ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

Analysis of Impacts of Speed and Traffic Volume at Black spot areas: Case of Addis Ababa city

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirement for the Degree of Masters of Science in Civil Engineering

(Road & Transport Planning Engineering)

BY

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May *2016*

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Declaration

The researcher declare that the project entitled "Analysis of Impacts of Speed and Traffic Volume at Black Spot Areas: Case of Addis Ababa City" has not been presented in A.A.I.T and /or any other university and that all sources of materials used for the project have been dully acknowledged.

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Acknowledgements

First, Glory to the ALMIGHTY GOD, I would like to express my deepest gratitude to you.

Next, I would like to express my sincere gratitude to my advisor Dr. Bikila Teklu (Assistant Professor) for the continuous support of my thesis, for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my thesis.

Besides my advisor, I would like to thank my co-advisor Mr. Raeed Ali (Lecturer) for his insightful comments and encouragement, but also for the hard question which incented me to widen my research from various perspectives.

My special thanks go to my mother Ayelech Moltotal, she sacrifice all her life for me "long live mama" and to my friend's thanks too much for your support and encouragement throughout the study.

I would like to thank my wife Hiwot Hailu and my lovely child Biruktayit Meron. Their support, encouragement, quiet patience and unwavering love were undeniably the bedrock upon which the past years of my life have been built.

Finally, my warmest gratitude goes to Addis Ababa City Traffic Police Commission all staffs, Addis Ababa City Roads Authority and that I didn't mention all staff of Investigation sector. In spite of your work burden, your door have been always open for me, be it for material resources or for in depth communication.

Abstract

Road traffic accidents (RTAs) are a major public health concern, resulting in an estimated 1.2 Million deaths and 50 million injuries worldwide in each year (Tibebe B. and Shawndra H., 2005). In the developing world, Road traffic accidents (RTAs) are among the leading cause of death and injury; Ethiopia in particular experiences the highest rate of such accidents.

The main aim of the study was to analyze the Impacts of Speed and Traffic volume at Black spot areas in Addis Abeba city. To identify the black spot areas carried out field data observation and identifying major urban road traffic accident black-spots which was a sub city based analysis of evidences from the city of Addis Ababa, Ethiopia and identified the major accident black spots in each sub-city of Addis Ababa separately. For this purpose, secondary data also obtained from Addis Ababa City Traffic police commission employed.

Finally, this research presents Traffic Volume, Speed study results, capacity and level of service of the selected black spot areas. Accordingly, KaraKore – W/Mariam and Torhailoch – Bethel have a level of service of B while Total – Zenebework have LOS of A. However, the segments are currently satisfactorily serving. Synthesis of strategies designed to improve urban transportation Safety and efficiency by targeting speeding and traffic volumes as improving pedestrian facilities in urban areas such as those found in Addis Ababa city.

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(Source: HCM D 2000 manual)

Acronyms

RATs = Road Traffic Accidents

WHO = World Health Organization

ABS = Accident Black – Spot

ECE = Economic Commission for Europe

MUTCD = Manual on Uniform Traffic Control Devices

ITE = Institute of Transportation Engineers

AATPC = Addis Ababa Traffic Police Commission

AASTHO =American Association of State Highway and Transportation Officials

LOS = Level of Service

ERA = Ethiopian Roads Authority

DSMD = Dynamic Speed monitoring Display Signs

DSDs = Dynamic Speed Display Signs

AACRA = Addis Ababa City Roads Authority

RTABs = Road Traffic Accident Black – Spots

APW =Accident Point Weightage

AADT = Annual Average Daily Traffic

DMS = Dynamic Message Signs

1. Introduction

Addis Ababa, with an area of 540 km^2 is divided into 10 sub-cities as shown in figure 1.1 and 116 woreda's. The city is the country's political and economic center, the seat of Head Offices of African Union and United Nations Economic commission for Africa. It also accommodates many international Aid and Development organization and more than 100 embassies. The total population of Addis Ababa was estimated to 3,048,631 of whom 1,595,968 were females and the rest 1,452,663 were males. This is 3.71 percent of Ethiopian population of 84.3 million and 22.42 percent of urban population (14 million) (City Government of Addis Ababa, Bureau of finance and Economic development, May2013). Addis Ababa is exhibiting high social, economic, structural and change is found to be a fast growing city. More than 70% of registered vehicles in the country are found in Addis Ababa (The Federal Democratic Republic of Ethiopia, Transport Policy of Addis Ababa, 2011). Taking into account Addis Ababa's fast growth and to enable the transport sector to play its required role, the Government has invested a huge resource to construct roads so as to expand the road network. An effort has been made to improve the transport service provisions.

Figure 1-1: ***Map of Addis Ababa city Administration (Source: Addis Ababa City Government, 2010)***

Road accident is in a state of rise and recognized as a major socioeconomic concern facing Ethiopia as the country is known as having one of the highest accident record in the world-about 136 fatalities per 10,000 motor vehicles in 2003 (National Road Safety Coordination Office). Every month, around 400 people are killed or hospitalized by road accidents. An estimate by a Study (TRL & Ross Silcock, 2001) reveals that, in addition to the above fatality rate, road accidents cost the Ethiopian economy between 350-430 million birr per year.

Traffic calming strategies can increase safety through a combination of physical, behavioral and psychological strategies. Traffic calming seeks to maintain flow and circulation through a network while guiding traffic through optimal routes at safe speeds for all users of the network. Through the implementation of mainly physical measures, traffic calming can improve safety in the urban environment by decreasing travel speeds, cut-through traffic and making facilities safer and more accessible to pedestrians. The definition of traffic calming can be limiting and a broader umbrella of strategies should be examined which aim to achieve common goals and objectives. Regardless of the category that a strategy may fall into, objectively examining a spectrum of measures to achieve community goals is an essential and critical component of the research process. Related strategies may target roadway infrastructure, such as signage or pavement markings, to improve clarity and reduce driver confusion or address behavior modification through community action programs.

There is a wide range of improvements that can be made through the implementation of traffic calming or related strategies to improve traffic safety in a community when properly selected and implemented. An incorrect placement of a selected strategy may have a negative effect on safety or result in more dangerous conditions for one or more users of the roadway. Care must be exercised when selecting, implementing and maintaining a chosen urban environment network optimization strategy. Implementation may need to supplement with other engineering strategies, enforcement, encouragement, or education.

1.1 STATEMENT OF THE PROBLEM

According to WHO (2010), road traffic injuries have become the leading cause of death for people aged 15–29 years. Over 90% of road traffic deaths and injuries occur in low-income and middle-income countries, which have only 48% of the world's registered vehicles. Nearly half (46%) of those dying on the world's roads are "vulnerable road users": pedestrians, cyclists and motorcyclists. In addition to the grief and suffering they cause, road traffic crashes result in considerable economic losses to victims, their families, and nations as a whole, costing most countries 1–3% of their gross national product; without action, road traffic crashes are predicted to result in the deaths of around 1.9 million people annually by 2020.

In similar fashion UNDP (1994), traffic accidents present great risks on personal security. In industrial countries, traffic accidents are the leading cause of death for people aged 15-30. And in developing countries, traffic accidents account for at least 50% of total accidental deaths. For example, the highway death toll in South Africa in 1993 was 10,000, which was three times the number of deaths from political violence. WHO (2004) argues that, road traffic injuries are a major but neglected public health challenge that requires concerted efforts for effective and sustainable prevention. Of all the systems with which people have to deal every day, road traffic systems are the most complex and the most dangerous.

In Ethiopia, the rate of road traffic accidents (RTAs) is very high; because of road transport is the major transportation mechanism along with poor road infrastructure, poor enforcement of traffic laws and other factors. The Ethiopian traffic control system archives data on various aspects of the traffic system, such as traffic volume, concentration, and vehicle accidents; with more vehicles and traffic, the capital, Addis Ababa, takes the lion's share of the risk, with an average of more than 20 accidents being recorded every day and even more going unreported (WHO, 2009). The costs of fatalities and injuries due to RTAs have a tremendous impact on societal well-being and socio-economic development endeavors. However, public policy responses to this epidemic have been muted at national and international levels (Nantulya and Reich, 2002). Hence, the issue of RTAs in Addis Ababa is worthy of investigation. The causes, effects and measures in reducing or preventing vehicle crashes in Addis Ababa context need to be analyzed to point out what should be done in a manner that contributes to the reduction of RTAs.

1.2 OBJECTIVES OF THE THESIS

The main objective of this research is to analyze the Cause of Road Accidents at Black-Spot Areas.

The specific objective of the study is:-

- ✓ To Analyze Road Traffic Black-Spots and their distribution by sub city
- ✓ To Analyze Spot Speed at selected Black – Spot areas
- ✓ To Analyze Traffic Volume at Selected Black – Spot areas
- ✓ Determine LOS and capacity of the selected black spot areas

1.3 SCOPE OF THE THESIS

The thesis mainly consists of five sections:-

Chapter 1:

- Introduction
- Statement of the problem
- Objective of the thesis
- Scope of the thesis

Chapter 2: Literature Review:-

- The Need for Safety Improvements
- Road Traffic accidents (RTAs) Defined
- Causes of Road traffic accidents On Black – Spot
- Speed Studies
- Traffic Volume Studies
- Black Spot

Chapter 3: Research Methodologies:-

- Description of Study Area
- Data Collection Methods
- Primary data collection method
    - Interview
    - Field observation
- Secondary data collection method

Chapter 4: Data Presentation, Analysis and Interpretation

- Road Traffic accidents black – Spots and their distribution by sub-city
- Spot speed data for Selected Black-spot areas
- Traffic Volume in selected Black-spot areas
- Analysis of Capacity and level of service

Chapter 5: Conclusions and Recommendations for future work.

2. Literature Review

2.1 The Need for Safety Improvements

Increasing trends in population, vehicle miles traveled and vehicle ownership are leading to more congestion and concerns about traffic safety. Driver demand is increasing, challenging networks which may be constrained by limited space, funding, and recent global warming awareness issues. An inefficient transportation network can be financially costly and emotionally taxing on its users. As congestion on major roads increases, drivers shift to alternate routes, often cutting through residential neighborhoods. Local roads are experiencing increases in volume, at higher speeds, which is causing many safety related concerns. Furthermore, motor vehicle crashes are the leading cause of death in children from the age of 18 to 30. Increased volume on local roads can present a community with many potential conflict areas and can be very unsafe (Stacy A. Metzger, 2008).

Urban environments contain many challenges for the local practitioner due to the abundance of multimodal traffic contained within a (generally) small region. This combination coupled with high volume and steady demand poses unique challenges to improving safety and efficiency; where a tradeoff is usually exhibited. Furthermore, many urban environments continually experience increasing population trends along with an increase in vehicle ownership.

2.2 Road Traffic Accidents (RTAs) Defined

A Road Traffic Accident (RTA) is when a road vehicle collides with another vehicle, pedestrian, animal or geographical or architectural obstacle. The RTAs can result in injury, property damage and death. RTA results in the deaths of 1.2 million people worldwide each year and injures about 4 times this number (WHO, 2004). In this study, a road traffic accident is defined as accident which took place on the road between two or more objects, one of which must be any kind of a moving vehicle (Jha et al., 2004).

IRTAD (1992) stated that, according to the Vienna Convention, the standard international definition of an injury road crash involves a collision of a moving vehicle on a public road in which a road user (human or animal), is injured. Besides, the widely accepted definition of RTAs is given by the Economic Commission for Europe (ECE); i.e., "Road Traffic Accidents (RTAs) are those accidents that occur on a way or street open to public traffic; resulted in one or more persons being killed or injured, and at least one moving vehicle was involved." Thus, RTA is collisions between vehicles;

between vehicles and pedestrians; between vehicles and animals; or between vehicles and fixed obstacles.

2.3 Causes of Road traffic accidents

A number of factors contribute to the risk of collision including; speed of operation, Traffic Volume, drink driving, motorcycle helmets, Seat-belts and child restraints, Distracted driving, road design, road environment, driver skill and/or impairment and driver behavior. (Wikipedia the free encyclopedia). (WHO, 2012).

2.3.1 Speeding

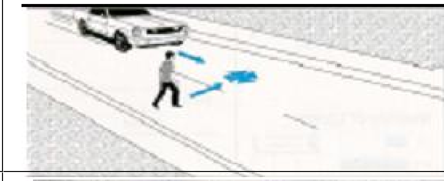
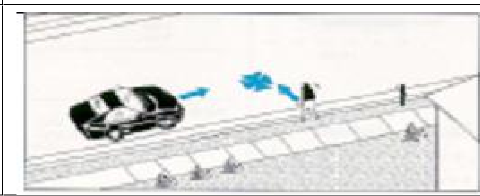
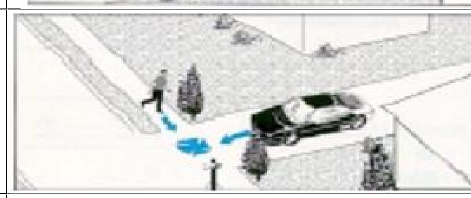
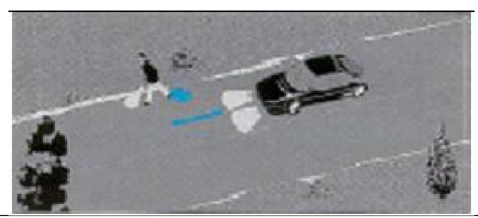
Driving in excess of the posted speed limit technically defines speeding. Speeding in urban environments can cause many safety challenges due to the abundance of activity in these settings. The effect of speeding is an increase in the distance needed to react to a stimulus and stop a vehicle, as well as a reduction of a driver's ability to steer safely around obstacles in the roadway. High speeds are not appropriate for such an area which may be inhabited by school zones, frequent bus stops, high pedestrian activity and the presence of commuting or recreational bicyclists. It is therefore critical that the appropriate design speed be selected for roadways in the urban environment. Residential streets in particular should not have high design speeds, but this may also apply to urban arterials depending on surrounding land use and pedestrian activity. Some contributors to speeding may include incorrect design speed, perceived environmental conditions and driver behavior.

The speed limit designation process must be performed in accordance with the Manual on Uniform Traffic Control Devices (MUTCD) and any state regulations. The design speed is based on the 85th percentile speed obtained from an engineering study and in most cases, is within 5 mph (10km/hr) of the 85th percentile speed of the roadway. Other roadway factors, such as geometry, leave room for engineering judgment to be exercised . An engineering study should be performed at any location to determine the best appropriate speed for a section of roadway. Since it is common for an arterial roadway in Addis Ababa to pass through a town, often through the town center, it is important to also pay particular attention to gradually decreasing and increasing speed limits. A higher design speed on a minor arterial roadway will feed into a smaller design speed for a local road, and this difference in speeds must be appropriately addressed. According to the Institute of Transportation Engineers (ITE) a "well-designed highway should produce natural driving behavior that results in modest speed changes between highway segments". Adequate space must be left between the lowering of posted speed as a vehicle approaches an urban environment and the physical act of the vehicle entering into that environment to allow the driver to react to the presented stimulus and slow the vehicle down. A lower speed limit, when placed too close to town center, may result in speeding because the driver does not have adequate time or distance to decrease their speed. Speeding occurring on roadways with accurate design speeds may also be a result of driver behavior. Assuming the posted speed is suitable for that roadway, one must look at other factors influencing driver behavior and choice. There may be many causes of speeding behavior but alterations in enforcement, education, environment and surrounding landscape may all influence driver behavior. Driver perception of road elements such as lane width, shoulder width, lateral clearance and clear zone may alter driver behaviors. Typically, the wider the road element, the less perceived danger to the driver and therefore, increased speeds. A road with a proper balance of roadway and roadside elements can help decrease operating speeds.

2.3.2 Vulnerable Road Users

pedestrians and two-wheel vehicle riders (both bicycles and motorcycles), constitute over half of all road fatalities in five of the eight African countries. While motorcyclists accounted for very few road fatalities, cyclist fatalities were significant in Uganda (almost one of every five fatalities), Tanzania and Kenya. In the USA, France and Germany for example, vulnerable road users constitute about 13 per cent of all casualties. Table 2.1 provides an overview of the most common pedestrian - vehicle conflicts, with the majority of incidents occurring at non-intersections. An understanding of the conflicts most often experience between pedestrians and vehicles can lead to a better understanding of the needs of a community during the planning process.

Table 2.1: Eight Most Common vulnerable Pedestrians to Vehicle Crash Types

Crash Type	Description	Picture
Midblock- Other	The crash occurred at midblock, but does not conform to any of the specified crash types	
Vehicle Turn/Merge	The pedestrian and vehicle collided while the vehicle was preparing to turn, in the process of turning, or had just completed a turn (or merge).	
Midblock Crash	At midblock location, the pedestrian was struck while running and the motorist's view of the pedestrian was not obstructed.	
Not In Roadway	The pedestrian was struck when not in the roadway. Areas included parking lots, driveways, private roads, sidewalks, services stations, yards, etc.	
Walking Along Road	The pedestrian was struck while walking (or running) along a road without sidewalks.	
Intersection Dash	The pedestrian was struck while running through an intersection and/or the motorist's view of the pedestrian was blocked until an instant before impact.	
Intersection-Other	The crash occurred at an intersection but does not conform to any of the specified crash types.	
Backing Vehicle	The pedestrian was stuck by a vehicle that was backing.	

2.3.3 Traffic Volumes

Traffic Volume study is the procedure to determine mainly the volume of traffic moving on the roads at a particular section during a particular time.

