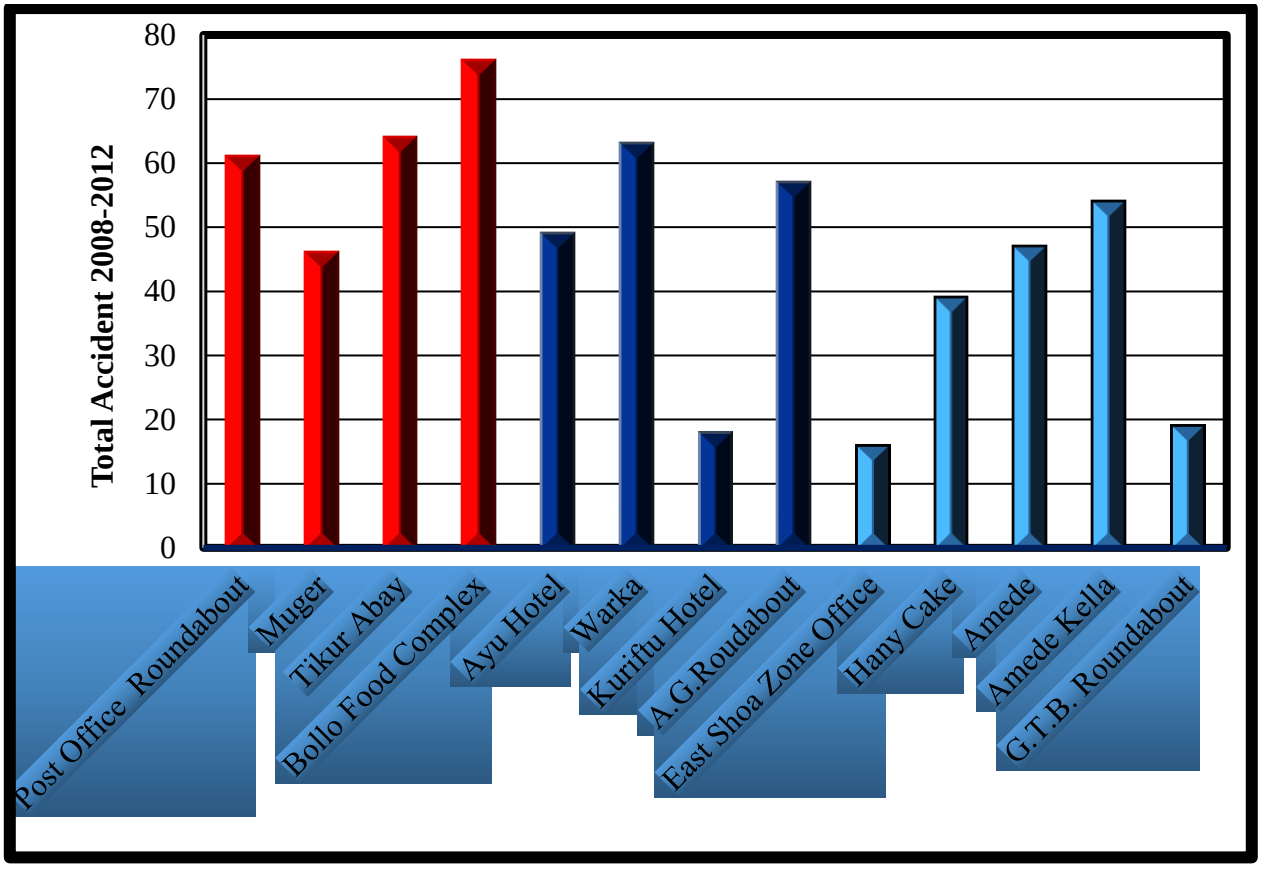


Figure 4.16. Summary of 2008-2012 casualties by location

4.3. Identification of black spot areas in Adama city

A location whether link or node that experiences abnormal crash frequencies, rate is considered as an accident black spot. The method also incorporates exposure data such as traffic volume and length of the road section to determine if the accident frequency at particular location is significantly higher than the average for each factor. Accordingly, this research used accident frequency methods to identify accident-spot locations of Calculation.

Frequency Method

This method was used to determine the number of accidents occurred in a year for each kilometer, so that the result will present which segment has the highest or lowest part of the accident rate (black spot). The equation for calculating accident rate by accident frequency method (Accident Frequency Method) is:

$$AF = \frac{A}{L*T} \quad \ldots (3.2)$$

Where:

AF = accident frequency (accident/km/year)

A = total of accident

L = segment length/road (km)

T = period (year)

Presented in the Table 4.15.

Accident Level Method

This method combines the frequency of accidents with the presence of vehicles (i.e. traffic volume) and expressed as "accidents per million vehicles for crossing" or "accidents per million vehicle - miles of travel" for the section of the highway. The place is then ranked in order of crash rates. A highway system of 10,000 miles or less can use this method.

Ranking of Sites

To prioritize those black spot areas, the ratios of accident costs by degree of severity were established by TRL, the weight given for fatal accident, serious injury, slight injury, and property damages are 5, 3, 2, and 1 respectively.

$$P = \frac{1 * W + 2 * X + 3 * Y + 5 * Z}{D} \quad \text{... (3.1)}$$

Where:

P = priority value;

W = Total number of property damages;

X = Total number of slight injury;

Y = Total number of serious injury;

Z = Total number of deadly injury;

D = Total number of distance of the black spot section in kilometer.

Presented in the Table 4.17 and Accident spot areas in Adama city major roads are shown in appendix B (Tab. B.13).

Ranking of accident spots helps to identify the place which is to be given for immediate attention. Quality control consider various road categories to rank high crash locations. This method compares site crash frequencies, densities, or rates against predetermined average values for sites with similar characteristics. Therefore, it used for identification of black spot segments and spots in Adama City roads so that the accident frequencies of all the spots over the 5-years period are calculated. The logic of this method is that a location is considered to be a black spot if its safety parameter shows higher values (location's crash rate) than the critical value, and then ranking of accident spots based on calculated severity established by Transport Research Laboratory value are ranked.

Table 4.14. Black spot segment in Adama City

Black Spot Segment

Black Spot Segment	2008 to 2012				Property Damage in birr	Rank
	Fatal	Serious Injury	Slight Injury	Property Damage		
Post Office Roundabout- Bollo Food Complex	74	95	78	311	13,248,261.312	1st

Table 4.15. Black spot sections in Adama City

Black Spot Sections

No	Black Spot Section	2008 to 2012					Rank
		Fatal	Serious Injury	Slight Injury	Property Damage	Property Damage in birr	
1	Warka	21	24	18	64	2,717,592.064	1st
2	Tikur Abay	19	24	21	103	4,373,624.728	2nd
3	Ayu Hotel	17	19	13	23	2,972,366.32	3rd
4	Amede	15	17	15	58	2,462,817.808	4th
5	Hany	10	12	17	50	2,123,118.8	5th
6	Amede Kella	14	21	19	78	3,312,065.228	6rd
7	Bollo Food Complex	23	31	22	105	4,458,549.48	7th

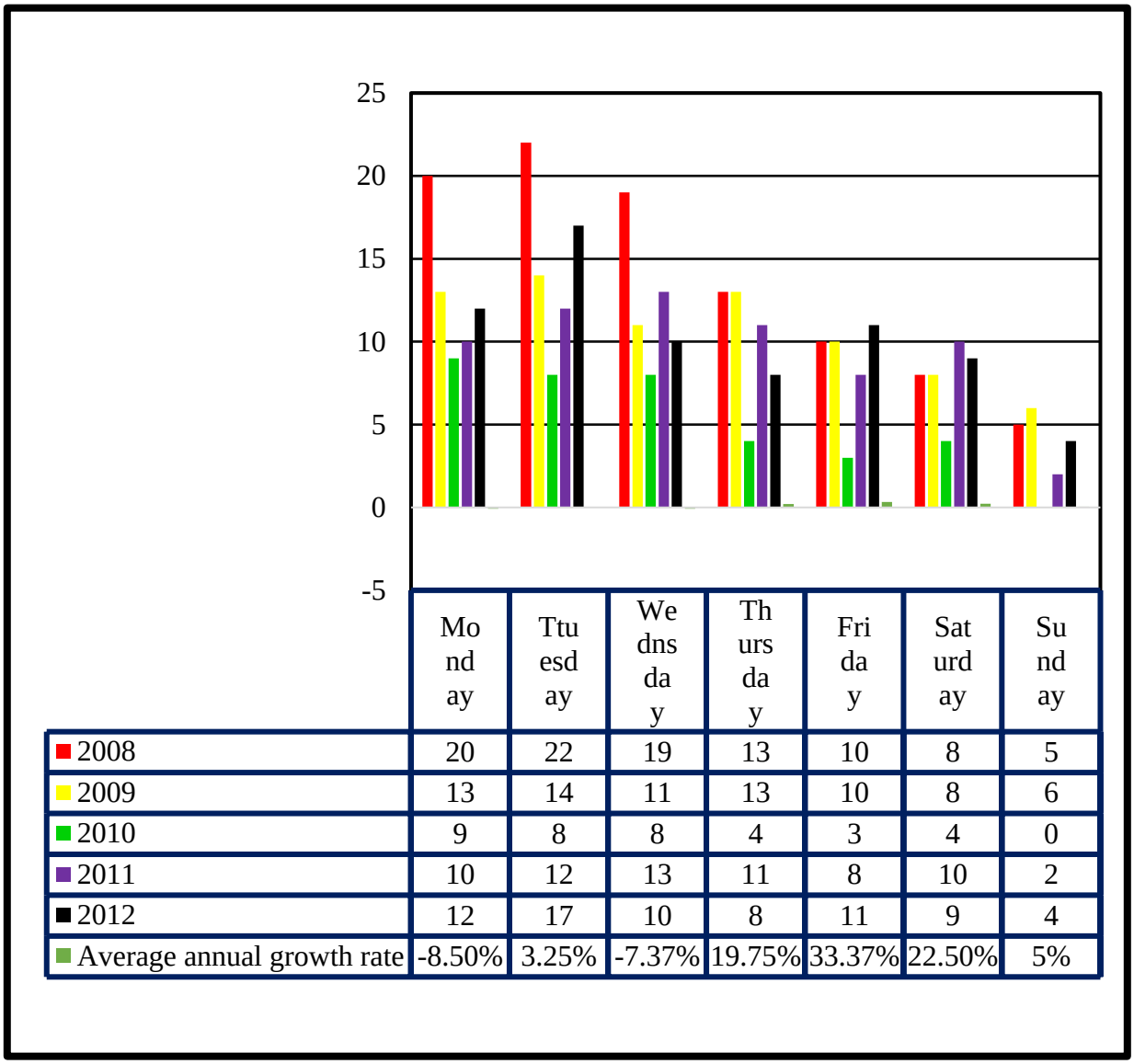
4.4. Temporal analysis of selected spot areas

Temporal analysis of road traffic accidents has paramount importance to determine when the accidents reached peak time and in which day the accidents were very severe. Hence, in this part of the current study, the researcher discussed the road traffic accident extent in days of the week and time of a day.

4.4.1. Traffic accidents by day of a week in the selected black spot segment and spot areas

Depending on the Figure 4.17 below, we can conclude that in 2008, comparatively maximum number of traffic accidents were recorded from Monday to Sunday with accident number of 20, 22, 19, 13, 10, 8, and 5. In 2009 total number of traffic accident recorded were slightly decreases from Monday to Sunday as compared from 2008, with accident number of 13, 14, 11, 13, 10, 8, and 6. But, unexpectedly decreases the number of traffic accident that were recorded about 9, 8, 8, 4, 3, 4, and 0 road traffic accidents on Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday respectively in 2010, i.e., and from this it confirmed

that the presence of slight accident difference by day of a week in 2010, except Sunday. Because, on Sunday there were no recorded traffic accident. Moreover in 2011, the number of road traffic accidents increased as compared to 2010 with high accident variation from Monday to Saturday. Like the data in 2010, Sunday had no road traffic accidents. This may be because of low movements of vehicles, passengers, and pedestrians on weekends in the selected black segment & spot areas. Similarly, the risk of road traffic accidents in 2012 remarkably increased as compared to 2011, with accident number of 12, 17, 10, 8, 11, 9, and 4.



	Monday	Ttuesday	Wednsday	Thursday	Friday	Saturday	Sunday
2008	20	22	19	13	10	8	5
2009	13	14	11	13	10	8	6
2010	9	8	8	4	3	4	0
2011	10	12	13	11	8	10	2
2012	12	17	10	8	11	9	4
Average annual growth rate	-8.50%	3.25%	-7.37%	19.75%	33.37%	22.50%	5%

Figure 4.17. Number of Accident 2008-2012 by Day of the Week

Generally, the trends of traffic accidents from 2008 to 2012, of the first two years from 2008 to 2009 and 2009 to 2010 shows an acute decrement on traffic accident records. But, the last two years it shows acute increments despite the Government's effort to undertake remedial measures like road traffic accidents awareness creation activities through mass media for the community, students, drivers, and Government trying to upgrade the quality of drivers by adopting new licensing systems for different types of vehicles. Besides, much effort have also been undertaken on increasing the road networks in the city (Figure 4.18).

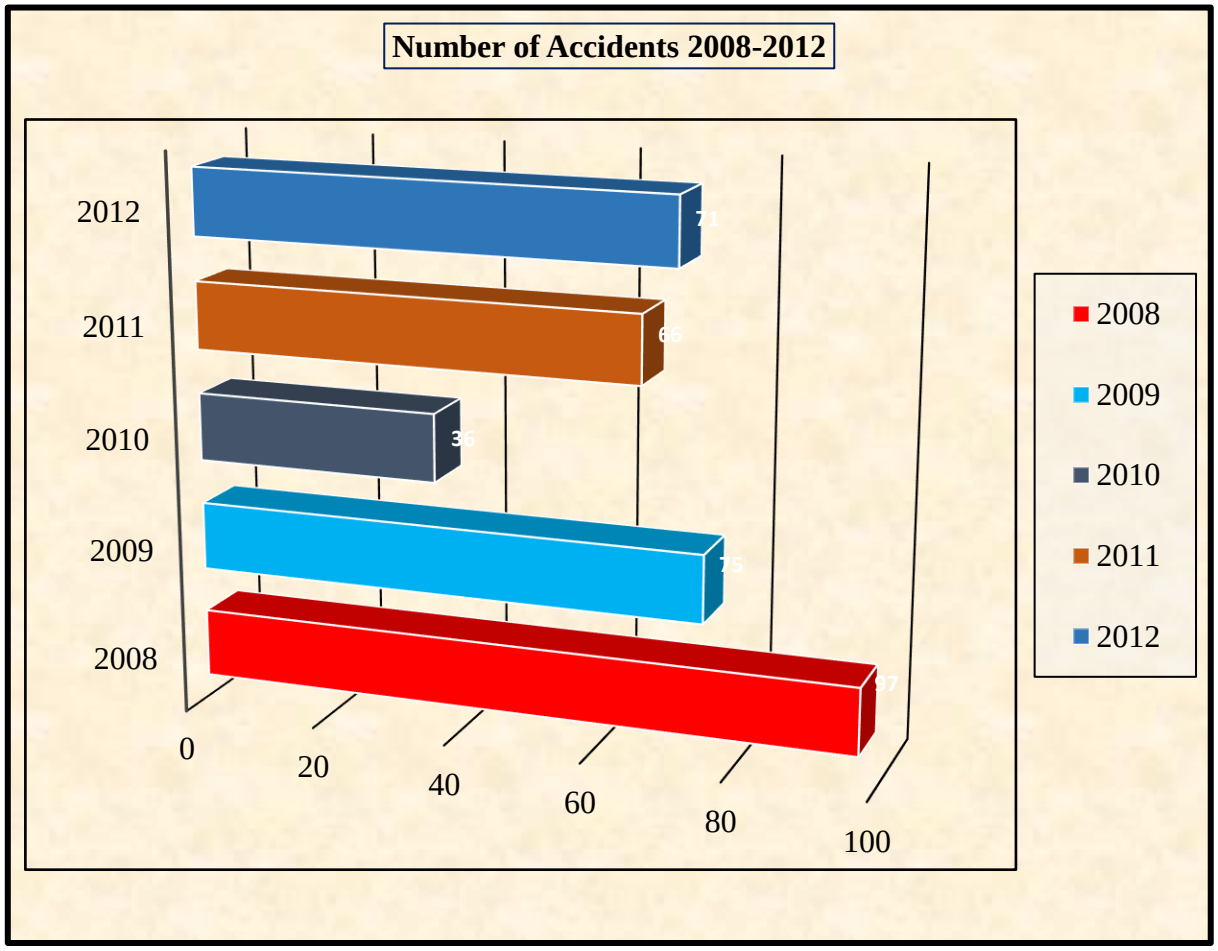


Figure 4.18. Comparison of road traffic accidents (2008-2012)