Traffic diverting to residential roadways from arterials pose many safety Threats to occupants of residential neighborhoods. This traffic seeks to take a "short-cut" through a residential neighborhood to decrease travel time and delay that would otherwise be experienced on the larger arterial roadway. Poor level of service (LOS) occurring on the arterial roadways forces impatient drivers to re-route, often traveling on roads that are not designed for higher speeds or increased capacity. Residential neighborhoods, lined with pedestrian activity (many including children), become very unsafe when higher volumes of traffic utilize the roadway. Furthermore, the traffic traveling on those roadways in an attempt to "cut-through" may represent a more aggressive niche of drivers, some of which who may be still operating at the higher speeds exhibited on arterial roadways. The combination of speeding and the presence of pedestrians that may occur as a result of cut-through traffic are especially troubling since a speeding car is less likely see and react to a pedestrian with enough time to avoid the interaction. An efficient transportation network can decrease this potential conflict by making the freely flowing arterial roadways more attractive than using residential roadways or physical measures are installed on the roadway to alter driver behavior.

2.3.4 Drink –driving

Drinking and driving increases both the risk of a crash and the likelihood that death or serious injury will result. (Ibid, 2012).

- The risk of being involved in a crash increases significantly above a blood alcohol concentration.
- Laws that establish blood alcohol concentration or below are effective at reducing the number of alcohol-related crashes.
- Enforcing sobriety checkpoints and random breath testing can lead to reductions in alcohol-related crashes of about 20% and have shown to be very cost-effective.

2.3.5 Distracted driving

There are many types of distractions that can lead to impaired driving, but recently there has been a marked increase around the world in the use of mobile phones by drivers that is becoming a growing concern for road safety. The distraction caused by mobile phones can impair driving performance in a number of ways, e.g. longer reaction times (notably braking reaction time, but also reaction to traffic signals), impaired ability to keep in the correct lane, and shorter following distances.

- Text messaging also results in considerably reduced driving performance, with young drivers at particular risk of the effects of distraction resulting from this use.
- Drivers using a mobile phone are approximately four times more likely to be involved in a crash than when a driver does not use a phone. Hands-free phones are not much safer than hand-held phone sets. (Ibid,2012).

2.3.6 Road design

A 1985 US study showed that about 34% of serious crashes had contributing factors related to the roadway or its environment. Most of these crashes also involved a human factor. The road or environmental factor either was noted as making a significant contribution to the circumstances of the crash, or did not allow room to recover. In these circumstances, it is frequently the driver who is blamed rather than the road; those reporting the accident have a tendency to overlook the human factors involved, such as the subtleties of design and maintenance that a driver could fail to observe or inadequately compensate for. (Ibid,2012).

Research has shown that careful design and maintenance, with well-designed intersections, road surfaces, visibility and traffic control devices, can result in significant improvements in accident rates. Individual roads also have widely differing performance in the event of an impact. In Europe there are now EuroRAP tests that indicate how "self-explaining" and forgiving a particular road and its roadside would be in the event of a major incident. (Ibid,2012).

2.4 Speed Studies

2.4.1 Spot Speed

Spot speed studies are used to determine the speed distribution of a traffic stream at a specific location. The data gathered in spot speed studies are used to determine vehicle speed percentiles, which are useful in making many speed-related decisions.

2.4.2 Speed Percentiles and how to use them

Speed percentiles are tools used to determine effective and adequate speed limits. The two speed percentiles most important to understand are the 50th and the 85th percentiles. The 50th percentile is the median speed of the observed data set. This percentile represents the speed at which half of the observed vehicles are below and half of the observed vehicles are above. The 50th percentile of speed represents the average speed of the traffic stream. The 85th percentile is the speed at which 85% of the observed vehicles are traveling at or below. This percentile is used in evaluating/recommending posted speed limits based on the assumption that 85% of the drivers are traveling at a speed they perceive to be safe (Homburger et al. 1996). In other words, the 85th percentile of speed is normally assumed to be the highest safe speed for a roadway section. Weather conditions may affect speed percentiles. For example, observed speeds may be slower in rainy or snowy conditions.

2.4.3 The relationship between speed and crash severity

The relation between speed and safety rests on two pillars. The first pillar is the relation between Collision speed and the severity of a crash; the second pillar is the relation between speed and the risk of a crash. The higher the collision speed the more serious the consequences in terms of injury and material damage. This is a law of physics that involves the quantity of kinetic energy that is converted in an instant into e.g. heat and matter distortion. In addition, the human body is physically very vulnerable in comparison with the enormous forces released in a collision. During the past decades, vehicles have become ever better equipped (with crush areas, airbags and seatbelts) to absorb the energy released in a crash, thus protecting the occupants. However, the collision speed still is very important for the crash outcome.

The incompatibility in collisions between vulnerable road users and practically any type of motor

Vehicle is of a completely different order. There are mass differences from a factor of 10 (light cars) to nearly 700 (Lorries of 50 tons). In addition, pedestrians, cyclists, (light-) moped riders and motorcyclists do not have an 'iron cage' around them that can absorb some of the energy released in a collision. For example, in a collision between a car and a cyclist or pedestrian, the survival rate of the latter two decreases enormously as the car's collision speed increases. According to an overview of recent studies (Rósen et al., 2011): at a collision speed of 20 km/h nearly all pedestrians survive a crash with a passenger car; about 90% survive at a collision speed of 40 km/h, at a collision speed of 80 km/h the number of survivors is less than 50%, and at a collision speed of 100 km/h only 10% of the pedestrians survive. (SWOV, Leidschendam, the Netherlands April 2012).

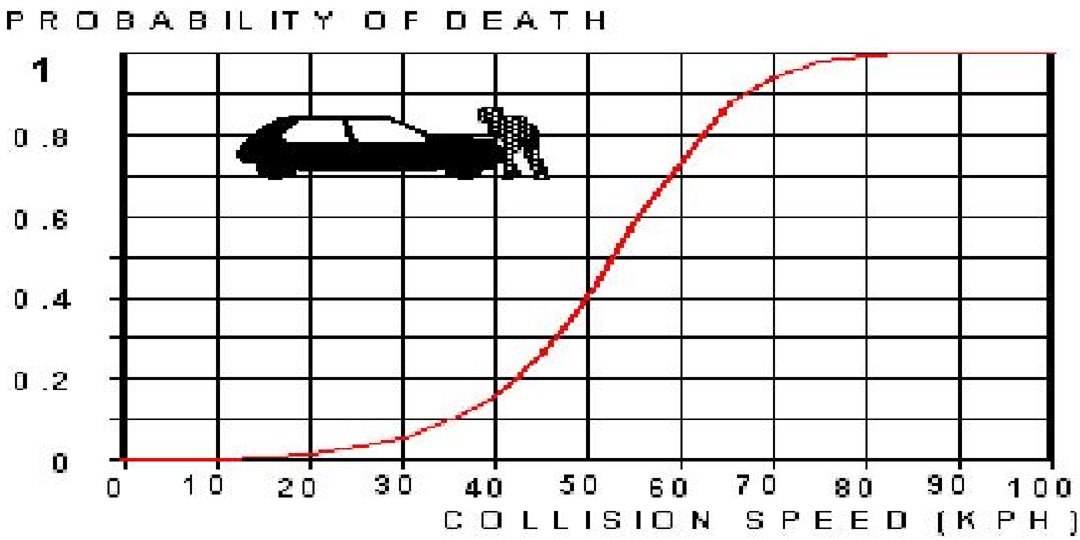


Figure 2.1 *The fatality rate of pedestrians in crashes with passenger cars as function of the collision speed (Source: Rosén et al., 2011).*

Table 2.2*: Accident severity level in AA city (Source: - Addis Ababa Traffic Police Commission, 2015)*

Year of Accident [E.C]	Death	High Severity	Low Severity	Property Damage	Total
1998	*363*	*833*	*1261*	*8557*	*11014*
1999	*347*	*640*	*850*	*7112*	*8949*
2000	*381*	*594*	*735*	*6459*	*8169*
2001	*371*	*731*	*576*	*5846*	*7524*
2002	*318*	*626*	*652*	*4689*	*6285*
2003	*332*	*904*	*831*	*7067*	*9134*
2004	*369*	*1190*	*820*	*9150*	*11529*
2005	*367*	*1336*	*1263*	*12849*	*15815*
Total	*2848*	*6854*	*6988*	*61729*	*78419*

2.5 Traffic Volume Studies

2.5.1Traffic Flow

Traffic flow is a complex system comprised of three interacting components:

- The driver
- The vehicle and
- The environment

Traffic flow consists of the movement of individual vehicles each under the control of a driver, generally operating independently, but interaction may occur. The behavior of these vehicles exhibits randomness brought about by the multitude of individual decision made by each of the drivers.

The three components of the stream interact with each other and as a consequence, the characteristics of the stream are different from those of the individual elements. Knowledge of traffic stream behavior provides the means of understanding situations involving maneuvers such as queuing, car following, turning, crossing, merging and weaving. Together with travel speeds, traffic volumes and traffic density, these parameters provide the major determinants of traffic capacity in any given situation.

Traffic streams vary according to the number of lanes occupied by the flow and the type of traffic in the stream, for example heavy vehicles, pedestrians, and cycles.

Traffic flow is categorized as interrupted and uninterrupted flow as shown in the table 2.3 below:

Table 2.3: Flow Categories and Road Types (Source: AACRA Geometric Design manual guide line 3)

Flow Type	Road Type
Uninterrupted Flow	Freeway Sections
	Weaving areas
	Free flowing entry and exit ramps
Interrupted Flow	Stop condition entry and exit ramps (i.e. ramps with an intersection at one terminal)
	Signalized intersections
	Unsignalized intersections (inc. STOP, GIVE-WAY, Roundabout)
	Arterial roads, sub - arterial roads, Collector roads and local streets
	Toll Booths

Uninterrupted flow describes flow on roads having no fixed elements external to the traffic stream that cause interruptions to traffic flow. The traffic flow conditions are the result of interactions among vehicles in the traffic stream and the geometric and environmental characteristics of the road. Flow is normally fluid, but will sometimes revert to "Stop – Go" flow if the arrival rate of vehicles exceeds the roadway capacity downstream. Accidents and breakdowns will also interrupted flow on this type of road.

Interrupted flow describes roads incorporating fixed elements such as traffic signals, stop signs, and other types of controls. These elements cause periodic interruptions to traffic flow irrespective of how much traffic exists.

2.5.2Traffic Volume Characteristics

- ✓ **Traffic Volume Patterns**

The traffic volume on a specific road section can vary significantly between peak hours, daily traffic volumes and seasonal flows. The extent of the variation depends on such factors as the road function, the traffic conditions and environment. Localized information on seasonal variations and periods within a specific traffic system should be used in the design of road network elements. It should be obtained by collection of appropriate traffic data. This information can also be obtained by local knowledge where no traffic studies, statistical or comparative counts are available.

- ✓ **Average Daily Traffic**

The average daily traffic (ADT) is the total number of vehicles in a time period (more than one day and less than a year) divided by the number of days in the period. It is a figure that may be used for a specific time period for purposes relating to that time period.

The Annual Average Daily Traffic (AADT) is the total volume of traffic for the whole year divided by the number of days in the year.

These parameters can be readily established when continuous counts are available. When only periodic counts are undertaken, the ADT and AADT can be estimated by applying relevant factors to account for season, month and day of week.

ADT and AADT are used in:-

i. Assessing annual usage
ii. Undertaking strategic link analysis
iii. Justifying expenditure of funds on projects
iv. Designing structural elements of the road

- ✓ **Design Hour Traffic**

Hourly volumes provide a much better measure of the operating conditions to be met by the design of the road. All roads exhibit a propensity to have brief periods of intense activity repeated regularly. This is particularly obvious in urban conditions but it is also the case that rural roads have significant variation in hourly volumes throughout the year. Or design purposes, it would be unreasonable to have to cater for the maximum hourly volume since the facility provided would be under used for most of the time. A balance between the inadequacy of the average traffic volume and the wastefulness of the maximum volume must be struck.

- ✓ **Peak-hour Factor**

PHF is the relationship between the peak 15-minute flow rate and the full hourly volume. Peak-hour factors for freeways range between 0.80 and 0.95. (Africon Ltd, 2011)

The peak hour factor (PHF) represents the variation in traffic flow within an hour. On the freeway, typical PHF ranges from 0.8-0.95 from which low PHF are characteristics of rural highways and higher PHF factors are typically urban and suburban highways. Generally 0.92 is recommended for urban and suburban highways. (HCM, 2000)

The analysis of level of service is based on peak rates of flow occurring within the peak hour because substantial short-term fluctuations typically occur during an hour. Common practice is to use a peak 15-minute rate of flow. Flow rates are usually expressed in vehicles per hour, not vehicles per 15 minutes. The relationship between the peak 15-minute flow rate and the full hourly volume is given by the peak-hour factor (PHF) as shown in the following equation (Roess, 3rd edition). If 15-minute periods are used, the PHF is computed as:

$$\text{PHF} = \frac{V}{(4 * V15)}$$

Where:

V =peak-hour volume (vph)

V_{15} = volume during the peak 15 minutes of flow (veh/15 minutes)

The four parameters listed are closely related, and all are expressed in terms of the same or similar units. They are not, however, the same.

1. **Volume**:-is the number of vehicles passing a point during a specified time period, which is usually one hour, but need not be.

   Annual Average Daily Traffic (AADT):- is the estimate of typical daily traffic on a road segment for all days of the week over the period of one year. AADT is determined by dividing the total volume of traffic on a highway segment for one year by the number of days in the year (FDOT, 2002). To forecast future AADT, traffic growth rate will be known.
2. **Rate of flow**: is the rate at which vehicles pass a point during a specified time period less than one hour, expressed as an equivalent hourly rate.
3. **Demand:** - is the number of vehicles that desire to travel past a pot during a specified period (also usually one hour). Demand is frequently higher than actual volumes where congestion exists. Some trips divert to alternative routes, while other trips are simply not made.
4. **Capacity**: - is the maximum rate at which vehicles can traverse a point or short segment during a specified time period. It is a characteristic of the roadway. Actual volume can never be observed at levels higher than the true capacity of the section.

2.5.3 Traffic Composition

With societies increasing emphasis on environmental, physical and financial constraints, traffif planning and demand management in the urban transport network are focusing on iimproved facility planning and design for all road users.

This focus is encouraging greater proportions of pedestrians, cyclists and higher occupancy vehicle modes of transport in the road corridor.

The vehicles in the stream can be divided into groups as follows:

i. Passenger cars – all passenger cars and light delivery trucks
ii. Trucks – all buses, single unit trucks and combination vehicles
iii. Motor cycles
iv. Bicycles

Motor cycles will rarely have an adverse effect on the operation of the traffic stream. Their performance exceeds that of the other vehicles and will not therefore adversely affect the capacity of the road.

2.6 Black Spot

The point where accident occurs frequently is known as black spot or accident point (Achuta Nanda,2013) . Economics of Australia (2001) locations are in general classified as black spots after an assessment of the level of risk and the likelihood of a crash occurring at each location. At certain sites, the level of risk will be higher than the general level of risk in surrounding areas. Crashes will tend to be concentrated at these relatively high-risk locations. Locations that have an abnormally high number of crashes are described as crash concentrated, high hazard, hazardous, hot spot or black spot sites.

2.6.1 PROFILING ACCIDENT BLACK SPOTS

The rules for targeting black spots based on the total number of reported accidents at a site. However, road accidents were connected with a number of features, which may be considered to analyze the occurrence in variance between accident frequencies on different locations:

- ✓ the severity of the accident, e.g. fatal, injury or property damage only
- ✓ The accident contributory factors present in the accident, e.g. weather conditions. These factors may be assigned to the driver, the location or the vehicle.
- ✓ The accident category, e.g. pedestrian, left-angle, left-turn, rear-end, head-on, and various run-off-road collisions.

After the data were secured, the next step was to determine the most hazardous accident locations/sites (i.e. RTABSs) based on the frequency of road traffic crashes at each site in each sub-city (Sayer, 1994). In this regard, many researchers employed reliable traffic data to determined RTABSs in their respective countries and their urban areas (Geurts & Wets, 2003; Getu, 2007) as Getu (2007) cited different sources, accident black spot identification varies from country to country.

For example, black-spots in Norway are defined as any place with a maximum length of 100 meters where at least 4 (four) injury accidents are reported during a four year period (Rune & Vaa, 2005). In the UK, it has only five injury accidents in three years, while in Bangladesh it is having more than 10 injury accidents in a year (Geurts & Wets, 2003). In most developed countries, black-spots are defined as the locations where there are 12 accidents in 3 years per 0.3 kilometers (Guo & Kong, 2003)- i.e. 4 accidents per year. In Czech Republic, junctions or 250 m-long road sections, where at least 3 road accidents with injuries occurred within 1 year or at least 3 road accidents with injuries of the same type occurred within 3 years or at least 5 road accidents of the same type occurred within 1 year, are considered as black-spots (Jitka, 2000). Moreover, Mustakim and Fujita (2011) forward methods of determining black-spots using Accident Point Weightage (APW).

3.0 Research methodologies

3.1 Study Area

Kolfe - Keranio Sub-city is one of the 10 sub cities in Addis Ababa city administration having large population of 477,284 (15.66% of the total population of Addis Ababa City) of who 231,067 are females and the rest 246,216 are males. With a total area of around 6510.4 ha, it borders with Oromia in the north, south and west, Lideta sub city in the east, Gulele, Addis ketema sub city and Gulele sub city in the north east, Nifasilk lafto sub city in the South east and Based on the 2011 Census conducted by the Central Statistical Agency of Ethiopia about 10,037 of the population under the age of 1 year; 32,849 of the population under the age of 5 years and 34.6% are in the reproductive age (15-49 years).

In this sub city there exists a number of intersections and midblock with different types. From these 10 of them has been selected as major Black-spots on the basis of the importance they give. The Black-spots are listed in Table 3.1 below.