Whereas, the summary report of data collected from the Adama City Traffic Police showed that, road traffic accidents reached maximum on Tuesday followed by Monday and Wednesday during week days from 2008 to 2012. The accident started declining on Saturday and reached minimum on Sunday (Figure 4.19).

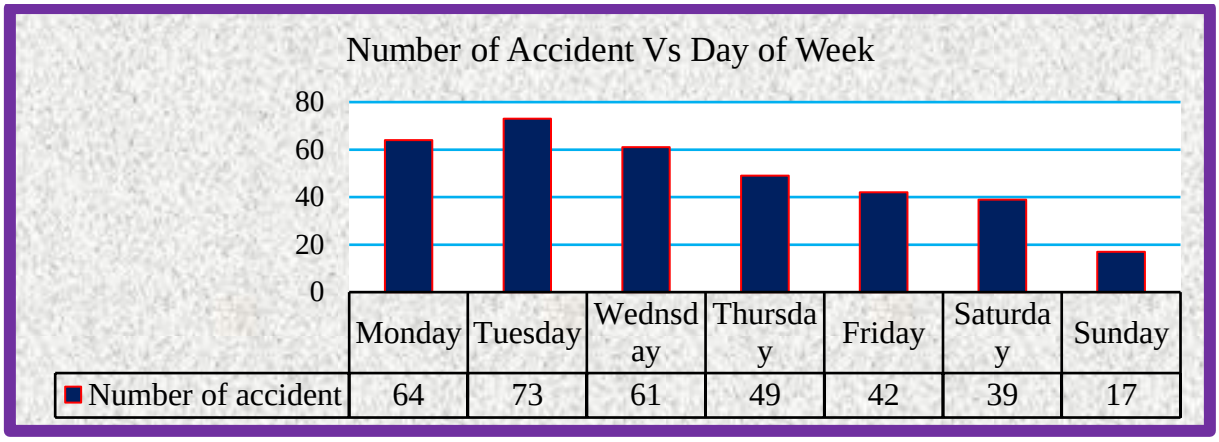


Figure 4.19. Summary of road traffic accidents

4.4.2. Traffic accidents by hour of the day (2008-2012) in the selected areas

Traffic accident rate varies upon the nature of hour of the day, and mostly road traffic accidents occurred when the passenger movements from place to place reached maximum levels. In this regard, the study reveals that in 2008, highest road traffic accidents were reported between 11:00-12:00 with 17 accidents followed by 10:00-11:00, and 12:00-13:00 with the total number of accidents of 11 and 9 respectively. While the lowest number of traffic accident occurred during 14:00-01:00 (see Figure 4.20).

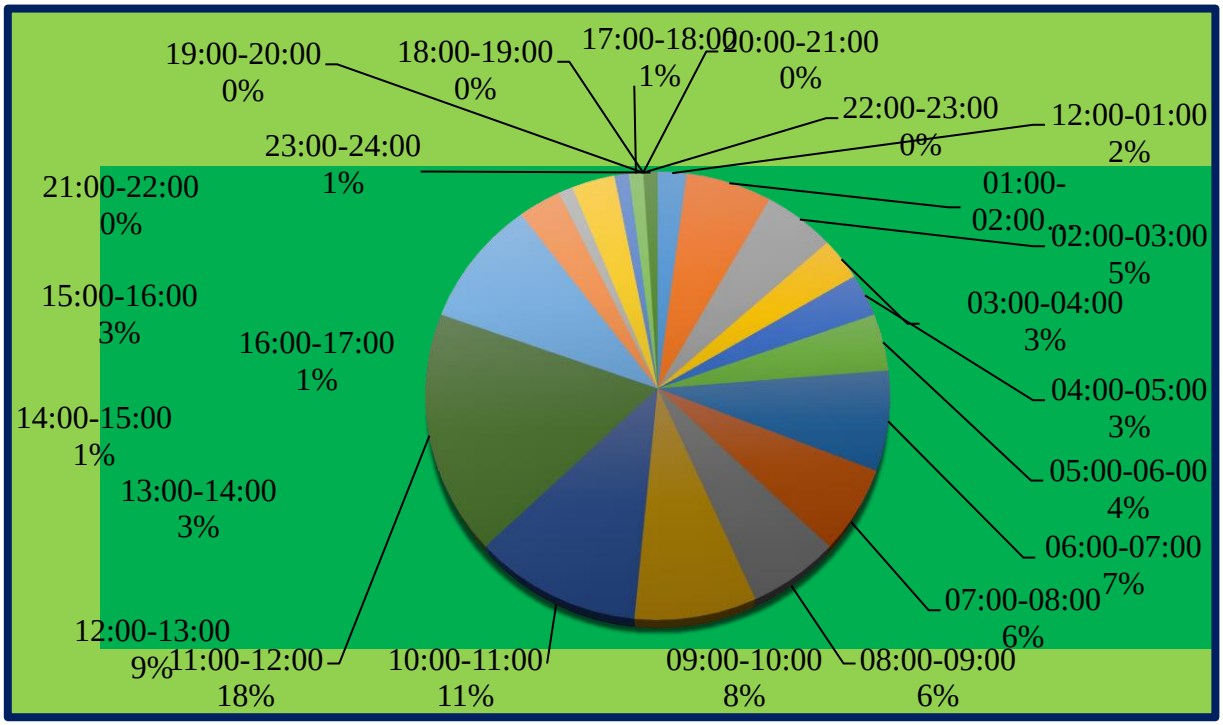


Figure 4.20. Graphical comparison crashes per hour of a day (2008-2012) in selected area

The table above shows that, in 2012 the highest number of crashes happened at the 07:00-08:00l local time, which is followed by at 11:00-12:00 and 08:00-09:00 with accident number of 9, 8, and 7, respectively.

Generally, in the above analysis, the summary of the descriptive statistics for number of crashes in 2008, 2009, 2010, 2011, and 2012 in hour of a day has shown no large difference among their calculated mean value of crash rate. Accordingly, table 4.28 illustrates the mean number of accidents in 2008, 2009, 2010, 2011, and 2012 as 4.0, 3.1, 1.5, 2.75, and 2.96 per hour per year respectively. That is, on average there were 4, 3, 1, 2, and 2 accident per hour during 2008-2012. Moreover, crash statistics confirmed that it decreased from 2008-2010 then, slightly increases from 2011-2012 in the selected Black spots of the Adama City.

Consequently, to check whether there is statistically significant difference among the selected years or not, and hence paired test was run since each comparable variable has continuous and scaled type. Accordingly, the paired test result confirmed the presence of statistically significant mean difference among the five selected years in hour of a day. It means that, the test showed the presence of statistically significant/severe crash difference/hour of a day at the probability level of (p=0.000). Accordingly, there were 0.916, 2.542, 1.292, 1.083, 1.625, 0.375, 0.167, -1.25, -1.485, and 0.208 crash mean differences between 2008 - 2009, 2008 – 2010, 2008 – 2011, 2008 – 2012, 2009 – 2010, 2009 – 2011, 2009 – 2012, 2010 – 2011, 2010 – 2012, and 2011 - 2012 per hour in a day, respectively.

4.4.3. Collisions types in selected black spots

Collision types that were used in this study include: head on collisions, rear end collisions, broadside collision, collision with pedestrians, sideswipe collision, rollover, collision with animals, fall from vehicles, collision with road side parked vehicles, collision with road side objects, and collision with train. The collision types were computed within 2008-2012 in the selected black spot areas and showed significant difference among all the types of collisions. Accordingly, from the totally 178 fatal accidents occurred in the selected spot areas, about 38, 36, 22, 18, and 17 were collisions types of roll-over, head-on collision, broadside, collision with road side parked vehicles and rear end collisions**.** The remaining collision types is not as much as such frequent fatal accidents. Whereas, the trends in serious accidents showed that from the total of 220 serious accident, about 30, 27, 25, 23, 21, and 21were recorded with

collision types of broadside collision, head on collisions, Others, collision with road side parked vehicles, collision with road side objects, and rear end collisions. As the same time the trends in light accidents showed that from the total of 211, about 21, 23, 23, 25, 29, and 39 were recorded with collision types of collision with road side parked vehicles, collisions with pedestrians, Unknown, broadside collision, head on collisions, and others. The trends showed that decreasing when compared with serious accident. But, still higher than the death reports (Table 4.20). The magnitude of property damage collisions types have very dramatic effects; for instance, 125, 107, 97, 81, and 69 property damages were recorded because of collision with sideswipe collision, rear-end collisions, broadside collision, collision with roadside object, and others respectively. In any way, this study were confirmed that the majority of fatal accidents were roll-over collision, head-on collision, and broadside collisions. In other types of collisions also had a moderate impact.

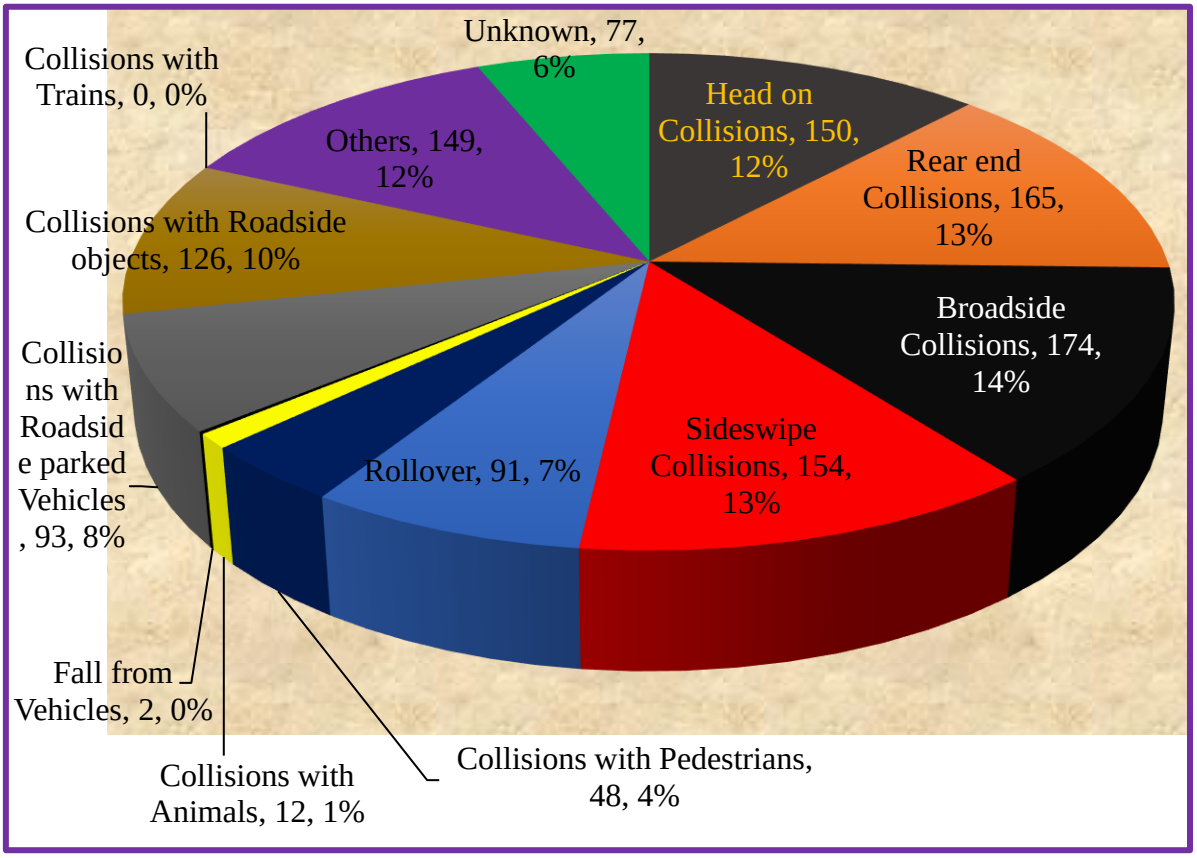


Figure 4.21. Collisions types in the selected black spot areas

4.5. Preventive measures (treatment) for the identified black spot areas.

4.5.1. Post office roundabout

Site description*:* *Post office Roundabout,* is surrounded by many is located on the dense traffic areas where majority of heavy to medium tracks, local shops, etc. Moreover, due to the presence of many peoples who visit this area frequently on foot, by taxi, and by their own vehicles besides the local communities' massive movement on the road. Thus, the area practiced that one of the highest RTAs Black spots identified areas of the city.

Field investigations*:* Post office Roundabout is surrounded by many residential, commercial, administrative settlements, and market areas with a significant number of vehicles from heavy to light vehicles using the road, especially during early in the morning and late in the evening. Photographs of some field observations on this area indicates that deficiencies of the rout contribution exposures for those type of collisions especially for pedestrian and vehicle crash are presented below

- There is high volume of on-street parking, and parked vehicles not safely parked inside the travelling lane and these conditions continue disturbing the smooth traffic movement, and they cause serious problems for drivers and vulnerable road users';
- No speed limit sign is there;
- High intensity of intercity freight and passenger vehicular traffic passes through the entire area;
- There is no roadside barrier used to separate roadways from pedestrian and to cause to lead the pedestrian to the correct way:
- Which were located at the center of the walkway on one side and which could create higher potential safety problems to the road users.

Because of absence of zebra crossing for pedestrians, it is common to see conflicts between pedestrians and vehicle, and pedestrians are forced to use the carriageways or the edge of carriageways as footways.

Improvement needs: The treatment is designed to reduce the number of traffic accidents.

Based on the identified types of vehicle crash found from analysis of the site inspection observed and the related countermeasures which have been successful in similar circumstances which is related to the types of crash found. Thus, easily implementable improvements are suggested for these black spots as follows**.**

- Needs to install the necessary traffic sign boards at sustainable locations;
- Zebra crossing can be provided and warning sign of pedestrian crossing can be placed at zebra crossing on both sides to minimize the accident collision with pedestrians.
- Provide fence to lead the pedestrian to safe crossing and avoid trading on the walkways so that it is easy to minimize the accident.
- Traffic policy of the city would be supplied with modern equipment and facilities to carry their tasks.
- To increase the visibility bright color of dress can help to avert many accidents under low light conditions, especially when trying to cross the road and while walking on the roads without footpath etc. Therefore, the accident collision with pedestrians gets minimized.
- Responsible authority should enforce the street shopping and neighbor stores not to sell or place some goods on the sidewalks.

4.5.2. Tikur Abay

Site description and traffic data analysis: Tikur Abay is known by another name of "Kereyu Street'' near to the Awash - Asella bus station. The frequency of communities were very high and hence, the area which is the second highest traffic accident record rate in the city. Types of collision faced on this area are: collisions with pedestrians, rear end collisions, head on collisions, broadside collision, rollover, and sideswipe collision. Furthermore, road users are not well aware of traffic rules and regulation in the city. In major area of the study road sections, carriageways or the edge of carriageways are used as footways. It is common to observe pedestrian and vehicle conflicts. Photographs of some field observations on the area, which shows that the deficiencies of the route contribution exposures for those types of collisions especially for pedestrian with vehicle conflicts and one vehicle with another vehicle, are discussed below.