Table 3.1: Kolfe –Keranyio Sub city Black-spot areas (Source: Addis Ababa City Black – Spot area map)

No.	***Major ABSs***
1	Total - Zenebe-work
2	Ayer Tena
3	Repi Soap Factory
4	Atana Tera Bridge
5	Kara Kore
6	Holland Embassy
7	Near Natran Company
8	Koshi Sefer
9	Woira Sefer
10	Kolfe Keranyo
11	Torhailoch - Bethel

Accordingly, in table 4.5, figure 4.2, figure 4.3 and figure 4.4 below identify and prioritize of black spots areas within the Kolfe Keranio subcity. Therefore, from Kolfe Keranyo sub city ZenebeWork Bridge leading first with priority value 314, in second place Karakore-W/Mariam with a priority value of 258, in third place Torhailoch – Bethel with a priority value of 156. Repi Soap Factory (156), Atana Tera Bridge (121), Ayer Tena (121), Holland Embassy (99), Near Natran Company (99), Koshe Sefer (99), Weyira Sefer (99) and Kolfe Keranyo (99) followed with 3rd, 4th and 5th ranks respectively.

Finally, based on the analysis of their Priority Value, Due to the Living standard and heavy cross movement of pedestrians who are living in this sub-city, in order to get high and mixed traffic volumes (Traffic Composition), pedestrian facilities, time and budget constraint, the researcher decided to take the first three leading black-spot areas for further analysis. These are:-

Table 3.3: Study Location and Type of Analysis

No.	Road Section studied (Name)	Section Type	Type of Analysis
1	Total 3kutir mazoria-Zenebewerk	Midblock or Road Segments	Spot speed and Traffic volume analysis
2	KaraKore - Weletemariam	Midblock or Road Segments	Spot speed and Traffic volume analysis
3	Torhailoch -Bethel	Midblock or Road Segments	Spot speed and Traffic volume analysis

3.2 Data collection method

The study was made based on both primary and secondary data collection methods.

3.2.1 Primary data collection method

3.2.1.1 Interview

The interview method was used for areas that the researches intend to collect critical data. It helps the researches to present their inquiries from different point of view (perspective) and give deep insight about the topic of the interview. Despite the variations in interview techniques, more information and that too in greater depth, can be obtained and interviewer by his own skill can overcome the resistance, if any of the respondents; the interview method can be made to yield an almost perfect sample of the general population (Kothari, 2004).

The questionnaire was designed with the objective of obtaining information about driver and pedestrian behavior and attitudes. The drivers and pedestrians used included individuals who were employed, unemployed or in higher education . This meant that a variety of individuals were used to represent the people of Kolfe- Keranio Sub city (See Appendix A-9 for the questionnaires used for Traffic Police, drivers and pedestrians).

The interview was chosen in order to provide the largest possible number of facts about the causes of RTAs (Truong et al., 2013) and these made it possible to identify the best ways to reduce them in the future. At the same time, it was useful to learn about the differences between the participant's individual opinions according to their work in the various traffic departments. However, some difficulties occasionally arose when interviewing subjects, some people felt that they do not want to take part. The duration of each interview was not more than 30 minutes.

Traffic Police and Patrols Directorate

Qualitative interviews were conducted with a number of traffic police investigators from the Addis Ababa Traffic Police Commission and Patrols Directorate from Federal Police Commission . All the Traffic Polices contacted responded positively as regards taking part in this project and the interviews took place at particular traffic departments. In order to obtain information from reliable sources, the traffic polices included all the sections involved with RTAs in terms of investigations, engineering, enforcement, education, training and traffic awareness. The departments targeted constituted all the sections since these were concerned with dealing with minor and major RTAs.

Drivers

Drivers are responsible for numerous RTAs. It has been shown that 90% of the causes of RTAs are a result of driver behaviour and human error. (Mearkle , 2009; World Health Organization, 2009; Sabbour & Mibrahim, 2010). Examples of this are: a lack of attention, falling asleep, excessive speed, overtaking at the wrong time or driving on the opposite side of the road to the direction of traffic. Drivers were selected to obtain the information relating to RTAs and their causes since it was important to identify their points of view concerning RTAs.

Vulnerable Road Users

It is estimated that a third of all traffic fatalities involve by vulnerable road users (Zhu et al., 2013). It was therefore very important to understand the relevant factors relating to impacts of speed and traffic volume and accidents among pedestrians in Kolfe Keranio sub city. The surveys for the vulnerable road users included questions based on crossing the roads near shopping centers, mid blocks and companies.

3.2.1.2 Sampling Technique and Size

Before identifying the sample frame, an observation made to estimate the total volume of passengers that travel along the road per hour. Thus, the carrying capacity of different modes of motor vehicles is assessed in the two travel times, morning and evening. As a result, the buses are almost using their full capacities in the morning hour and 50% to 75% to their capacities in evening hour, where as the private vehicles carrying 25% of their capacities in the two-travel times. Thus, the researcher decided to allocate according to what have been observed. Spot counts indicated that, on average 992, 2014 and 2279 vehicles are passing at karakore, Torhailoch and zenebewerk simultaneously along the streets per hour in both directions with estimated carrying total passengers of 8045, 19957 and 17,800 simultaneously on average (see appendix).
To achieve a stated objective with resource on hand, the research has adequate sample size depending on the size of the sample frame mentioned above. As the sample frame (passengers) is greater than 10,000 per day the sample size is determined as follows:-

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2 \left(N-1\right) + z^2 \cdot p \cdot q}$$

Where:-

n = Size of sample

z = is the standard normal variable at required 95% level of confidence = 1.96

p = is the proportion in the target population to have characteristics being measured =0.5

q =l-p = 1 -0.5 = 0.5: is the opposite of "p" above and

e = is the sample error =5%

N= 15,268

Therefore the sample data /Interviewers/ = **376**

The validity or relevance of the data was assured through applying purposive non- probability sampling technique in determining the sampling unit of the study. So that, three group of the society who make at least two trips per day along the street - all passengers: government and private employees, business persons, all motorized vehicles drivers, and traffic polices are selected. From them, 150 representative sample elements were randomly drawn, that is, 150 (40%) from all employees: government and non- government employees, 94 (25%) from business men and others, 124 (33%), from different motor vehicle drivers, and the remaining 8 (2%) from traffic police.

3.2.1.3 Field Observation

This kind of collecting data was very essential to gather spot speed, volume, road type, pedestrian facility and other supporting information to this research. Therefore, Manually traffic volume counts , travel time data and Spot Speed data were collected using tally sheet paper format at the selected black spot areas.

Speed and Traffic Volume

Sample Size

Spot speed studies represent a sample of measurements selected from a virtually infinite population, the average can never be measured with complete precision and 100% confidence. The most common approach uses the 95% confidence interval as to compute the precision and confidence of the sample mean as an estimator of the true mean of the underlying distribution. (Roger and Elena S, 2001).

Since many vehicles negotiate the entry point at a time, vehicles were selected randomly but statistically significant sample size was determined for each 15 & 30 min of count. The sample size was determined according to the procedure and equation on the handbook.

According to travel time data collection Handbook the sample size for manually transcript travel time data is given by the equation:

$$N \geq \frac{1.96^2 * S^2}{e^2!}$$

N = 35

Where: - 1.96 = t-statistics from student t-distribution for 95% confidence interval.

S = Coefficient of variance /Standard deviation/ =15min

e = relative error / tolerance/ =5%

However, the handbook using the above statistical equation provides a sample sizes for different traffic conditions and level of confidence. Accordingly, traffic condition at 95% confidence interval and ± 5% error, the minimum sample size was calculated to be 35 for 15 & 30 min count.

Spot Speed

At Zenebe – Work Bridge

This stretch was conducted by stopwatch method used to successfully complete a spot speed study using a small sample size taken over a relatively short period of time. As shown figure 3.1 and 3.2 the stopwatch method was a quick and inexpensive method for collecting speed data.

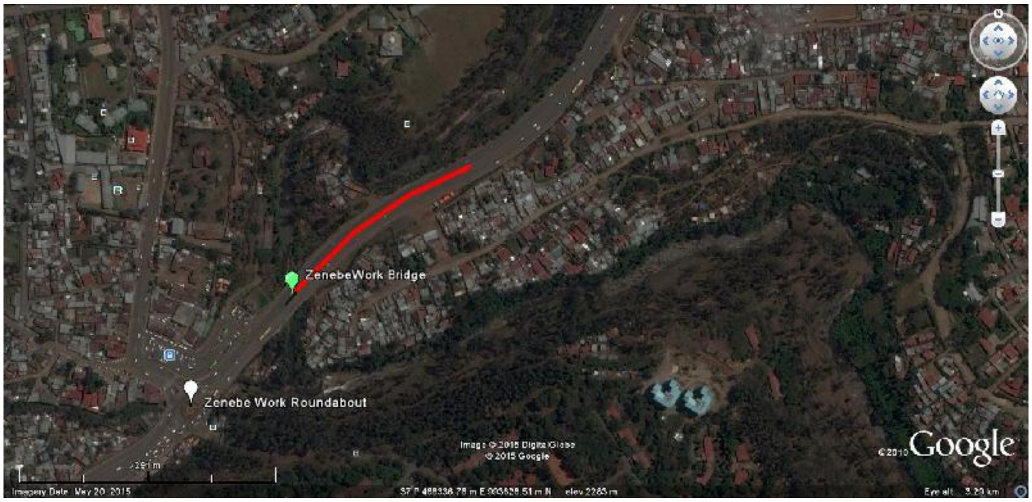


Figure 3-1: ZenebeWork Bridge black spot (Source: Google earth)

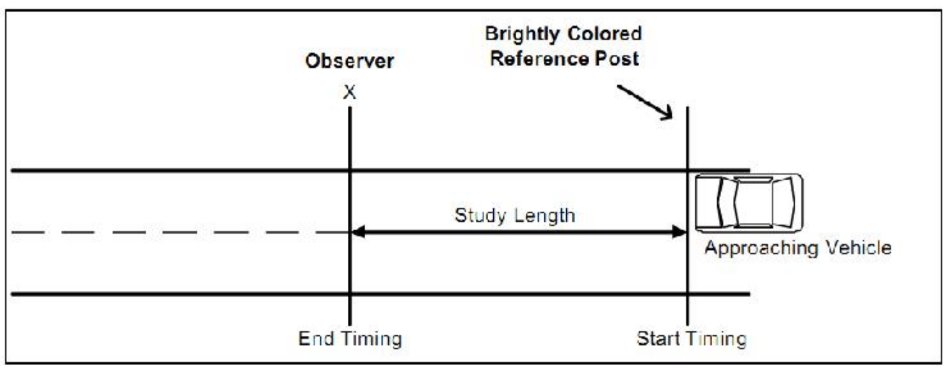


Figure 3.2: - Stopwatch Spot Speed Study Layout

At Kara – Kore infront of Yetebaberut Oil Company and around Tor-Hayiloch

The spot speed data was carried out by a radar meter (True cam speed gun Image which is laser technology) which was commonly used device for directly measuring speeds in spot speed studies (see Figure 3.3, figure 3.4 and figure 3.5). This device was hand-held. The effective measuring distance for radar meters ranges from 200 feet up to 2 miles (Parma 2001). A radar meter requires line-of-sight to accurately measure speed and is easily operated by one person.

For this spot speed study at a selected locations a sample size of at 100 vehicles were obtained (Ewing 1999). Traffic counts during a Monday morning or a Friday peak period may show exceptionally high volumes and were not normally used in the analysis; therefore, counts were usually conducted on a Tuesday, Wednesday, and Thursday.

Figure 3.3.: - Kara-Kore black spot (Source: Google earth)

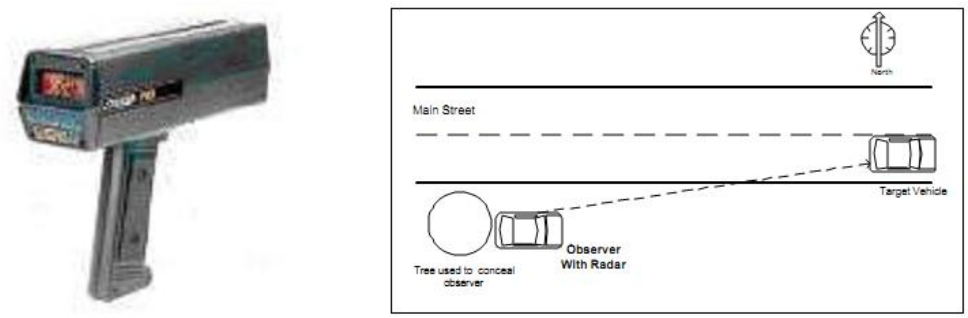


Figure 3.4: - Radar meter (Speed gun) and Example of Radar Meter Spot Speed Study Layout

Figure 3.5: - Around Tor - Hayloch black spot (Source: Google earth)

Traffic Volume

Sampling

Traffic survey was conducted to collect data on number of vehicles that pass a point on a highway facility during specified time period. The collected data used to compare the current traffic volume (Current Average Annual Daily Traffic data) to the design AADT.

The traffic counts were taken from 17 August 2015 to 23 August 2015. In each of the data was collected for seven consecutive days for 12 - hours (6:00 AM - 6:00 PM) supplemented by a full 24-hour count on two of the weekdays (i.e. One on market day at “Thursday” and the other on normal day at “Wednesday”). The raw data was collected manually using eight vehicle categories, which were grouped into five for the purpose of analysis.

3.2.2 Secondary data collection method

As researches employ a descriptive type of data, it tends to collect information from any source available; the researcher gives emphasis on secondary sources besides gathering first hand information.

In addition to internal sources, the researches referred archive materials that are vital for the study.

Therefore, the data employed to conduct this study was obtained from Addis Ababa traffic police commission office and Federal Police commission archives. Because of data limitation, the identification of RTABSs was based on traffic accident records of 2004, 2005 and 2006 E.C. This year data is not available, due to the absence of fully available data from Addis Ababa traffic police office of the city by sub-city. In other words, during the remaining recent years, data couldn’t be found for all sub-cities for the same year. Due to this reason, data for the year were gathered on all forms of road car accidents (deaths, slight injuries, serious injuries and property damages) in each sub-city at each accident site. In addition to that, the recorded data it doesn’t tells specific site which the accident was occurred. Moreover, although this particular study of RTABSs is generally based on the data acquired during 2004,2005 and 2006 i.e. July 2003 – June 2004, July 2004 – June 2005 and July 2005 – June 2006 E.C. The number of RTABSs in each sub-city doesn’t imply the total number of accident that show the rank orders. Rather the respective numbers of RTABSs were determined separately for each sub-city considering only the top ten ranks of the frequency of accident at each hazardous site in each sub-city.

Finally, in order to correlate the collected secondary data with current condition especially Annual Average Daily Traffic data’s, the researcher decide to use for Total - Zenebework & Torhailoch -

Bethel = AACRA Pavement design manual Guideline 2004 and For Karakore – W/Mariam BS ERA Geometric Design manual "Design control and criteria,2002)" for Forecasting the AADT.

4.0 Data presentation, Analysis and Interpretation

4.1 Road Traffic Accidents Black-Spots and Their Distribution by Sub-City

The study was clearly identify the location of major RTABSs in each Sub-city by ranking the total number of RTAs of each Sub-city rather than for Addis Ababa as a whole. Table 4.1 shows the distribution of traffic accidents, its rank order based on their priority value and the number of RTABSs as identified through current study.

However, in this study, the frequencies of occurrences of road crashes were used to determine RTABSs by identifying the rank orders which was based on priority value (P) of each RTABS in each sub-city. Thus, the intensity of accident is weighted in terms of the frequency accident data, which has been employed by many writers (Jitka, 2000; Guo & Kong, 2003; Geurts & Wets, 2003).

Accordingly, based on the rank orders based on priority value in the frequency of accidents, the author determined the accident black-spots of each sub-city. In most sub-cities, the first 10 hazardous sites in the rank order were determined to be the most hazardous black-spots although in others where the intensity of accidents is relatively lower, RTABSs were determined accordingly. However, as a general principle, in this study the first 10 hazardous sites are taken as accident black-spots.

4.1.1 Identification and Prioritization of Black Spots

Black spot identification means the process of the selections the weakest places on the city road network ("black spots"). It is possible to distinguish at least two levels in the evaluation of road network safety. In the lowest level the black spot is considered a single junction, short road section or another specific traffic element such as a pedestrian crossing. In the higher level the black spot may be whole arterial road in a village or town or one part of a village, town or city.

There are alternative ways of identifying and prioritizing black spots. However, taking into consideration the type of data in Ethiopia, the following approach has been adapted. That is, the potential accident reduction ranking method is employed taking in to account weight for each severity for individual stretch or each site where in three years three or more accidents have occurred is selected.

However, literature points out that there is no universally accepted definition of what should be considered as 'dangerous' (Geurts and Wets, 2003). Indeed, according to Hauer (1996) some researchers rank locations by accident rate (accidents per vehicle-kilometers or per entering vehicles), some use accident frequency (accidents per km-year or accidents per year) and some use a combination of the two. Furthermore, there is a wide range of methodologies available, ranging from simple models based on actual accident counts to advanced statistical models based on estimates. According to Taylor and Thompson (1977), seven methods can be used to identify dangerous sites on the road network, each with different order of importance and precision (European Union Road Federation, 2002): Accidents frequency, Hazard potential ratio, Joint method with accident frequency and accident risk ratio, Confidence interval method, Method of the accident severity ratio, Risk rate method and Inventory of the accident risk elements in the road.

For prioritizing those black spots, the ratios of accident costs by degree of severity were established by TRL (2); the weight given for fatal accident is 5, for serious injury is 3 and for light injury 1 .