Field investigations:

- There is no guard fencing or safety barrier and road marking completely at the Ditch;
- Absence of routine maintenance which could lead to serious accidents has been observed;
- There is invisible (faded) road lane marking and pedestrian crossing observed;
- Pedestrians are Susceptible for accidents. In general, there is terrible road way surface condition;
- Poor drainage systems and pond of water have been observed and these problems create high potential safety problems to vehicle drivers and vulnerable road users;
- There is no pedestrian walkway provided. Carriageways and the edges of carriageways are used as footways. It is common to observe pedestrian and vehicle conflicts (see figure below)

Improvement needs:

- Taking necessary enforcement actions to prevent the overloading of passengers;
- There is a need of surfacing of a pavement;
- Forcing the road users to follow the traffic rules;
- Guard fencing or safety barrier and road marking completely at the Ditch.

4.5.3. Bollo food complex

Site description: Bollo food complex is located near to the Hawas Preparatory School. It is surrounded by many shops, schools, illegal market areas, and high number of vehicles from light to heavy vehicles using this road throughout the day and night.

Site description:

- Parking of freight vehicles on roadside shoulders;
- There was no properly constructed side walkway;
- Inadequate road width with non-uniform road cross-section and this affects traffic flows;

- Absence of proper routine maintenance, which caused vehicles to have sudden break or parked on the outer travelled lane, which could lead to serious accidents has been observed;
- Absence of controlled pedestrian crossing facilities.

Improvement needs:

- Provide and properly constructed side walkway;
- Prohibiting of a vehicle to park on the road side;
- Zebra crossing should be marked with vertical signs and horizontal marking;
- Warning sign of pedestrian crossing should be placed at zebra crossing on both sides in order to minimize the accident collision with pedestrians;
- Conducting drunk and drive tests and to check the license and permit documents frequently. Due to these eligible drivers will drives the commercial vehicles.

4.5.4. Warka

Site description: Warka is located near (in front of Kidane mihret butchery). It is surrounded by commercials, shops, market areas, and high number of vehicles using the road (see the following figures).

Field investigations: -

- Absence of proper routine maintenance, which caused vehicles to have sudden break or parked on the outer travelled lane, which could lead to serious accidents has been observed;
- There is no guard fencing or safety barrier and road marking completely at the Ditch;
- There is invisible (faded) road lane marking and pedestrian crossing observed;
- Poor drainage systems and pond of water have been observed and these problems create high potential safety problems to vehicle drivers and vulnerable road users;
- There was no properly constructed side walkway.

Improvement needs:

- Warning sign of pedestrian crossing should be placed at zebra crossing on both sides in order to minimize the accident collision with pedestrians;
- Prohibiting the vehicles to park on the road side;
- Provide and properly constructed side walkway;
- Guard fencing or safety barrier and road marking completely at the Ditch.

4.6. Summary

The result obtained throughout the assessment of Adama city traffic police commission (ACTPC), Adama city transport authority office (ACTAO), East Shoa zone transport authority office (ESZTAO), Adama traffic complex (ATC), and field investigation data in the above chapter 3 and 4 indicated that road traffic accident is a serious problem in the city.

According to the traffic police report and all other responsible city administrations office data analyzed that 57 percent of all the total traffic accidents in Adama city were caused by driver's error. About 99.7% of the driver errors are caused by male drivers, and only female drivers caused by the remaining 0.3% of road traffic accidents during 2008-2012 in Adama City Administration. And also, passengers with an age of between 18 and 30 are the smallest sufferers of road traffic accidents from 2008 to 2012. This study showed that the majority of the death reports are on the male pedestrians is within the age group of 18-30 years. Similarly, high death reports of female pedestrians with an age group of 31-50. These confirmed that most of road traffic accidents were highly affecting the economically active citizens i.e., youths and young adult groups. Significantly, the analysis showed that almost all the RTAs occurred during the day light from 2008-2012.

The alternate hypothesis is that accidents occurred on weekdays have significant difference when compared with weekends. 83.7 percent of all from the total accidents occurred on weekdays with significant difference when compared with weekends. Most of vehicles are usually parked on pedestrian paths and pedestrians including animals walk in the center of roadways, also heavy trucks were used almost all routes without any restrictions or regulations. This, in turn, negatively affects the economy of the country and social structure of the population in the city.

Poor road maintenances and drainage system have also identified as a problem facing the infrastructure to smooth mobility and safety. Therefore, the analysis underlined that under reporting of road traffic accidents assumed to be really bad in the city.

Generally, road traffic accident safety in Adama city is not seen as the key priority by any specific organization; coordinated and integrated traffic accident management and enforcement is very poor.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

According to findings revealed about Road Traffic accidents in Adama city in general the following conclusions are drawn:

- The study implied the existence of large difference in road traffic victims among drivers, passengers, and pedestrians with respect to ages and sexes. As a result, male drivers, passengers, and pedestrians were the most affected as compared to females;
- The study also identifies collision types mostly occurred in the City, and hence collisions like rear end, head on, broad side, and collision with roadside parked vehicles are the most dominant type of collisions which frequently occurred in the city during in the 2008-2012;
- The analysis of accident by vehicle type indicates that most of the accidents were caused by Taxi, Mini bus up to 12 seats, Truck 11-40 quintal, Truck 40-100 quintals, and Bus 13-45 seats;
- Areas like Bollo food complex, Tikur Abay, Amede, Muger, Warka, and Hany experienced the highest accident rates (i.e., which were ranked from 1-7, respectively);
- Besides, highest accidents were recorded in straight and grade road character in the city while up hill road character practice the lowest accident frequency in the city;
- Moreover, most of traffic accidents occurred in the dry road surface conditions than wet road surface conditions;
- Finally, the study identifies the collisions types in the Selected Black Spot Areas. The types which include rear-end collisions, sideswipe collision, broadside collision, collision with pedestrians, head-on collision, rollover, collision with animals, fall from vehicles, collision with roadside parked vehicles, and collision with road side objects though their degree of occurrences varies;

- As a result, the trends in serious accidents, slight accident, and property damage dramatically increased in all the collision types except collision with animals, fall from vehicles, collision with roadside-parked vehicles, and collision with roadside objects.

5.2. Recommendations

Based on deep understanding of the main causes of traffic accidents, low-cost engineering measures were proposed. On the existing situation or identified causes, improvement was suggested. In general, the following recommendations can be taken into consideration as future work:

- The analysis of the study verifies that driver casualties are among the dominant causes of road traffic accidents. 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. Additionally, there should be additional prerequisite criteria for drivers with regard to their educational background, good behavior, free from any addiction like alcoholic drinks, chewing chat, free from criminal acts as well as offending and frequent violation of traffic regulations;
- Road safety education should be provided in the schools as a short-term solution. But in the long run, this should be included in the school curricula;
- Strict traffic police enforcement and speed control.

5.3. Future work

Here most of the data were taken from different responsible administrative offices and field observations, the analysis was made only for the accident reduction system.

If any additional it is necessary to work on it, as a future work area any one can do on the all-traffic accident at the sub-city level of roads, vehicle speed, and integrate all traffic controlling mechanisms with computerized systems which is controlled by an authorized administrative office.

It is difficult to do this thesis since no body has done it which makes it difficult for me but, now it is already proposed in this thesis so as this work is the first work many more things and modifications can be done while the references obtained are related issues.

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APPENDICES

Appendix A. Actual and compiled data from ACTAO

Table A.1. Adama accident fatalities

Year	Killed	Registered Vehicles	License holders	Fatalities per	
				100 Vehicles	100 Licenses
2008	48	1489	5961	3.2	0.8
2009	36	1559	9570	2.3	0.4
2010	25	1461	11821	1.7	0.2
2011	31	1376	14275	2.2	0.2
2012	38	1811	10851	1.8	0.35

Data Source: ACTAO, ESZTAO, and Oromia Transport Authority Drivers and Technicians Competency Assurance Center.

Table A.2. License holders in Adama up to 2012

YEAR	BEFORE 2008	2008	2009	2010	2011	2012	TOTAL
MALE	31512	5361	9359	11100	12088	9379	78799
FEMALE	964	600	211	721	2187	1472	6155
TOTAL	32476	5961	9570	11821	14275	10851	84954

Data Source: Adama City transport offices, East Shoa Zone Transport Office, and Oromia Transport Authority Drivers and Technicians Competency Assurance Center.

Table A.3. Vehicles register in Adama up to 2012

Year	Before 2008	2008	2009	2010	2011	2012
Vehicles On Register	8000	1389	1427	1381	1112	450

Data Source: ACTAO and ESZTAO

Table A.4. Traffic accident by road user type 2008-2009

No	Accident	Age	2008						2009					
			Deaths		Serious injury		light injury		Deaths		Serious injury		light injury	
			Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1	Drivers	<18 <18	1	0	1	0	0	0	2	0	1	1	0	0
		18-30	9	0	11	0	12	0	6	0	9	0	10	0
		31-50	11	0	13	0	21	0	9	0	8	0	17	0
		>50	6	0	8	0	4	0	5	0	4	0	3	0
Sub-Total			27	0	33	0	37	0	22	0	22	1	30	**0**

2	Passengers	<18	4	2	2	0	1	0	0	2	1	0	0	1
		18-30	4	1	2	1	2	1	3	2	2	1	2	0
		31-50	3	0	1	1	0	0	2	1	1	1	0	1
		>50	1	1	2	0	0	1	1	0	0	1	0	0
Sub-Total			12	4	7	2	3	2	6	5	4	3	2	**2**
3	Pedestrians	<18	1	0	2	1	1	1	1	0	2	1	1	0
		18-30	3	2	5	2	3	1	1	0	4	1	2	1
		31-50	1	1	5	4	5	3	0	1	3	2	3	2
		>50	0	1	4	6	2	1	1	0	2	3	1	1
Sub-Total			5	4	16	13	11	6	3	1	11	7	7	4
Total			44	8	56	15	51	8	31	6	37	11	39	6

Data Source: Adama City transport Authority offices and Adama City Police Commission.

Table A.5. Traffic accident by road user type 2010-2011

No	Accident	Age	2010						2011					
			Deaths		Serious injury		light injury		Deaths		Serious injury		light injury	
			Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1	Derivers	<18	0	0	0	1	0	0	1	0	2	0	1	0
		18-30	2	0	1	0	5	0	6	0	5	0	11	0
		31-50	6	0	3	0	9	0	7	0	4	0	12	0
		>50	2	0	6	0	1	0	4	0	7	0	6	0
Sub-Total			10	0	10	1	15	0	18	0	18	0	30	0
2	Pedestrians	<18	0	0	0	0	0	0	0	0	1	0	0	0
		18-30	1	0	2	0	0	0	0	0	2	1	1	0
		31-50	0	0	1	1	1	1	0	1	4	2	3	2
		>50	0	0	0	1	0	0	1	0	2	1	1	1
Sub-Total			1	0	3	2	1	1	1	1	9	4	5	3
3	Passengers	<18	1	0	0	0	0	0	1	1	1	0	0	1
		18-30	3	2	1	1	2	0	3	1	1	2	2	1
		31-50	2	3	0	1	0	1	2	1	1	1	0	0
		>50	1	0	1	0	0	0	0	1	0	0	0	0
Sub-Total			7	5	2	2	2	1	6	4	3	3	2	2
Total			18	5	15	5	18	2	25	5	30	7	37	5

Data Source: Adama City transport Authority offices and Adama City Police Commission.

Table A.6. Traffic accident by road user type in 2012

No	Accident	Age	2012					
			deaths		Serious injury		light injury	
			Male	Female	Male	Female	Male	Female
1	Derivers	<18	0	0	0	1	0	0
		18-30	4	0	7	0	12	0
		31-50	13	0	6	0	15	0
		>50	4	0	5	0	4	0
Sub-Total			*21*	*0*	*18*	*1*	*31*	*0*
2	Pedestrians	<18	0	0	2	0	1	0
		18-30	1	0	4	2	2	0
		31-50	1	0	3	2	3	1
		>50	0	0	2	2	1	0
Sub-Total			2	0	11	6	7	1
3	Passengers	<18	1	0	0	1	0	0
		18-30	3	4	2	1	1	1
		31-50	2	1	2	1	2	1
		>50	0	2	1	0	1	0
Sub-Total			6	7	5	3	4	2
Total			29	7	34	10	42	3

Data Source: Adama City transport offices and Adama City Police Commission.

Table A.7. Causes of road traffic accidents in Adama City as identified by police

Possible reasons	Total 2008-2012				Total	Percent
	Fatal	Serious	Slight	Property Damage		
drunk driving	16	9	24	36	85	6.85
drug driving	14	10	17	41	82	6.61
failure to give way for vehicle	7	11	11	52	81	6.53
failure to give way for pedestrian	11	14	9	27	61	4.92
followed too closely	0	0	0	7	7	0.56
driving above speed limit	25	21	28	48	122	9.83
improper turning	5	11	8	39	63	5.07
no respect traffic rule	2	7	5	27	41	3.30
failure to respect right of way	0	0	0	9	9	0.73
Improper starting from parked Position	3	6	2	33	44	3.55

Wrong/improper parking	0	2	1	38	41	3.30
Asleep or fatigued or sick	9	14	22	29	74	5.96
Improper use of head lights-causing glare	5	0	1	19	25	2.01
Excess loading	1	3	4	23	31	2.50
Defective brakes	12	15	3	30	60	4.83
Puncture tyres or burst tiers	0	1	0	25	26	2.09
Defective steering	0	0	2	43	45	3.63
Defective lighting systems	1	3	1	24	29	2.34
Defective road environment	48	33	27	31	139	11.20
Pedestrian error	15	23	13	21	72	5.80
Unidentified	4	37	33	30	104	8.38
Total	178	220	211	632	1241	100

Source: Adama City Police Commission Office

Table A.8. Total vehicles fleet by vehicle type in Adama City up to 2012

Vehicle type	Total	Total in %
	up to 2012	
Motor Bicycle	2800	36.4
Station wagon	391	5.1
Automobile	688	8.9
Pick-up <=10 quintal	99	1.3
Truck 11-40 quintal	54	0.7
Truck 40-100 quintal	77	1
Truck with Trailer	2	0.02
Liquid Cargo	5	0.06
Taxi	707	9.2
Minibus up to 12 seats	193	2.5
Bus 13-45 seats	84	1.1
Bus >46 seats	27	0.35
Earth moving	9	0.11
Earth moving with trailer	31	0.40
Cart	2500	32.5
Others	29	0.36
Total	7696	100.00

Source: Adama City Transport Authority Office

Appendix B. Actual and compiled data of ACTAO and ACPC

Table B.1. Accident by roadway surface condition

Roadway surface condition	Adama City					
	Year					2008-2012
	2008	2009	2010	2011	2012	
Dry	68	51	27	44	59	249
Wet	13	6	2	7	3	31
Slush	0	0	0	0	0	0
Unidentified	16	18	7	15	9	65
Total	97	75	36	66	71	345

Table B.2. Accident by type of vehicle defect

Types of vehicle defect	Adama					
	Year					
	2008	2009	2010	2011	2012	2008-2012
Defective brake	10	9	1	5	5	30
Defective steering	1	1	0	0	0	2
Light system	3	2	0	1	0	6
other serious mechanical defect	0	0	0	0	0	0
punctured or burst tires	1	0	0	0	0	1
Without any defect	55	44	27	36	39	201
Unknown	27	19	8	24	27	105
Total	97	75	36	66	71	345

Table B.3. Calculating of accident black spot identification areas in Adama city roads.