Then, a site is considered to be dangerous when its priority value (P). The mathematical expression is:-

$$P = 1 * X + 3 * Y + 5 * Z$$

Where: -

P = Priority Value;

X = Total Number of Light Injuries;

Y = Total Number of Serious Injuries;

Z = Total Number of deadly injuries

Table 4.1: Number of RTAs, Rank orders and RTABSs by Sub-city in 2004 E.C

Major ABSs	Total Road Traffic Accidents No.	Degree of severity				Priority Value (P) P=X+3Y+5Z	Rank
		Deadly Injury (Z)	Serious Injury (Y)	Light Injury (X)	Property Damage		
Kirkos /Cherkos/	2285	53	193	183	1857	1027	1
Bole	1931	45	163	154	1569	868	2
Nifas - Silk/ Lafto	1193	28	101	95	969	538	3
Akaki	1189	28	100	95	966	535	4
Yeka	998	23	84	80	811	447	5
Lideta	819	19	69	65	665	367	6
Kolfe	819	19	69	65	665	367	7
Arada	789	18	67	63	641	354	8
Addis - Ketema	665	15	56	53	540	296	9
Gullele	475	11	40	38	386	213	10
Total	**11163**	**259**	**942**	**891**	**9069**		

Table 4.2: Number of RTAs, Rank orders and RTABSs by Sub-city in 2005 E.C

Major ABSs	Total Road Traffic Accidents No.	Degree of severity				Priority Value (P) P=X+3Y+5Z	Rank
		Deadly Injury (Z)	Serious Injury (Y)	Light Injury (X)	Property Damage		
Bole	2862	66	242	229	2325	1285	1
Kirkos	2807	65	237	224	2281	1260	2
Nifas - Silk/ Lafto	1700	39	144	136	1381	763	3
Yeka	1595	37	135	127	1296	717	4
Akaki	1511	35	128	121	1228	680	5
Kolfe	1272	30	107	102	1034	573	6
Arada	1217	28	103	97	989	546	7
Lideta	1074	25	91	86	873	484	8
Addis - Ketema	746	17	63	60	606	334	9
Gullele	678	16	57	54	551	305	10
Total	15462	358	1307	1236	12,564		

Table 4.3: Number of RTAs, Rank orders and RTABSs by Sub-city in 2006 E.C

Major ABSs	Total Road Traffic Accidents No.	Degree of severity				Priority Value (P) P=X+3Y+5Z	Rank
		Deadly Injury (Z)	Serious Injury (Y)	Light Injury (X)	Property Damage		
Bole	3229	75	273	258	2624	1452	1
Kirkos	2919	68	247	233	2372	1314	2
Nifas - Silk/ Lafto	2030	47	172	162	1649	913	3
Yeka	1895	44	160	151	1540	851	4
Akaki	1786	41	151	143	1451	801	5
Kolfe	1510	35	128	121	1227	680	6
Arada	1367	32	116	109	1111	617	7
Lideta	1258	29	106	101	1022	564	8
Addis - Ketema	800	19	68	64	650	363	9
Gullele	718	17	61	57	583	325	10
Total	17,512	407	1482	1399	14,229		

Table 4.4: Total Number of RTAs, Rank orders and RTABSs by Sub-city from 2004 – 2006 E.C

Major ABSs	Total Road Traffic Accidents No.	Degree of severity				Priority Value (P) P=X+3Y+5Z	Rank
		Deadly Injury (Z)	*Serious Injury (Y)*	*Light Injury (X)*	*Property Damage*		
Bole	*2674*	62	226	214	2173	1202	1
Kirkos	*2670*	62	226	213	2170	1201	2
Nifas - Silk/ Lafto	*1641*	38	139	131	1333	738	3
Yeka	*1496*	35	126	120	1216	673	4
Akaki	*1495*	35	126	119	1215	672	5
Kolfe	*1205*	28	104	94	978	546	6
Arada	*1124*	26	95	90	914	505	7
Lideta	*1050*	24	89	84	853	471	8
Addis - Ketema	*737*	17	62	59	599	330	9
Gullele	*624*	14	53	50	507	279	10
Total	***14717***	***341***	***1246***	***1174***	***11958***		

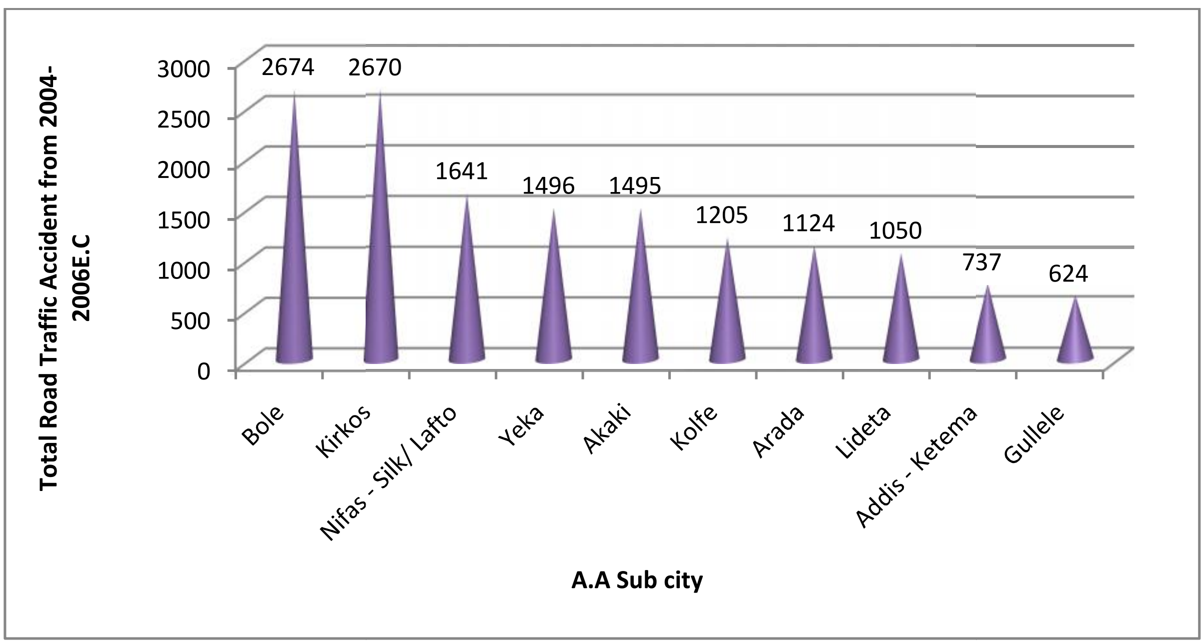


Figure 4.1: Sub-city Vs Average Percentage of Accidents, Source: Computed from Data obtained from AATPO (2004 – 2006 E.C) by the Author, 2015

Obviously the frequency of road car crashes in Addis Ababa varies from one sub-city to the other. This variation in the frequency and intensity of road accidents has led to the need for identification of RTABSs for taking appropriate policy measures at relevant accident locations by considering each sub-city. Table 4.3 and figure 4.1 shows the distribution of number of respective accidents and black-spots in each sub-city. Accordingly, Bole (18.18%), Kirkos (18.15%) and Nifas Silk (Lafto) (11.15%) sub-cities were the three leading sub-cities in the frequency of RTAs being the 1st, 2nd and the 3rd for the year specified. Yeka (10.17%), Akaki (10.16%), Kolfe (8.16%) and Arada (7.64%) sub-cities followed with 4th, 5th, 6th and 7th ranks respectively. On the other hand, Lideta (7.14%), Addis Ketema (5.01%) and Gullele (4.24%) sub-cities, with rank orders of 8th, 9th and 10th respectively were found to be the last with regard to the priority value of road accidents.

Since Kolfe Keranyo sub-city is situated along the Arterial road that connects Addis Ababa to Jima, Hossana, ButaJira, Wolaita Soddo, Arbaminch and Ambo, Due to the Living standard and heavy cross movement of pedestrians (having Large no of populations among the ten sub-cities), in order to get high and mixed traffic volumes (Traffic Composition), pedestrian facilities, time and budget constraint, the researcher decided to use Kolfe Keranyo Sub city for further analysis. These are

Table 4.5: Kolfe Keranyo Subcity number of RTAs, Rank orders and RTABSs from 2004 – 2006 E.C

Major ABSs	Total Road Traffic Accidents No.	*Degree of severity*				*Priority Value (P), P=X+3Y+5Z*	Rank
		Dead	*Serious Injury*	*Light Injury*	*Property Damage*		
Zenebe Werk /Bridge/Ring Road	*705*	16	58	58	573	314	1
Kara Kore	*570*	14	48	47	462	258	2
Torhailoch - Bethel	*348*	8	29	28	284	156	3
Repi Soap Factory	*351*	8	29	28	286	156	3
Atana Tera Bridge	*282*	5	24	22	230	121	4
AyerTena	*282*	5	24	22	230	121	4
Holland Embassy	*211*	5	19	17	170	99	5
Near Natran Company	*213*	5	19	17	173	99	5
Koshe Sefer	*213*	5	19	17	173	99	5
Weyira Sefer	*213*	5	19	17	173	99	5
Kolfe Keraniyo	*213*	5	19	17	173	99	5
Total	***3601***	***84***	***304***	***288***	***2926***		

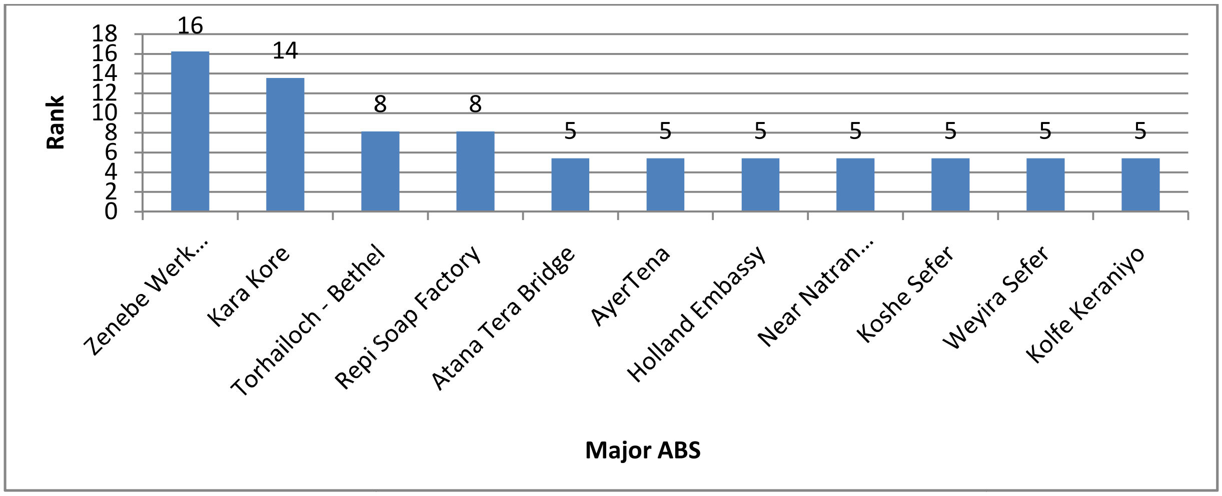


Figure 4.2: Kolfe - Keranyo sub city accident black - spots Vs Rank of accident spots

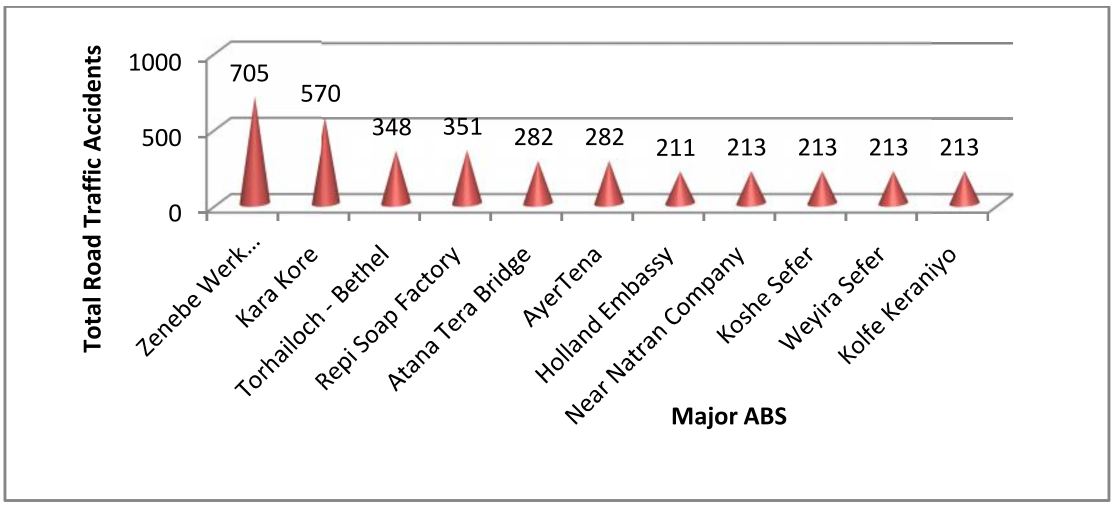


Figure 4.3: Kolfe - Keranyo sub city accident black - spots Vs Total Road Traffic Accidents

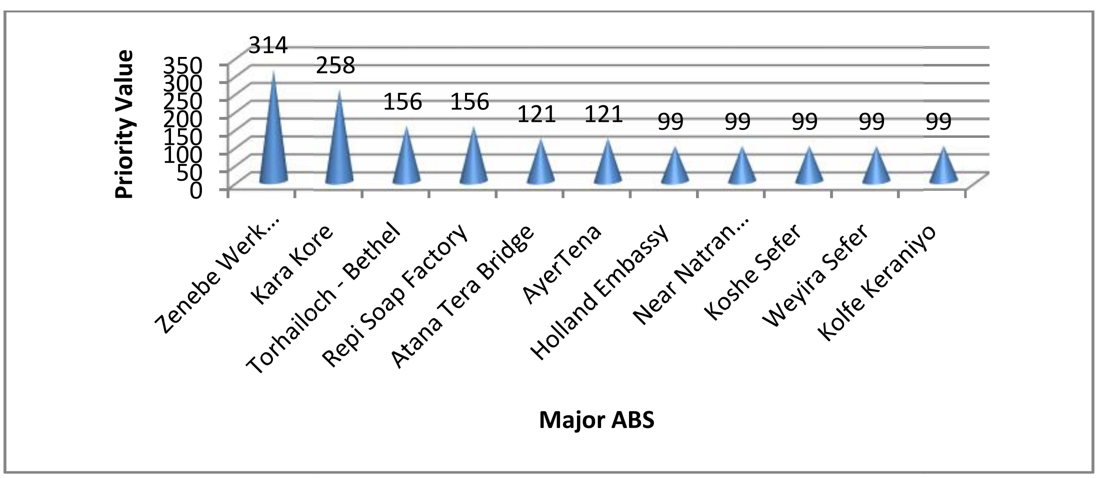


Figure 4.4: Kolfe - Keranyo sub city accident black - spots Vs Priority Value

Table 4.5 and figure 4.2, figure 4.3 and figure 4.4 shows the distribution of number of respective accidents and black-spots in Kolfe Keranyo sub city. Accordingly, from Kolfe Keranyo sub city ZenebeWork Bridge leading first with priority value 314, in second place Karakore with a priority value of 258, in third place Torhailoch – Bethel with a priority value of 156. Repi Soap Factory (156), Atana Tera Bridge (121), Ayer Tena (121), Holland Embassy (99), Near Natran Company (99), Koshe Sefer (99), Weyira Sefer (99) and Kolfe Keranyo (99) followed with 3rd, 4th and 5th ranks respectively.

4.2 Spot Speed data for selected black-spot areas

Median (50th Percentile Speed): The speed that equally divides the distribution of spot speeds; 50 percent of observed speeds are higher than the median; 50th percent of observed speeds are lower than the median.

85th Percentile Speed: The speed at or below which 85th percent of a sample of free flowing vehicles is traveling; this is typically used as a baseline for establishing the speed (based on a spot speed study).

In order to calculate Median (50th Percentile Speed) and 85th Percentile Speed a frequency distribution table is a convenient way to determine speed percentiles. The frequency of vehicles is the number of vehicles recorded at each speed. The cumulative frequency is the total of each of the numbers (frequencies) added together row by row from lower to higher speed. The fourth column is a running percentage of the cumulative frequency. To reach these exact percentages, a calculation is completed using percentages and speeds from the distribution table.