No.	Type	Sections	Road length (km)	Period (Year)	No of accident in Five years (2008-2012)	Accident Frequency
1	Segment	Post office Roundabout – Bollo F.C	4.508	5	559	24.80
	Spot	Post office	0	5	95	
	Spot	Muger	1.651	5	116	
	Spot	Tikur Abay	0.577	5	167	
	Sport	Bollo Food Complex	2.280	5	181	
2	Segment	Post office Roundabout – Aba Geda	2.647	5	310	23.42
	Spot	AYU Hotel	0,513	5	72	
	Spot	Warka	0.277	5	127	
	Spot	Kuriftu Hotel	0.813	5	31	
	Spot	A. G. Roundabout	1.044	5	80	
3	Segment	Post office Roundabout – G.T.B Roundabout	6.596	5	377	11.43
	Spot	East Shoa zone Administration	0.518	5	24	
	Spot	Hany cake	0.604	5	89	
	Spot	Amede	0.615	5	105	
	Spot	Amede Kella	1.210	5	132	
	Spot	G.T.B Roundabout	3.649	5	27	

Table B.4. Total number of crashes in 2008, 2009, 2010, 2011, and 2012

Crash Hour	Total Number of Crash	Selected black spot areas					Classification
		2008	2009	2010	2011	2012	
12:00-01:00	9	2	3	1	2	1	
01:00-02:00	16	6	4	1	1	4	Relatively intermediate
02:00-03:00	14	5	2	1	3	3	
03:00-04:00	7	3	1	0	2	1	
04:00-05:00	13	3	4	1	0	5	Relatively intermediate
05:00-06:00	16	4	3	0	4	5	
06:00-07:00	20	7	2	2	5	4	
07:00-08:00	35	6	7	5	8	9	Maximum crash hours/Peak hours
08:00-09:00	32	6	9	4	6	7	
09:00-10:00	25	8	6	2	4	5	
10:00-11:00	36	11	8	5	7	5	
11:00-12:00	54	17	11	7	11	8	
12:00-13:00	24	9	6	2	3	4	
13:00-14:00	16	3	4	2	4	3	Relatively intermediate
14:00-15:00	7	1	2	1	2	1	Minimum crashes/Plateau hours
15:00-16:00	8	3	1	1	0	3	
16:00-17:00	3	1	0	0	1	1	
17:00-18:00	3	1	1	0	1	0	
18:00-19:00	0	0	0	0	0	0	
19:00-20:00	0	0	0	0	0	0	
20:00-21:00	1	0	0	0	0	1	
21:00-22:00	0	0	0	0	0	0	
22:00-23:00	2	0	0	1	1	0	
23:00-24:00	4	1	1	0	1	1	
Total	345	97	75	36	66	71	

Table B.5. Accident by vehicle type

Vehicle Type (transport mode)	Year					Total
	2008	2009	2010	2011	2012	2008 to 2012
Bicycle	1	0	0	2	0	3
Motor Bicycle	2	2	3	4	2	13
Station wagon	8	3	1	0	4	16
Automobile	6	7	3	5	7	28
Pick-up <=10 quintal	5	2	1	2	1	11
Truck 11-40 quintal	7	5	5	9	7	33
Truck 40-100 quintal	8	8	3	6	7	32
Truck with Trailer	3	3	2	0	4	12
Liquid Cargo	3	1	0	0	2	6
Taxi	25	19	12	14	9	79
Minibus up to 12 seats	11	13	3	8	14	49
Bus 13-45 seats	9	6	1	7	7	30
Bus >46 seats	3	1	-	5	3	12
Earth moving	0	0	0	2	0	2
Earth moving with trailer	0	0	0	1	0	1
Cart	4	1	0	1	1	7
Others	1	1	0	0	1	3
Unknown	1	3	2	0	2	8
Total	97	75	36	66	71	345

Table B.6. Collisions types in the selected black spot areas

No	Collisions Type	2008-2012				Total
		Fatal	Serious injury	Light injury	Property damage	
1	Head on Collisions	36	27	29	58	150
2	Rear end Collisions	17	21	20	107	165
3	Broadside Collisions	22	30	25	97	174
4	Sideswipe Collisions	5	14	10	125	154
5	Rollover	38	13	0	40	91
6	Collisions with Pedestrians	7	18	23	0	48
7	Collisions with Animals	3	7	2	0	12
8	Fall from Vehicles	0	1	1	0	2
9	Collisions with Roadside parked Vehicles	18	23	21	31	93
10	Collisions with Roadside objects	6	21	18	81	126
11	Collisions with Trains	0	0	0	0	0
12	Others	16	25	39	69	149
13	Unknown	10	20	23	24	77
	Total	178	220	211	632	1241

Table B.7. Accident by light condition

Light condition	Adama City					
	Year					
	2008	2009	2010	2011	2012	2008-2012
Day light	76	57	28	51	56	268
Dawn	3	4	2	4	3	16
Dust	13	12	5	9	8	47
Dark road-lighted	2	0	0	0	1	3
Dark road weak lighted	1	0	0	1	0	2
Dark road unlighted	0	0	0	0	0	0
Unidentified	2	2	1	1	3	9
Total	97	75	36	66	71	345

Data Source: Adama City transport offices and Adama City Police Commission Office.

Table B.8. Accident by road character

Road character	Number of road accidents in year					Total
	2008	2009	2010	2011	2012	2008 to 2012
Straight and level	23	23	9	18	16	89
Straight and grade	25	21	7	21	23	97
Up hill	9	4	7	7	9	36
Down hill	27	19	10	15	18	89
Unidentified (others)	13	8	3	5	5	34
Total	97	75	36	66	71	345

Table B.9. Accident by road junction type

Road junction type	Adama City					
	Year					
	2008	2009	2010	2011	2012	2008-2012
Midblock	21	14	12	8	12	67
Y-junction	27	27	16	27	19	116
T-junction	52	30	27	28	19	156
Roundabout	55	44	28	29	23	179
Four-leg junction	57	70	15	53	52	247
Unspecification	111	105	65	95	80	456
Total	323	290	163	240	205	1221

Table B.10. Accident by road lane type

Road lane type	Adama City					
	Year					
	2008	2009	2010	2011	2012	2008-2012
Undivided two way	63	67	45	61	50	286
Double carriage(with median)	181	171	98	140	128	718
Two way (divided with broken lines road marking)	45	27	22	22	16	132
Half roundabout with single carriage	34	25	18	18	12	107
Total	323	290	183	241	206	1241

Source: Adama City Police Commission Office.

Table B.11. Accident by land use

Land Use	Adama city					
	Year					
	2008	2009	2010	2011	2012	2008 - 2012
Rural Village Area	0	0	0	0	0	0
Agricultural Area	0	0	0	0	0	0
School Area	11	9	2	7	6	35
Industrial Area	4	3	2	5	6	20
Church area	5	2	1	3	3	14
Market area	20	15	12	15	16	78
Recreation area	5	5	1	3	3	17
Hospital area	14	11	5	8	8	46
CBD	24	21	10	16	18	89
Urban residential	11	8	3	7	7	36
Other	3	1	0	2	4	10
Total	97	75	36	66	71	345

Table B.12. Accident by collisions type

Collision type	Adama City					
	Year					
	2008	2009	2010	2011	2012	2008-2012
Head on collisions	17	10	4	8	8	47
Rear end collisions	15	11	4	12	12	54
Broadside collisions	10	8	6	9	12	45
Sideswipe collisions	10	9	4	7	8	38
Rollover	5	2	2	5	4	18
Collisions with pedestrians	8	5	2	5	4	24
Collisions with animals	4	3	2	1	2	12
Fall from vehicles	1	0	0	1	0	2
Collisions with roadside parked vehicles	9	11	4	7	8	39
Collisions with roadside objects	6	8	3	5	6	28
Others	7	4	3	4	3	21
Unknown	5	4	2	2	4	17
Total	97	75	36	66	71	345

Data Source: Adama City transport Authority offices and Adama City Police Commission Office.