4.2.1 Total - ZenebeWork Black spot

Table 4.6*: frequency distribution Table*

Speed (KPh)	Frequency of Vehicles	Cumulative Frequency	Cumulative Percent (%)	Speed Percentile
35.05	1	1	1.67	
38.01	1	2	3.33	
41.79	1	3	5.00	
45.16	1	4	6.67	
45.24	3	7	11.67	
49.90	3	10	16.67	
53.16	5	15	25.00	
55.38	2	17	28.33	
59.86	2	19	31.67	
63.00	5	24	40.00	
64.12	4	28	46.67	*50th*
73.68	5	33	55.00	
74.12	6	39	65.00	
75.68	4	43	71.67	
78.50	3	46	76.67	
82.08	1	47	78.33	
83.72	1	48	80.00	*85th*
84.00	4	52	86.67	
89.68	2	54	90.00	
91.30	4	58	96.67	
93.33	1	59	98.33	
98.05	1	60	100.00	
Sample size	60			

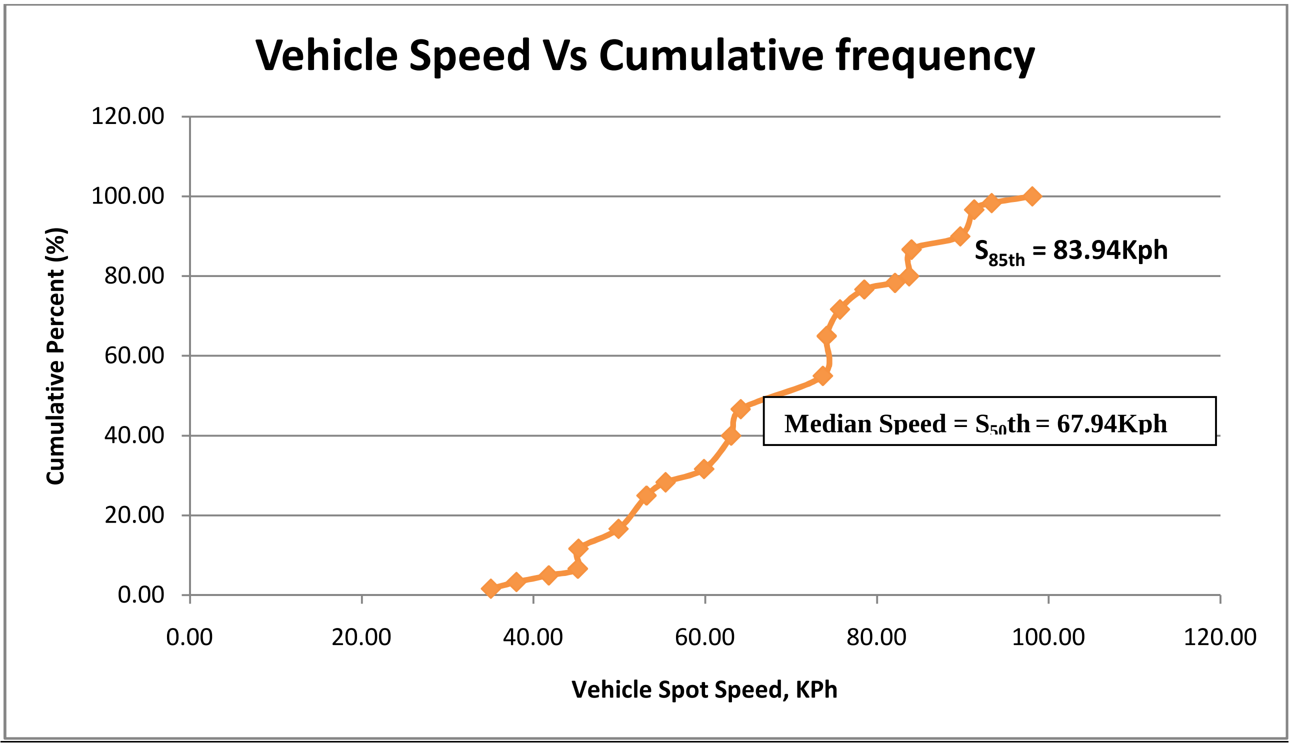


Figure 4.5: Cumulative Frequency Distribution Plot for Total - Zenebework BS Data.

The 50th and 85th speed percentiles are determined from the cumulative frequency distribution figure 4.5 above.

Therefore,

- Median (50th percent of observed vehicle speed) :-

  $S_{50}{}^{th}$ = 67.94Kph and

- 85th Percentile of observed vehicle speed :-

  $S_{85}{}^{th}$ = 83.93Kph

Posted Speed at Total – Zenebework Black Spot is 80Kph!

4.2.2 KaraKore – Weletemariam Black spot

Table 4.7: - *frequency distribution Table*

Spot - Speed (KPh)	Frequency of Vehicles	Cumulative Frequency	Cumulative Percent (%)	Speed Percentile
30	*10*	*10*	*10*	
35	*8*	*18*	*18*	
40	*25*	*43*	*43*	*50th*
45	*15*	*58*	*58*	
50	*14*	*72*	*72*	
55	*8*	*80*	*80*	*85th*
60	*15*	*95*	*95*	
65	*1*	*96*	*96*	
70	*3*	*99*	*99*	
75	*1*	*100*	*100*	
Sample size	*100*			

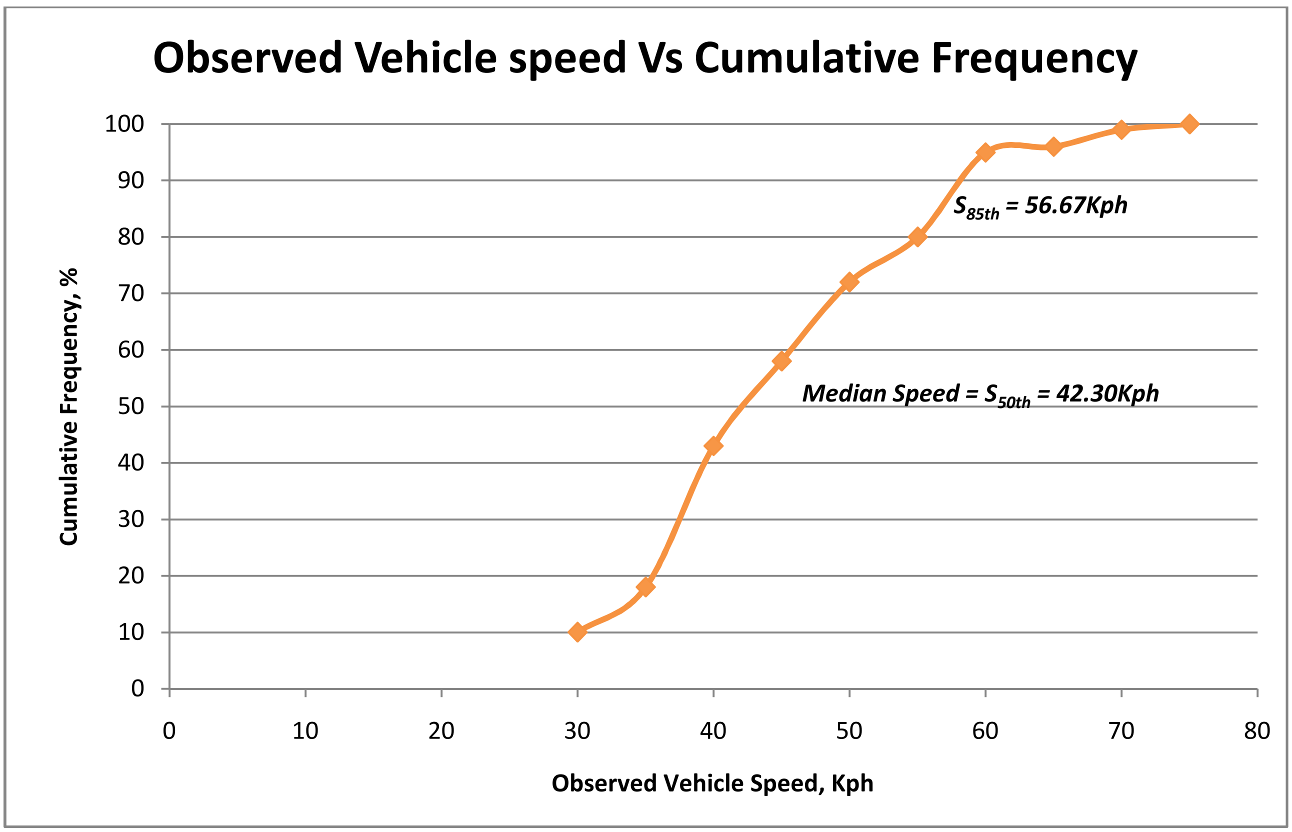


Figure 4.6: Cumulative Frequency Distribution Plot for KaraKore – W/Mariam BS Data.

As similar to previous:-the 50^{th} and 85^{th} speed percentiles are determined from the cumulative frequency distribution figure 4.6 above.

Therefore,

- Median (50^{th} percent of observed vehicle speed) :-

  $S_{50}{}^{th}$ = 42.30Kph and

- 85^{th} Percentile of observed vehicle speed :-

  $S_{85}{}^{th}$ = 56.67Kph

Posted Speed at KaraKore – W/Mariam Black Spot is 40Kph!

4.2.3 Torhailoch – Bethel Black Spot

Table 4.8: frequency distribution Table

Speed (KPh)	Frequency of Vehicles	Cumulative Frequency	Cumulative Percent (%)	Speed Percentile
30	*7*	*7*	*7*	
35	*7*	*14*	*14*	
40	*25*	*39*	*39*	*50^{th}*
45	*14*	*53*	*53*	
47	*1*	*54*	*54*	
50	*16*	*70*	*70*	
55	*11*	*81*	*81*	*85^{th}*
60	*14*	*95*	*95*	
65	*3*	*98*	*98*	
70	*2*	*100*	*100*	
Sample size	*100*			

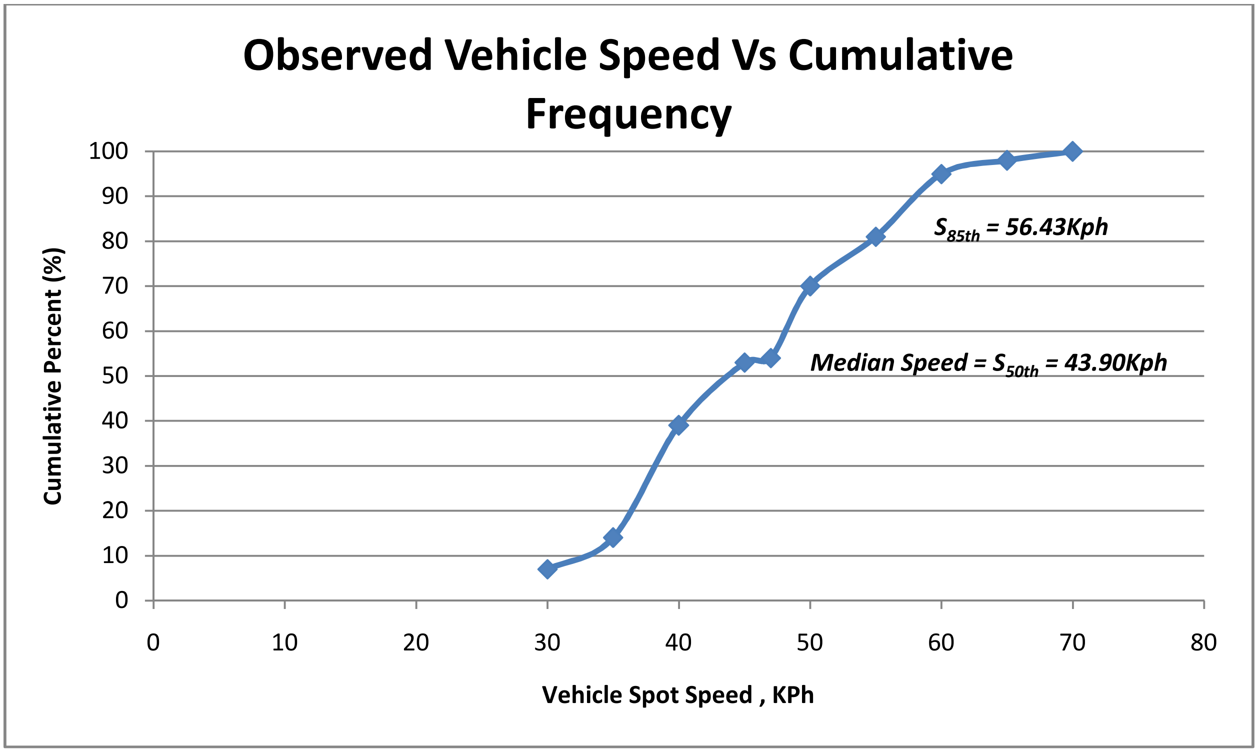


Figure 4.7: Cumulative Frequency Distribution Plot for Torhailoch - Bethel BS Data.

Similarly the 50th and 85th speed percentiles are determined from the cumulative frequency distribution figure 4.6 above.

Therefore,

- Median (50th percent of observed vehicle speed) :-

  $S_{50}{}^{th}$ = <u>42.30Kph</u> and

- 85th Percentile of observed vehicle speed :-

  $S_{85}{}^{th}$ = <u>56.67Kph</u>

Posted Speed at Torhailoch - Bethel Black Spot is 40Kph!

Finally, based on traffic management guidelines and Safety net speeding (2009) the faster a vehicle is being driven when it hits a pedestrian or another vehicle, the more likely it is to cause serious or fatal injuries. Table 4.9 indicates the risk of a pedestrian being killed or seriously injured when hit by a car travelling at various speeds. The risk of a pedestrian being killed when hit by a car travelling at 30mph rather than 20mph increases by nine times(from 5% to 45%) and nearly doubles again for a car travelling at 40mph. It can be seen clearly that the risk of death and injury decreases markedly as speeds reduce.

Table 4.9: Risk of Pedestrian when hit by a car travelling at various Speeds

Collision Speed (KPH)	Probability of surviving
0	100
20	100
40	90
80	50
100	10
120	0

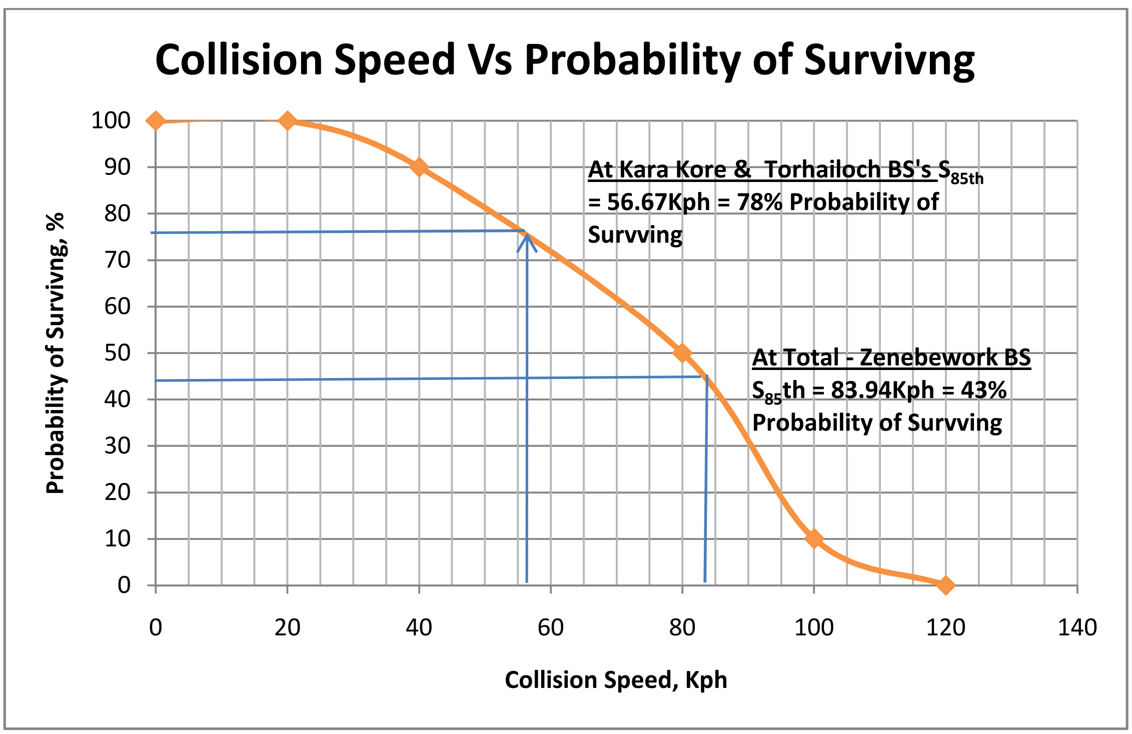


Figure 4.8: Collision Speed Vs Probability of Surviving

4.3 Traffic Volume Analysis at three black –spot areas

4.3.1 Classification of Vehicles

According to Addis Ababa city Roads Authority (AACRA) has classified vehicles into five categories based on their size (four passenger and four freight vehicles) Table 4.10 shows the detail vehicle classification.

Table 4.10: Classification of vehicles (Source: AACRA traffic & axle load study manual, guideline 1, January 2003))

Category	Cars	Light	Medium	Heavy	Articulated
Axles	2	2	3	4	>4
Tyres	4	6	10	14	>14
Length	<3 m	3m – 7.5m	3m – 7.5m	>7.5m	>7.5m
GVW	<3.5T	3.5T-12T	>12T	>12T	>12T
Includes	Cars Utility Minibus 4WD	Bus 1 Axle Truck	2 Rear Axle Truck	4 Axle Truck	Large Truck

Motorized volume data is to be collected at peak hour (data collection at peak hour each hour is divided in to 15 min time interval and recorded the data for each 15min time interval and take the highest value of the data from the four 15min time interval and change in to hourly volume and the different traffic category into similar values which is passenger car unit by using EPCU) with their direction of movements.