Table B.13. Accident by vehicle type

Vehicle Type (by transport mode)	Year					Total
	2008	2009	2010	2011	2012	2008 - 2012
Bicycle	1	0	0	2	0	3
Motor Bicycle	2	2	3	4	2	13
Station wagon	8	3	1	0	4	16
Automobile	6	7	3	5	7	28
Pick-up <=10 quintal	5	2	1	2	1	11
Truck 11-40 quintal	7	5	5	9	7	33
Truck 40-100 quintal	8	8	3	6	7	32
Truck with Trailer	3	3	2	0	4	12
Liquid Cargo	3	1	0	0	2	6
Taxi	25	19	12	14	9	79
Minibus up to 12 seats	11	13	3	8	14	49
Bus 13-45 seats	9	6	1	7	7	30
Bus >46 seats	3	1	0	5	3	12
Earth moving	0	0	0	2	0	2
Earth moving with trailer	0	0	0	1	0	1
Cart	4	1	0	1	1	7
Others	1	1	0	0	1	3
Unknown	1	3	2	0	2	8
Total	97	75	36	66	71	345

Data Source: Adama City Police Commission

Table B.14. Calculation for Chi-Square

Hours	Observed frequency	Expected frequency	D.F	Critical X^2	$\sum \frac{(O-E)2}{E}$
12:00AM-6:00AM	114	86.3	3	7.815	142.13
6:00AM-12:00PM	161	86.25			
12:00PM-6:00PM	53	86.25			
6:00PM-12:00AM	17	86.25			
Total	345	S.f		.05	.000

Table B.36. Above shows calculated χ 2 - value of 142.13 for 3 D.f. and a critical χ 2 - value of 7.815 at 0.05 alpha level. Since the calculated χ 2 - value is greater than the critical χ 2 - value, the null hypothesis i.e. accidents are uniformly distributed over the hours of the day is rejected. Thus, it indicates that accidents are not uniformly distributed over the hours of the day.

Table B.15. Post office roundabout accident by, year, day of the week, crash hour, and collisions type

Post Office roundabout						
Day of the weak	Number of accident 2008-2012 by day of the week					
	2008	2009	2010	2011	2012	Total
Monday	6	5	2	3	3	19
Tuesday	7	6	3	3	3	22
Wednesday	6	5	2	2	3	18
Thursday	4	3	2	2	2	13
Friday	3	3	1	1	2	10
Saturday	2	2	1	1	1	7
Sunday	2	1	1	1	1	6
Total	30	25	12	13	15	95

Table B.16. RTA's by spatial distribution with accident spot

No	Location/Area	2008				2009				2010				2011				2012				Total Casualty	Total Accident	
		F	S.I	SL.I	P.D	F	S.I	SL.I	P.D	F	S.I	SL.E	P.D	F	S.I	SL.I	P.D	F	S.I	SL.I	P.D		No	%
1	Post Office Roundabout	6	8	5	11	3	5	5	12	2	2	1	7	4	3	3	3	3	5	6	1	61	95	7.655
2	Muger	3	5	2	17	4	4	5	14	1	2	0	13	2	2	4	19	4	4	4	7	46	116	9.3
3	Tikur Abay	7	6	4	19	4	5	7	23	1	4	0	14	3	4	4	27	4	5	6	20	64	167	13.456
4	Bollo Food Complex	4	9	7	19	7	4	4	26	5	3	3	16	4	6	3	26	3	9	5	18	76	181	14.585

5	Ayu Hotel	6	9	6	6	2	5	1	6	1	0	1	7	3	2	2	4	5	3	3	0	49	72	5.8011
6	Warka	3	7	5	14	6	5	5	13	4	2	2	10	5	4	2	16	3	6	4	11	63	127	10.2336
7	Kuriftu Hotel	0	2	3	4	0	1	1	6	0	0	2	3	1	1	3	0	1	1	2	0	18	31	2.49779
8	Aba Geda Roundabout	7	7	3	5	5	4	4	8	5	1	6	3	3	2	3	6	1	4	2	1	57	80	6.4466
9	East Shoa Zone Office	0	1	4	2	0	1	2	0	0	0	1	4	0	1	3	2	0	1	2	0	16	24	1.93399

10	Hany Cake	3	2	4	10	3	3	5	15	1	2	1	11	1	2	4	5	2	3	3	9	39	89	7.1716
11	Amede	4	3	3	14	2	5	2	17	1	2	2	13	3	4	5	10	5	3	3	4	47	105	8.46009
12	Kella	9	7	8	21	1	4	2	20	2	2	1	17	1	5	4	12	1	3	4	8	54	132	10.636
13	G.I.B. Mini Roundabout	0	5	5	2	0	2	2	0	0	0	0	3	0	1	2	1	0	1	1	2	19	27	2.17
Total		52	71	59	144	37	48	45	155	23	20	20	121	30	37	42	131	36	44	45	81	609	1241	100

Table B.17. Accident spot areas in Adama city major roads

No	Location/Area	2008				2009				2010				2011				2012				Casualty	Total Accident	
		F	S.I	SL.I	P.D	F	S.I	SL.I	P.D	F	S.I	SL.I	P.D	F	S.I	SL.I	P.D	F	S.I	SL.I	P.D	No	No	%
1	Post Office Roundabout	6	8	5	11	3	5	5	12	2	2	1	7	4	3	3	3	3	5	6	1	61	95	7.6
2	Mugger	3	5	2	17	4	4	5	14	1	2	0	13	2	2	4	19	4	4	4	7	46	116	9.3
3	Tikur Abay	7	6	4	19	4	5	7	23	1	4	0	13	3	4	4	27	4	5	6	20	64	166	13.4
4	Bollo Food Co	4	9	7	19	7	4	4	26	5	3	3	16	4	6	3	26	3	9	5	18	76	181	14.5

	mplex																							
5	Ayu Hotel	6	9	6	6	2	5	1	6	1	0	1	7	3	2	2	4	5	3	3	0	49	72	5.8
6	Warka	3	7	5	14	6	5	5	13	4	2	2	10	5	4	2	16	3	6	4	11	63	127	10.2
7	Kurftu Hotel	0	2	3	4	0	1	1	6	0	0	2	3	1	1	3	0	1	1	2	0	18	31	2.4
8	A. G. Roundabout	7	7	3	5	5	4	4	8	5	1	6	3	3	2	3	6	1	4	2	1	57	80	6.4
	East Shoa Zone Office	0	1	4	2	0	1	2	0	0	0	1	4	0	1	3	2	0	1	2	0	16	24	1.9

10	Hany Cake	3	2	4	10	3	3	5	15	1	2	1	11	1	2	4	5	2	3	3	9	39	89	7.2
11	Amede	4	3	3	14	2	5	2	17	1	2	2	13	3	4	5	10	5	3	3	4	47	105	8.4
12	Amede Kella	9	7	8	21	1	4	2	20	2	2	1	17	1	5	4	12	1	3	4	8	54	132	10.6
13	G. T. B. Roundabout	0	5	5	2	0	2	2	0	0	0	0	3	0	1	2	1	0	1	1	2	19	27	2.2

Appendix C. Photos of some black spot area of the city

Figure C.1**.** Photo no zebra crossing (Lack of pedestrian crossing) at P.O


DAANDII KARRAYYUU
SPARK
LIGHT UP


SPARK
LIGHT UP


DAANDII KARRAYYUU
SPARK
LIGHT UP

Figure C.2**.** Photo no zebra crossing (Lack of pedestrian crossing) at Tikur Abay.


MITSUBISHI
SPARKz
LIGHT UP


TOYOTA
SPARKz
LIGHT UP

Figure C.3**.** Photo no zebra crossing (Lack of pedestrian crossing), walkway etc at B.F.C.

Figure C.4**.** Photo no zebra crossing, no properly constructed side walkway, no guard fencing or safety barrier on the ditch at Warka.

Figure C.5**.** Photo zebra crossing not visible, no pedestrian crossing traffic light, no properly constructed side walkway at Mebrat Hail.

Figure C.6**.** Photo no zebra crossing, no pedestrian crossing, no properly constructed side walkway at 04 Condominium.