4.3.2 KaraKore - Weletemariam BlackSpot

Table 4.11: - Peak hour traffic counted data

TRAFFIC COUNT TALLY SHEET Sheet : **-2-**

Name of Road /Street :- **Kara Kore Road** No.: .... Direction From: **Kara Kore (Gate)** To: **W/Mariam**

Station Name: .... Station No. : .... Date: **18, August , 2015** *(Tuesday)*

Enumerator : **Ato Abel Z.** Supervisor: **Meron B.**

Hours Counted	***Category***	***Cars***	***Light***	***Medium***	***Heavy***	***Articulated***	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
		Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
8:00 - 8:15 A.M		*111*	*12*	*3*	*1*	*1*	*128*
8:15 - 8:30 A.M		*103*	*11*	*3*	*1*	*1*	*119*
8:30 - 8:45 A.M		*98*	*10*	*2*	*1*	*1*	*112*
8:45- 9:00 A.M		*81*	*9*	*2*	*1*	*1*	*94*
Total		***393***	***42***	***10***	***4***	***4***	***453***

Therefore the peak hour factor become:-

$$PHF = V/\ (4*V_{15}) = 453/\ (4*128)$$

$$= \underline{\mathbf{0.885}}$$

4.3.3 Tor-Hayiloch – Bethel Black Spot

Table 4.12: - Peak hour traffic counted data

TRAFFIC COUNT TALLY SHEET Sheet : ***-4-***

Name of Road /Street :- ***Tor Hayiloch*** No.: …………… Direction From: ***Tor Hayiloch*** To: ***Bethel***

Station Name: ……………………………………… Station No. : ………………………………… Date: **20, August , 2015** *(Thursday)*

Enumerator : ***Ato T. K.*** Supervisor: ***Mr. M. B.***

Hours Counted	***Category***	***Cars***	***Light***	***Medium***	***Heavy***	***Articulated***	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
	Includes	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
9:00 - 9:15A.M		*265*	*66*	*6*	*4*	*0*	*341*
9:15 - 9:30A.M		*253*	*63*	*6*	*4*	*0*	*326*
9:30 - 9:45A.M		*244*	*61*	*6*	*4*	*0*	*315*
9:45 - 10:00A.M		*158*	*40*	*4*	*3*	*1*	*206*
Total (9:00 -10:00A.M.)		***920***	***230***	***22***	***15***	***1***	***1188***

Therefore the peak hour factor become:-

$$PHF = V/(4*V_{15}) = 1188/(4*341)$$

$$= \underline{\mathbf{0.871}}$$

4.3.4 KaraKore – WeleteMariam Black Spot

Table 4.13: - Peak hour traffic counted data

TRAFFIC COUNT TALLY SHEET Sheet : **-2-**

Name of Road /Street :- **Kara Kore Road** No.: .... Direction From: **Kara Kore (Gate)** To: **W/Mariam**

Station Name: .... Station No. : .... Date: **18 August , 2015** *(Tuesday)*

Enumerator : **Ato Abel Z.** Supervisor: **Meron B.**

Hours Counted	***Category***	***Cars***	***Light***	***Medium***	***Heavy***	***Articulated***	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
		Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
8:00 - 8:15 A.M		*111*	*12*	*3*	*1*	*1*	*128*
8:15 - 8:30 A.M		*103*	*11*	*3*	*1*	*1*	*119*
8:30 - 8:45 A.M		*98*	*10*	*2*	*1*	*1*	*112*
8:45- 9:00 A.M		*81*	*9*	*2*	*1*	*1*	*94*
Total		***393***	***42***	***10***	***4***	***4***	***453***

Therefore the peak hour factor become:-

$$PHF = V/ (4*V_{15}) = 453/ (4*128)$$

$$= \underline{\mathbf{0.885}}$$

Therefore, from tables 4.8, 4.9 and 4.10 the current Annual Average Daily Traffic Data (AADT) is:-

Table 4.14: - Current Annual Average Daily Traffic (AADT) of each black spot areas

No	Assigned BS segment	Vehicle Category										Total
		Cars	***AADT = V/K30th***	***Light***	***AADT = V/K30th***	***Medium***	***AADT = V/K30th***	***Heavy***	***AADT = V/K30th***	***Articulated***	***AADT = V/K30th***	
		2		2		3		4		***Articulated***		
		4		6		10		14		> 4		
		< 3m		3m - 7.5m		3m - 7.5m		>7.5m		> 14		
		< 3.5T		3.5T -12T		>12T		> 12T		> 7.5m		
		Cars		Bus		2 Rear axle Truck		4 Axle Truck		> 12T		
										Large Truck		
1	KaraKore - Weletemariam	393	3930	42	420	10	100	3	30	3	30	4,510
2	Total - Zenebewerk	1042	10420	419	4190	27	270	15	150	1	10	15,040
3	Torhailoch - Bethel	920	9200	230	2300	22	220	15	150	1	10	11,880
Total			**23550**		**6910**		**590**		**330**		**50**	**31,430**

In general, the *daily traffic count data attached in the annex!*

Finally Due to the lack of Forecasted design Annual Average Daily Traffic data's, the researcher decide to use for Total - Zenebework & Torhailoch - Bethel = AACRA Pavement design manual Guideline 2004 and For Karakore – W/Mariam BS ERA Geometric Design manual "Design control and criteria,2002)" for Forecasting the AADT.

Therefore, the estimated Annual Average Daily Traffic Data is calculated by:-

$$AADT_{2015} = AADT_{o} * (1 + i)^{N}$$

Where: - $AADT_{2015}$ = Forecasted Design Average Annual Daily Traffic at 2015

$AADT_{0}$ = Initial Average Annual Daily Traffic Volume

i = Traffic growth rate according to AACRA Pavement design Manual, 2004

N = Number of years = 3Years, N =0, 1, 2 & 3

Table 4.15: -Forecasted Design Annual Average Daily Traffic (AADT) of each black spot areas

AADT Calculation	Selected BS'S			Remark
	Total - Zenebework Bridge	Torhailoch - Bethel	Karakore - W/Mariam	
$AADT_{1997}$	4500	4500	3000	Total - Zenebework & Torhailoch - Bethel = AACRA Pavement design manual 2004 but For Karakore – W/Mariam ERA Geometric Design manual "Design control and criteria,2002)"
Growth Rate = 9.3%	0.093	0.093	0.093	
No. of years = N	18	8	18	
$(1 +i)^{N}$	4.956	2.037	4.956	
$AADT_{2015}$ = AADT1997 *(1 + i) ^{N}	22,302.00	9,166.50	14,868.00	

4.4 Effect of traffic volume.

4.4.1 Traffic composition

It is not practical to design for a heterogeneous traffic stream and, for this reason, trucks and other types of vehicles are converted to equivalent Passenger Car Units (PCUs). Furthermore, PCU for different vehicle classes in Addis Ababa city were reviewed and recommend as shown below. (ERC, 2015).

Table 4.16: Recommended passenger car equivalent factor

Vehicle Type	Suggested Passenger car equivalent factors
Bicycles	0.30
Motor Cycles	0.40
Cars and Vans	1.00
Light Vehicle (Bus & 1 - Axle truck)	2.00
Medium trucks (2 - Rear Axle Truck)	2.50
Heavy & Articulated Trucks (4 - Axle Truck & Large Trucks)	3.00

Therefore, the converted passenger Car Unit (PCU) of each Black Spot are introduced below in the table 4.17.

Table 4.17: Current Year at 2015 Converted Passenger Car Unit (PCU) of each BS'S

Name of Black Spots & Converted PCU	***Cars***	***Light***	***Medium***	***Heavy***	***Articulated***	Total Converted PCU , Veh/hr
	2	2	3	4	> 4	
	4	6	10	14	> 14	
	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
Torhailoch - Bethel	*920*	*460*	*55*	*45*	*3*	*1483*
Total - Zenebework	*1042*	*838*	*67.5*	*45*	*3*	*1995.5*
Karakore - W/Mariam	*393*	*84*	*25*	*9*	*9*	*520*

Traffic growth rate: - is used to estimate yearly rate of traffic growth and to estimate future traffic condition. (Sheladia Associates, lnc.USA in Association with Pan Africa Consultants PLc, 2003) estimated traffic growth rates of region of Ethiopia from 2011-2025 periods.

Table 4.18: Traffic growth rates for 2011-2025 years (Sheladia Associates, 2003)

Region	LCW	Medium	Heavy	Articulated Trucks	Passenger Car, 4WD	Light/Heavy Bus
Addis Ababa & Dire Dawa	8.50	7.10	7.80	9.90	10.60	7.80
Harer	9.00	7.50	8.20	10.50	11.20	8.20
Benishangul - Gumuz & Gmabella	7.20	6.00	6.60	8.40	9.60	6.60
Oromia	6.60	5.50	6.10	7.70	8.20	6.10
Afar and Somalia	6.00	5.00	5.50	7.00	7.50	5.50
Amhara and Tigray	5.40	4.50	5.00	6.30	6.70	5.00

4.4.2 Traffic forecasting of the selected Black spots:-

In order to compare the collected Traffic volume data's in 2015 to the accident data (i.e. 3yeras collected from AATPC in 2004,2005 and 2006E.C) , apply traffic forecasting formula:-

$$AADT_{2015} = AADT_{2012} (1 + i)^{x}$$

Where: - $AADT_{2015}$ = Average Annual Daily Traffic at 2015, PCU

$AADT_{2012}$ = Average Annual Daily Traffic Volume at 2015, PCU

i = Traffic growth rate which describe in table 4.17,

x = Number of years = 3Years, x =0, 1, 2 & 3

Therefore, in order to get the Passenger Car unit in 2014, 2013 and 2012 use the above formula:-

Table 4.19: Passenger Car Unit at selected Black spots in 2015

Selected Black Spot's	***Cars***	***Light***	***Medium***	***Heavy***	***Articulated***	***Total Converted PCU, Veh/hr at 2015***
	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
Traffic Growth Rate (%),i	10.60	7.80	7.10	7.80	9.90	
(1+i)	1.11	1.08	1.07	1.08	1.10	
$(1+i)^x$, where x = 0 (i.e 2015)	1.00	1.00	1.00	1.00	1.00	
Torhailoch - Bethel	920.00	460.00	55.00	45.00	3.00	1483.00
Total - Zenebework	1042.00	838.00	67.50	45.00	3.00	1995.50
Karakore - W/Mariam	393.00	84.00	25.00	9.00	9.00	520.00

Table 4.20: Passenger Car Unit at selected Black spots in 2014

Selected Black Spot's	***Cars***	***Light***	***Medium***	***Heavy***	***Articulated***	***Total Converted PCU,Veh/hr at 2014***
	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
Traffic Growth Rate (%)	10.60	7.80	7.10	7.80	9.90	
(1+i)	1.11	1.08	1.07	1.08	1.10	
$(1+i)^x$, where x = 1 (i.e 2014)	1.11	1.08	1.07	1.08	1.10	
Torhailoch - Bethel	831.83	426.72	51.35	41.74	2.73	1354.37
Total - Zenebework	942.13	777.37	63.03	41.74	2.73	1827.00
Karakore - W/Mariam	355.33	77.92	23.34	8.35	8.19	473.14

Table 4.20: Passenger Car Unit at selected Black spots in 2013

Selected Black Spot's	***Cars***	***Light***	***Medium***	***Heavy***	***Articulated***	***Total Converted PCU,Veh/hr at 2013***
	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
Traffic Growth Rate (%)	10.60	7.80	7.10	7.80	9.90	
(1+i)	1.11	1.08	1.07	1.08	1.10	
$(1+i)^x$, where x = 2 (i.e 2013)	1.22	1.16	1.15	1.16	1.21	
Torhailoch - Bethel	752.10	395.84	47.95	38.72	2.48	1237.10
Total - Zenebework	851.84	721.12	58.85	38.72	2.48	1673.01
Karakore - W/Mariam	321.28	72.28	21.80	7.74	7.45	430.55

Table 4.21: Passenger Car Unit at selected Black spots in 2012

Selected Black Spot's	*Cars* Cars	*Light* Bus	*Medium* 2 Rear axle Truck	*Heavy* 4 Axle Truck	*Articulated* Large Truck	*Total Converted PCU,Veh/hr at 2012*
Traffic Growth Rate (%)	10.60	7.80	7.10	7.80	9.90	
(1+i)	1.11	1.08	1.07	1.08	1.10	
$(1+i)^x$, where x = 3 (i.e 2012)	1.35	1.25	1.23	1.25	1.33	
Torhailoch - Bethel	680.02	367.20	44.77	35.92	2.26	1130.17
Total - Zenebework	770.20	668.94	54.95	35.92	2.26	1532.27
Karakore - W/Mariam	290.49	67.05	20.35	7.18	6.78	391.86

Table 4.22: Passenger Car Unit at selected Black spots from 2012 - 2014

Selected Black Spot's	**Total Converted PCU, Veh/hr**		
	Year 2014	**Year 2013**	**Year 2012**
Torhailoch - Bethel	1354.37	1237.10	1130.17
Total - Zenebework	1827.00	1673.01	1532.27
Karakore - W/Mariam	473.14	430.55	391.86

Finally Traffic volume has been expressed as Passenger Car Unit (PCU) of the road per peak hour in table 4.22 above to account for different plying along these spots. To know the effects of the traffic volume on accidents of each BS'S scattered diagrams plotted below and the regression analysis has been carried out for the following cases.

- **Total – ZenebeWork Black Spot**
  - **Total no. of accidents V/s Traffic volume in PCU per hour**.

Table 4.23: Total – ZenebeWork Black Spot Total Number of Accidents and its Traffic Volume in PCU ,Veh/hr

Year	Total No. of Accidents	Traffic Vol. in PCU Vehicle per hr
2012	160	1532.27
2013	249	1673.01
2014	295	1827

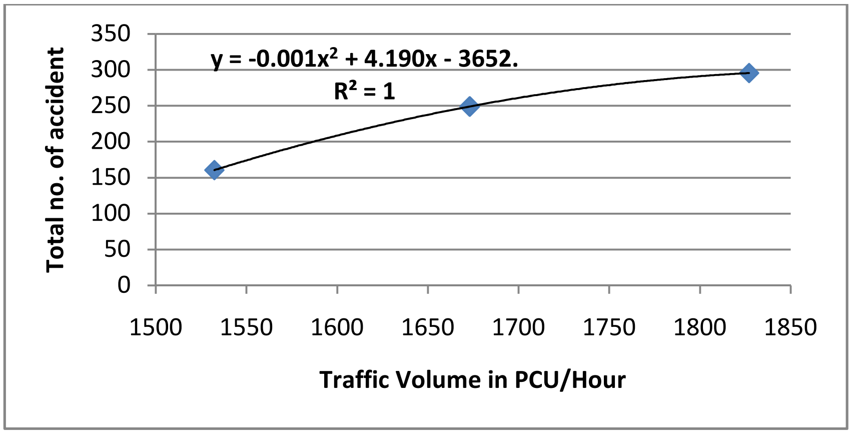


Fig. 4.9: Scatter diagram of Total no. of accidents V/s Traffic volume in PCU per hour.

- **Total no. of fatal accidents V/s Traffic volume in PCU per hour.**

Table 4.24: Total – ZenebeWork Black Spot Total Number of fatal accidents and its Traffic Volume in PCU, Veh/hr

Year	Total No. of fatal Accidents	Traffic Vol. in PCU Vehicle per hr
2012	4	1532.27
2013	6	1673.01
2014	7	1827

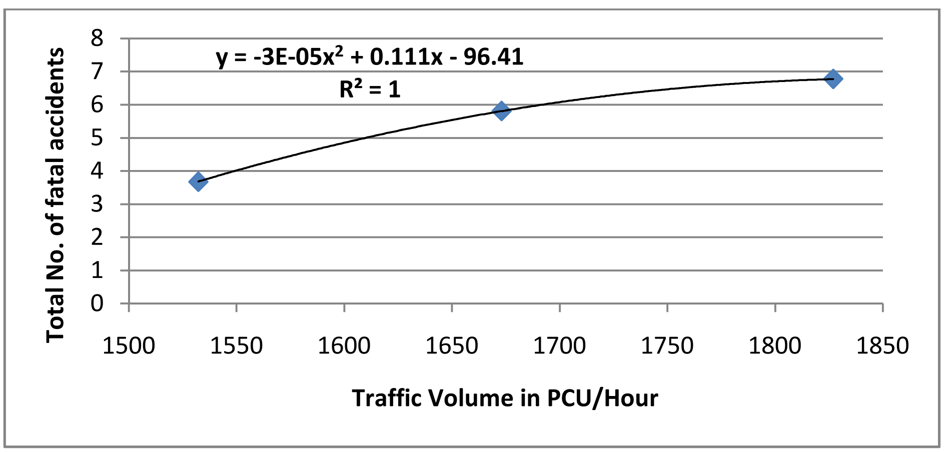


Fig. 4.9: Scatter diagram of Total no. of fatal accidents V/s Traffic volume in PCU per hour.

- **Total no. of Non-fatal accidents V/s Traffic volume in PCU per hour.**

Table 4.24: Total – ZenebeWork Black Spot Total Number of non - fatal accidents and its Traffic Volume in PCU, Veh/hr

Year	Total No. of Non fatal Accidents	Traffic Vol. in PCU Vehicle per hr
2012	26	1532.27
2013	41	1673.01
2014	49	1827

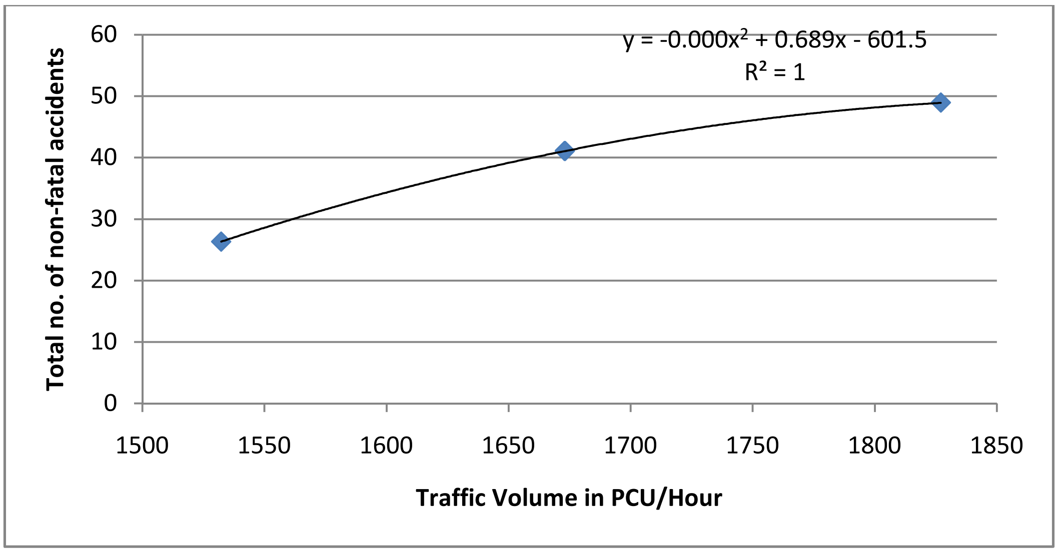


Fig. 4.10: Scatter diagram of Total no. of Non-Fatal accidents V/s Traffic volume in PCU per hour.

- **Total no. property damage V/s Traffic volume in PCU per hour.**

Table 4.24: Total – ZenebeWork Black Spot Total Number of damages and its Traffic Volume in PCU, Veh/hr

Year	Total No. of Property damages	Traffic Vol. in PCU Vehicle per hr
2012	130	1532.27
2013	202	1673.01
2014	239	1827

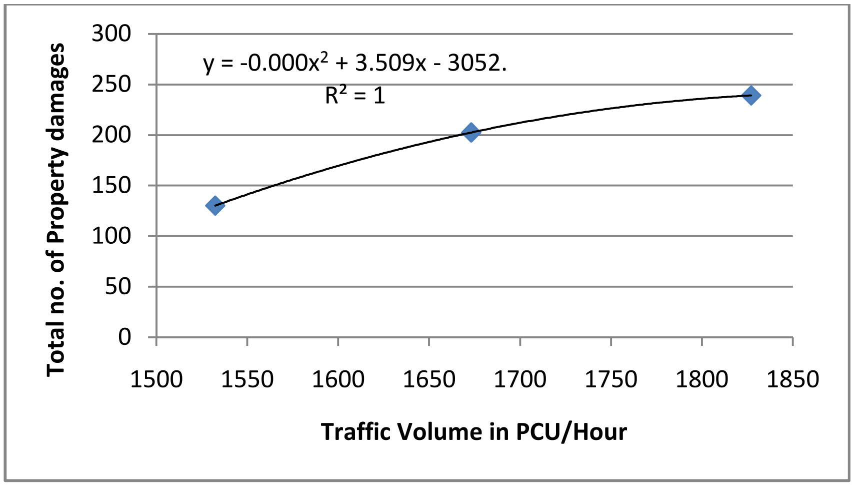


Fig. 4.11:- Scatter diagram of Total Damages V/s Traffic volume in PCU per hour.

Torhailoch – Bethel Black Spot

- **Total no. of accidents V/s Traffic volume in PCU per hour**.

Table 4.26: Torhailoch - Bethel Black Spot Total Number of Accidents and its Traffic Volume in PCU, Veh/hr

Year	Total No. of Accidents	Traffic Vol. in PCU Vehicle per hr
2012	79	1130.17
2013	123	1237.1
2014	146	1354.37

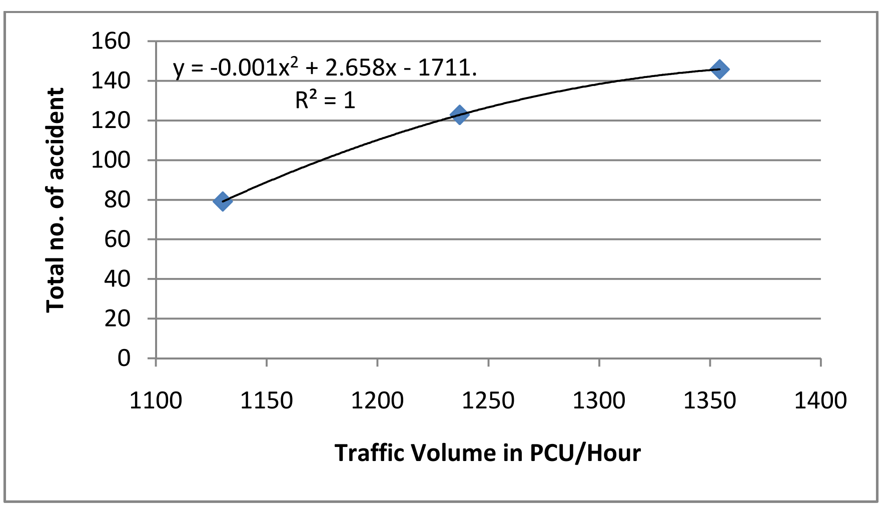


Fig. 4.12: Scatter diagram of Total no. of accidents V/s Traffic volume in PCU per hour.

- **Total no. of fatal accidents V/s Traffic volume in PCU per hour.**

Table 4.27: Torhailoch - Bethel Black Spot Total Number of fatal accidents and its Traffic Volume in PCU, Veh/hr

Year	Total No. of fatal Accidents	Traffic Vol. in PCU Vehicle per hr
2012	2	1130.17
2013	3	1237.1
2014	3	1354.37

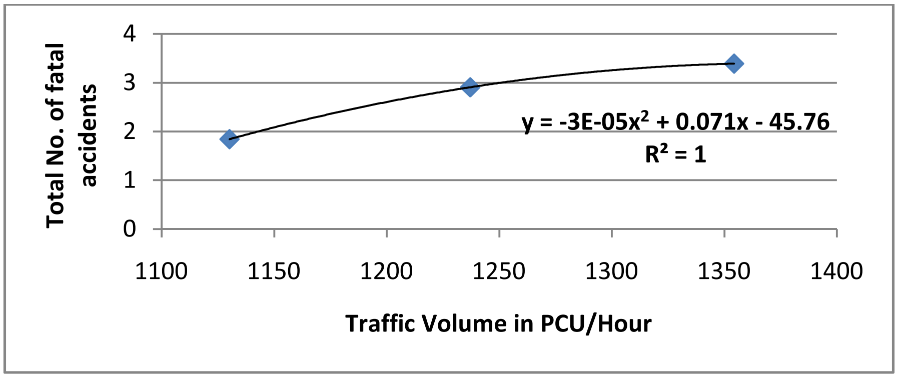


Fig. 4.13: Scatter diagram of Total no. of fatal accidents V/s Traffic volume in PCU per hour.

- **Total no. of Non-fatal accidents V/s Traffic volume in PCU per hour.**

Table 4.28: Torhailoch – Bethel Black Spot Total Number of non - fatal accidents and its Traffic Volume in PCU, Veh/hr

Year	Total No. of Non fatal Accidents	Traffic Vol. in PCU Vehicle per hr
2012	13	1130.17
2013	20	1237.1
2014	24	1354.37

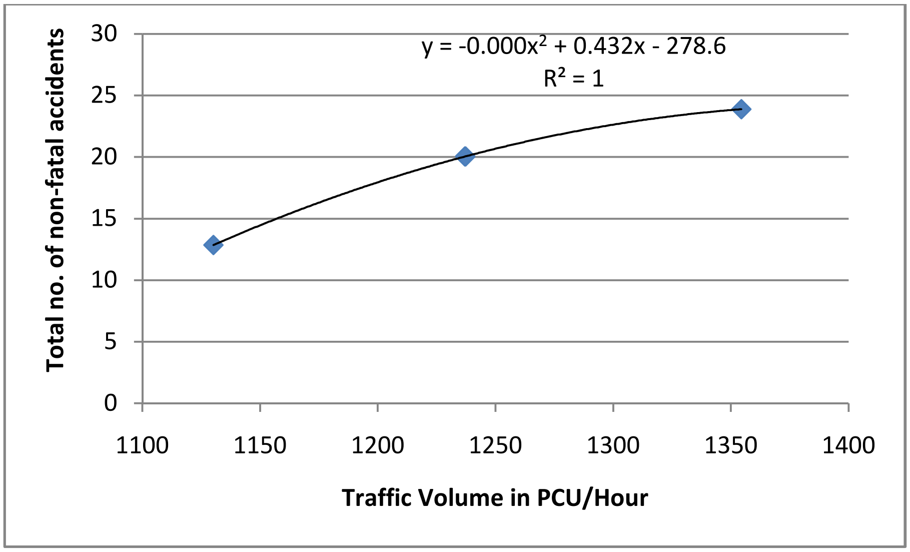


Fig. 4.14: Scatter diagram of Total no. of Non-Fatal accidents V/s Traffic volume in PCU per hour.

- **Total no. property damage V/s Traffic volume in PCU per hour.**

Table 4.29: Torhailoch – Bethel Black Spot Total Number of damages and its Traffic Volume in PCU, Veh/hr

Year	Total No. of Property damages	Traffic Vol. in PCU Vehicle per hr
2012	64	1130.17
2013	100	1237.1
2014	118	1354.37

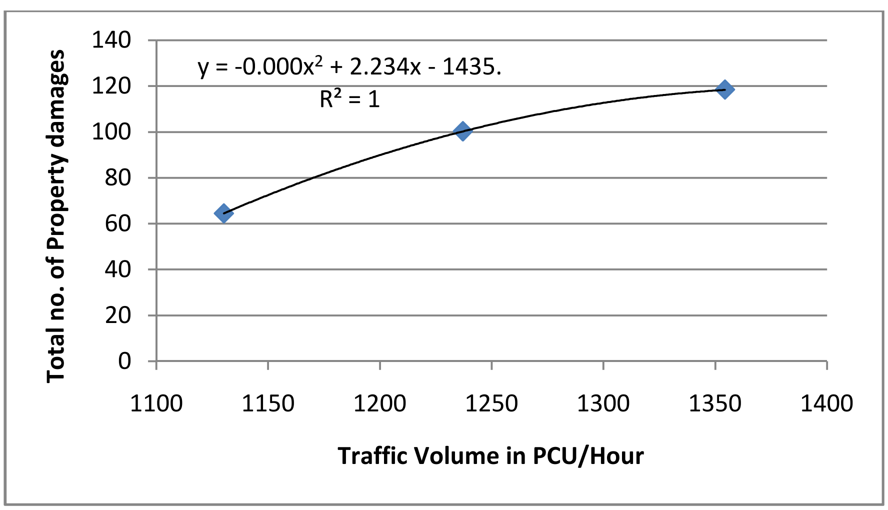


Fig. 4.15:- Scatter diagram of Total Damages V/s Traffic volume in PCU per hour.

KaraKore – W/Mariam

- **Total no. of accidents V/s Traffic volume in PCU per hour.**

Table 4.30: Kara – W/Mariam Black Spot Total Number of Accidents and its Traffic Volume in PCU, Veh/hr

Year	Total No. of Accidents	Traffic Vol. in PCU Vehicle per hr
2012	130	391.86
2013	201	430.55
2014	239	473.14

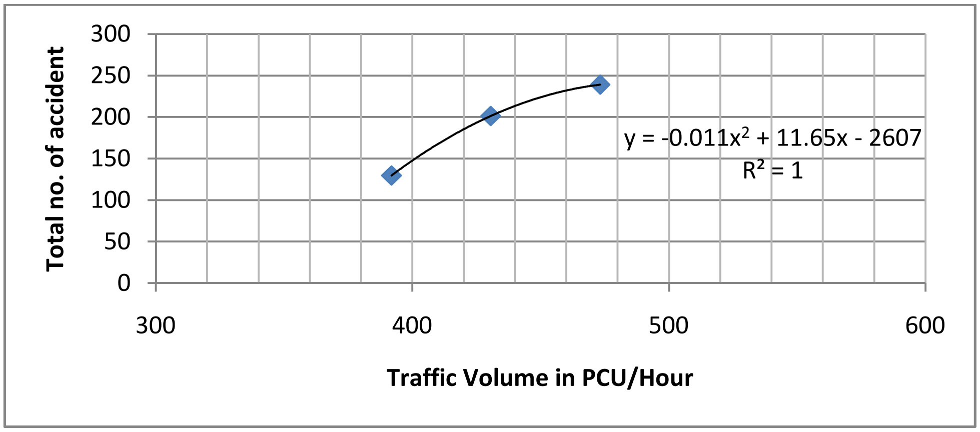


Fig. 4.16: Scatter diagram of Total no. of accidents V/s Traffic volume in PCU per hour.

- **Total no. of fatal accidents V/s Traffic volume in PCU per hour.**

Table 4.31: Kara – W/Mariam Black Spot Total Number of fatal accidents and its Traffic Volume in PCU, Veh/hr

Year	Total No. of fatal Accidents	Traffic Vol. in PCU Vehicle per hr
2012	3	391.86
2013	5	430.55
2014	6	473.14

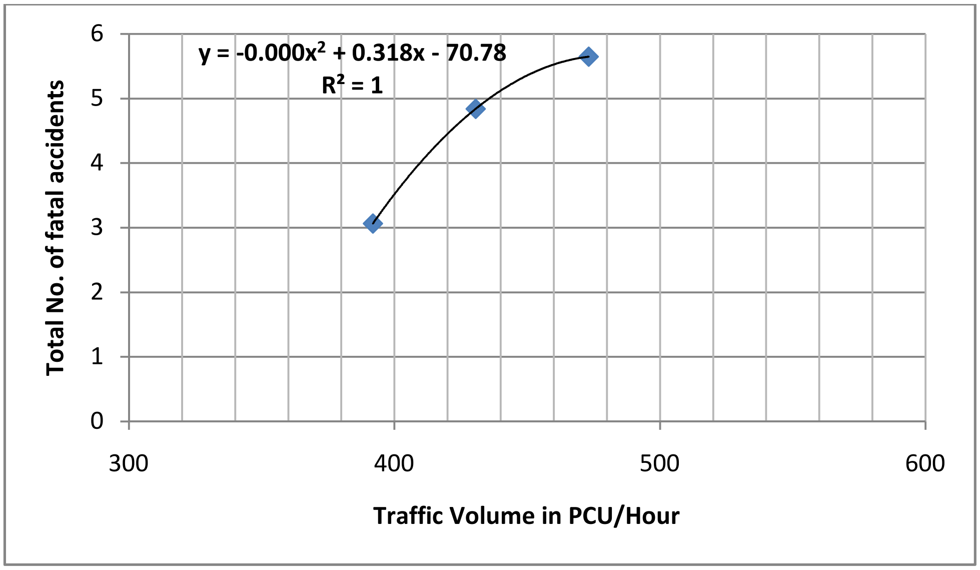


Fig. 4.17: Scatter diagram of Total no. of fatal accidents V/s Traffic volume in PCU per hour.

- **Total no. of Non-fatal accidents V/s Traffic volume in PCU per hour.**

Table 4.32: Kara – W/Mariam Black Spot Total Number of non - fatal accidents and its Traffic Volume in PCU, Veh/hr

Year	Total No. of Non fatal Accidents	Traffic Vol. in PCU Vehicle per hr
2012	21	391.86
2013	33	430.55
2014	40	473.14

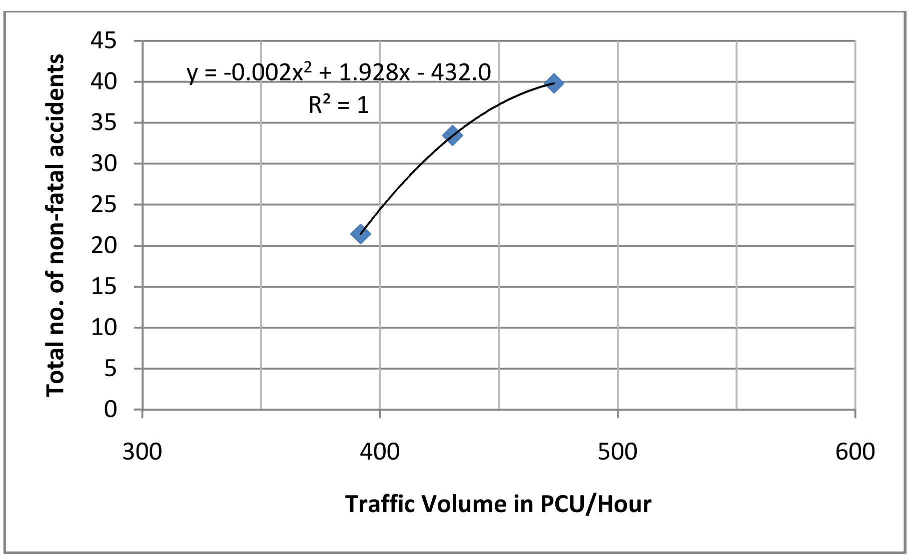


Fig. 4.18: Scatter diagram of Total no. of Non-Fatal accidents V/s Traffic volume in PCU per hour.

- **Total no. property damage V/s Traffic volume in PCU per hour.**

Table 4.33: Kara – W/Mariam Black Spot Total Number of damages and its Traffic Volume in PCU, Veh/hr

Year	Total No. of Property damages	Traffic Vol. in PCU Vehicle per hr
2012	105	391.86
2013	163	430.55
2014	193	473.14

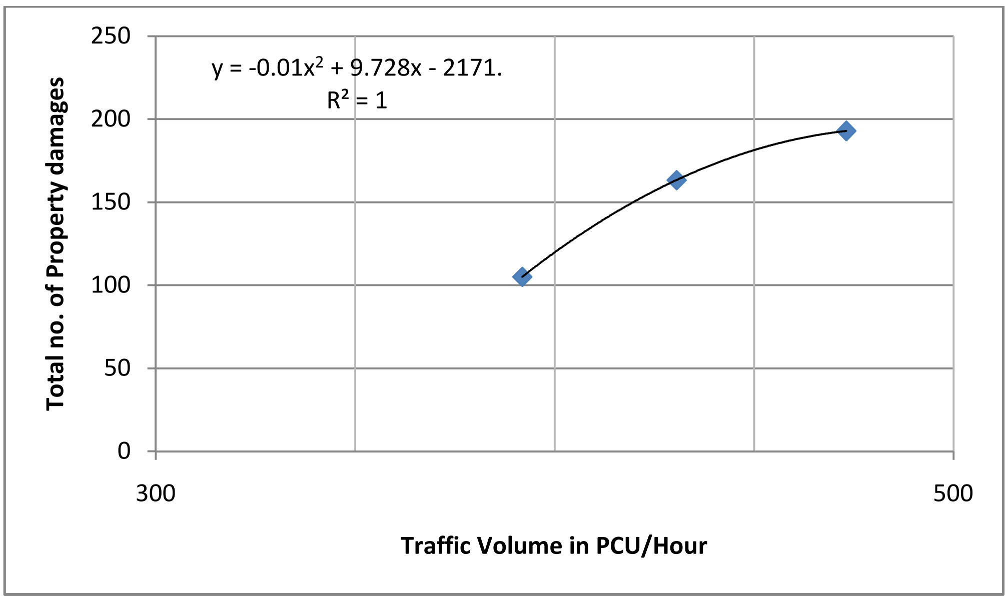


Fig. 4.19:- Scatter diagram of Total Damages V/s Traffic volume in PCU per hour.

Generally, it is observed from the analysis that as in all selected Black Spot areas:-

- The total number of accident increases when increase in Passenger Car Units in all Black spot areas from 2012 – 2015.
- The Total number of fatal accidents is also increases when increases in Passenger Car Units.
- Total number of non-fatal accidents is also increases when the passenger Car unit also increases simultaneously.
- Number of accidents with Property Damage is also increases as similar to the others.

4.5. Analysis of Capacity and level of service

Taking in to consideration all the above geometric and traffic summarized data which are obtained from AACRA and site observation, the capacity and level of service of each lane is precedes using three performance characteristics (Flow rate in passenger, pc/h/ln Average passenger car speed and Density) at current condition of the BS's.

For traffic data analysis percentage of heavy vehicles (bus and truck) are essential. The data which is shown table 4.15 converted to passenger car unit and also computed percentage of heavy vehicle as shown below.

Table 4.15: - Total number of vehicle and Percentage of heavy vehicle

No	Assigned Road Segment	Heavy Vehicles			Light vehicles	Total No. of Veh/h	Percentage of heavy veh. (PT)
		Buses	Truck	Total			
1	Torhailoch - Bethel	230	38	268	920	1188	22.56
2	Total - Zenebewerk	419	43	462	1042	1504	30.72
3	Karakore - Weletemariam	42	16	58	393	451	12.86

4.5.1 Flow Rate Analysis (Vp)

The basic approach is to convert the existing or forecast demand volumes to an equivalent flow rate under ideal conditions table 4.13 shows flow rate demand analysis :-

$$Vp = \frac{V}{(PHF * N * fHV * fP)}$$

Where:

V_p = demand flow rate under equivalent ideal conditions, pc/h/ln

PHF = peak-hour factor

N = number of lanes (in one direction) on the facility

f_{HV} = adjustment factor for presence of heavy vehicles $= \frac{1}{(1+PT(ET-1)+PR(ER-1))}$

PT = Portion of trucks and buses

PR = Portion of recreational vehicles

ET = Passenger car equivalency for trucks

ER = Passenger car equivalency for recreational vehicle

f_p = adjustment factor for presence of occasional or non-familiar users of a facility

Table 4.16: - Summarized Flow Rate at selected black spot areas at peak hour

No	Assigned Road Segment	Traffic Veh/h	PT	ET	RV	$f_{HV} = 1/(1+PT(ET-1))$	PHF	N	f_P	Demand Flow $VP = V/((PHF)*(N)*(f_P)*(f_{HV})$ (Pc/h/ln)
1	Torhailoch - Bethel	1188	0.2256	2.17	0	0.791	0.870968	3	0.98	587
2	Total - Zenebewerk	1504	0.3072	2.17	0	0.736	0.961637	3	0.98	723
3	Karakore - Weletemariam	451	0.1286	2.17	0	0.869	0.880859	1	0.98	601

4.5.2 Determining the Free-Flow Speed (FFS)

The free-flow speed of a main line of multilane can be determined on site during low to moderate traffic flow or can be estimated as follows base on HCM 2000 Manual:

$$FFS = BFFS - f_{LW} - f_{LC} - f_M - f_A$$

Where: - FFS = Free-Flow Speed of the multilane highway, mi/h

BFFS = Base free-flow speed

f_{LW} = adjustment for lane width, mi/h

f_{LC} = adjustment for lateral clearance, mi/h

f_M = adjustment for type median, mi/h

f_A = adjustment for access point, mi/h

Base Free – Flow Speed (BFFS) = According to AACRA Speed Parameters 2004, base free-flow speed of the freeway (110km/h for urban and suburban freeways, 120km/h for rural freeways) for only main lines.

Lane Width Adjustment (f_{LW}) :- the base lane width for multilane highways is 12 ft (3.66m) , as was the case for free- ways. For narrower lanes, the free-flow speed is reduced by the values shown in Table 4.17.

Table 4.17: Adjustment to Free-Flow Speed for Lane Width on a Multilane Highway (Source: HCM D 2000 manual)

Lane Width (ft)	Reduction in Free Flow Speed, f_{LW} (mi/h)
≥ 12.00	0.00
11.00	1.90
10.00	6.60

Lateral Clearance Adjustment (f_{LC}):- For multilane highways, this adjustment is based on the total lateral clearance, which is the sum of the lateral clearances on the right side of the roadway and on the left (median) side of the roadway. While this seems like a simple concept, there are some details that must be observed:

Table 4.18: Adjustment to Free-Flow Speed for Total Lateral Clearance on a Multilane Highway (Source: HCM D 2000 manual)

4-Lane Multilane Highways		6-Lane Multilane Highways	
Total Lateral Clearance (ft)	Reduction in Free- Flow Speed, f_{Lc} (mi/h)	Total Lateral Clearance (ft)	Reduction in Free- Flow Speed, f_{Lc} (mi/h)
≥ 12	0.00	≥ 12	0.00
10	0.40	10	0.40
8	0.90	8	0.90
6	1.30	6	1.30
4	1.80	4	1.70
2	3.60	2	2.80
0	5.40	0	3.90

Median-Type Adjustment:- The median-type adjustment is shown in Table 4.19. A reduction of 1.6 mi/h is made for undivided configurations, while divided multilane highways, or multilane highways with two-way left-turn lanes, represent base conditions.

Table 4.19: Adjustment to Free-Flow Speed for Median Type on Multilane Highways (Source: HCM D 2000 manual)

Median Type	Reduction in Free - Flow Speed, f_M (mi/h)
Undivided	1.60
TWLTLs	0.00
Divided	0.00

Access-Point Density Adjustment: - A critical adjustment to base free-flow speed is related to access-point density. Access-point density is the average number of unsignalized driveways or roadways per mile that provide access to the multilane highway on the right side of the roadway (for the subject direction of traffic). Driveways or other entrances with little traffic, or that, for other reasons, do not affect driver behavior, should not be included in the access-point density. Adjustments are shown in Table 4.20.

Table 4.20: Adjustment to Free-Flow Speed for Access-Point Density on a Multilane Highway (Source: HCM D 2000 manual)

Access Density (Access Points/Mi)	Reduction in Free - Flow Speed, f_A (mi/h)
0	0.00
10	2.50
20	5.00
30	7.50
≥ 40	10.00

From geometric data main line of lane width is 3.5m it's lane adjustment factor is 1kph, lateral clearance is 0.75m and from table 4.18 adjustment factor of lateral clearance =4.10kph, to compute free flow speed of main line of freeway type median adjustment and Access Point adjustment also required on table 4.18 and 4.19 simultaneously .

Table 4.21: Adjustment Factors that used to calculate Free-Flow Speed

No	Adjustments	Values for factors (m)	Corresponding adjustment factors (KPh)
1	Lane Width	3.50	1.59
2	Lateral Clearance	0.75	4.10
3	Type Median	Divided	0.00
4	Access Point	0.00	0.00

Table 4.17: - Free – flow speed of selected black spot areas

No	Segment Name	Base Free - Flow Speed ,BFFS (Km/h)	f_{LW}	f_{LC}	f_M	f_A	FFS = FFS - f_{LW} - f_{LC} - f_M - f_A (mi/h)	FFS = FFS - f_{LW} - f_{LC} - f_M - f_A (KPh)
1	KaraKore - W/Mariam	80	1.59	3.19	0.00	0.00	***75.22***	46.72
2	Total - Zenebewerk	110	1.59	4.10	0.00	0.00	***104.31***	64.79
3	Torhailoch - Bethel	80	1.59	4.10	0.00	0.00	***74.31***	46.17

4.5.3 Analysis of Level of Service (LOS)

To determine the level of service which is expressed by average speed and maximum flow rate that means the amount of density defines the level of service of the road.

Table 4.18 - Average car speed, Density and LOS of each Accident Black-spot area

No.	Accident BS"s areas	Flow rate = Vp	Free - Flow Speed = FFS	Density , D = Vp/FFS	Level Of Service
1	Karakore - W/Mariam	601	46.72	13	B
2	Total - Zenebewerk	723	65	11	A
3	Torhailoch - Bethel	587	46.17	12.71	B

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study clearly shows that,

- ✓ It is found that the number of Total accidents, number of fatal accidents, the number of non – fatal (i.e. Serious & Light injuries) and property damage is increases when increase in Traffic volume at all the selected Black Spot areas from 2012 – 2015.
- ✓ The 50th percentile (the median) vehicle speed of the observed data set of Zenebework Bridge, Karakore and Tor-hayiloch are 67.94kph, 42.3kph and 42.30kph simultaneously. Therefore, at KaraKore – W/Mariam, Total – Zenebework Bridge and Tor-Hayiloch – Bethel BS's half of the observed vehicle speeds are moving below their Base Free – Flow Speed which is 80KPh, 110 KPh and 110KPh simultaneously.
- ✓ The 85th percentile of Karakore – W/Mariam, Total - Zenebework Bridge and Torhayiloch – Bethel BS'S are 56.67kph, 83.93kph and 56.67kph simultaneously. Therefore, 85th of the observed vehicles are still traveling below the Base Free – Flow Speed which is 80KPh, 110 KPh and 110KPh simultaneously.

  Note that, a 5-mph (≈10Kph according to AACRA manual) rule of thumb is used to determine whether the 85th percentile of speed is too high compared to the posted speed limit. If the 85th percentile of speed is 5 mph or more above the posted speed limit, the situation should be evaluated.
- ✓ The current Annual Average Daily Traffic (AADT) data at KaraKore – W/Mariam, Total – Zenebework and Torhayiloch – Bethel BS'S is 4,510Veh/day, 15,040veh/day and 11,880veh/day but the estimated Annual Average Daily Traffic design data is 14,868veh/day,22,302veh/day and 9,166.5veh/day simultaneously. This indicates that, all the current existing segments are not carrying beyond their capacity.
- ✓ The Density analysis of KaraKore – W/Mariam, Total – ZenebeWork bridge and Torhailoch – Bethel black-spots indicate that 13 Pc/Km/ln, 11 Pc/Km/ln and 13 Pc/Km/ln which tells the demand flow exceeds than capacity (v/c > l.00), queuing will occur and propagate upstream of the segment in question there may be delay depends upon the length of time that the condition exists .

- ✓ The Level Of service (LOS) of the selected black-spot areas are A and B, that means for Total - Zenebework Bridge l black spots , Level of service A is intended to describe free-flow operations. At these low densities, the operation of each vehicle is not greatly influenced by the presence of others. Speeds are not affected by flow in this level of service, and operation is at the free-flow speed. Lane changing, merging, and diverging maneuvers are easily accomplished, as many large gaps in lane flow exist. Short-duration lane blockages may cause the level of service to deteriorate somewhat, but do not cause significant disruption to flow. Average spacing between vehicles is a minimum of 148 m, or approximately 24 car lengths at this level of service. At KaraKore – W/Mariam and Torhailoch – Bethel Black Spots level of service B, drivers begin to respond to the existence of other vehicles in the traffic stream, although operation is still at the free-flow speed. Maneuvering within the traffic stream is still relatively easy, but drivers must be more vigilant in searching for gaps in lane flows. The traffic stream still has sufficient gaps to dampen the impact of most minor lane disruptions. Average spacing is a minimum of 89m, or approximately 15 car lengths.

5.2 RECOMMENDATION

- ✓ At KaraKore – W/Mariam Black spot, in order to minimize accidents and to accommodate the current and future traffic volume, it needs further treatment, like upgrading the existing road and route change.

- ✓ Public transport should be improved to address the road transport safety needs of vulnerable road users (passengers), e.g., setting standards on minibuses and to enforce their compliance.

- ✓ In each Black Spot area, there should be critical study of the causes/factors contributing to the incidence of Road Traffic Accidents. Such studies should be followed by the development and improvement of Road Infrastructures, improving traffic management system and law enforcement, traffic education for pedestrian and students, driver training and testing, and continuous inspection of vehicles perhaps monthly and special training programmes to drivers regularly. In general, appropriate traffic control system should be designed and implemented at each RTABS in each sub-city if the incidence of accident is to be reduced significantly in the city.
- ✓ File recording Systems should be organized and modified especially to those responsible authorities /organizations.
- ✓ Posted speed sign should be placed in clear and observable area.

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APPENDIX

Appendix A –1: Accident Record sheet of each sub – cities from 2004 – 2006E.C

Table: Kirkose Sub city Accident Record sheet

Major ABSs	Total Road Traffic Accidents	%	Rank
	No.		
Olompia	385	14.42	1
Kasanchis	365	13.67	2
Wollo - Sefer	319	11.93	3
Mexico - Square	292	10.94	4
Teshale - Garage	290	10.87	5
Meskel - Square	216	8.08	6
Bambis	208	7.80	7
Urael	206	7.70	8
Legahar	204	7.63	9
Stadium	186	6.95	10
Total	2670	100.00	

Table: Bole Sub city Accident Record sheet

Major ABSs	Total Road Traffic Accidents	%	Rank
	No.		
Megenagna - Imperial - Gerji	414	15.48	1
22- Mazoria - Lem -Hotel - Megenagna	400	14.95	2
Bole M/alem - Atlas - Raguel	277	10.37	3
Urael Zuria	267	9.99	4
Gurdshola - CMC - Meri	211	7.89	5
Imperial - Ras Hotel - Tele M/alem	201	7.51	6
Ras Hospital - Ring Road - Bole Mikael	191	7.13	7
Zerfeshewa - Shool - Gurd Shola	186	6.94	8
Gerji - Yerer	181	6.75	9
22 Mazoriya - Awuraris Hotel - Bole School	181	6.75	9
Japan Embassy - Ruwanda - Karamara Bridge	166	6.22	10
Total	2674	100.00	

Table: Arada Sub city Accident Record sheet

Major ABSs	Total Road Traffic Accidents		Rank
	No.	%	
Around Arat Kilo Square	*110*	*9.75*	*1*
Around Arat Kilo Palace	*81*	*7.22*	*2*
Minilik Square - Municipality	*69*	*6.14*	*3*
Around Abune Petros Square	*61*	*5.42*	*4*
Piassa Cinima Empire	*61*	*5.42*	*4*
Around Tewodros Square	*57*	*5.05*	*5*
Main Piassa	*57*	*5.05*	*5*
Kidist Mariam Church	*57*	*5.05*	*5*
Around Semen Hotel	*57*	*5.05*	*5*
Ras Mekonen Bridge	*45*	*3.97*	*6*
Around Sidist Kilo Lions Park	*45*	*3.97*	*6*
Piassa Atikilit Tera	*45*	*3.97*	*6*
Around Amist Kilo	*45*	*3.97*	*6*
Churchil Godana	*41*	*3.61*	*7*
Somalia Tera	*41*	*3.61*	*7*
Tourist Hotel (Arat Kilo)	*32*	*2.89*	*8*
Sebara Babur	*32*	*2.89*	*8*
Ginfile Bridge	*32*	*2.89*	*8*
Main Post Office	*28*	*2.53*	*9*
Downway to Sheraton Addis	*28*	*2.53*	*9*
Afincho Ber	*28*	*2.53*	*9*
Around Fikire Hotel (Arat Kilo)	*24*	*2.17*	*10*
Abakoran Sefer	*24*	*2.17*	*10*
Around Kelifa Building	*24*	*2.17*	*10*
Total	*1124*	*100.00*	

Table: Yeka Sub city Accident Record sheet

Major ABSs	Total Road Traffic Accidents		Rank
	No.	%	
Around Yeka Mobile	256	17.13	1
Wondirad School	223	14.89	2
Megenagna Cross Road	206	13.76	3
Around Lady Pastry	189	12.64	4
Around Zerihun Building	181	12.08	5
Et-fruit	176	11.80	6
Zerfeshebel School	59	3.93	7
Yeka Primary School	59	3.93	7
Jin Bank	55	3.65	8
Mission Pharmacy	50	3.37	9
Shola	42	2.81	10
Total	1496	100.00	

Table: Lideta Sub city Accident Record sheet

Major ABSs	Total Road Traffic Accidents		Rank
	No.	%	
Around Tor - Hayiloch	129	12.26	1
Tekle-Haimanot Square	117	11.14	2
Tikur Anibessa Hospital	97	9.19	3
Mexico Tegbareid	79	7.52	4
Mexico Square	76	7.24	5
Goma Kuteba	56	5.29	6
Senga Tera	56	5.29	6
Lideta Church	38	3.62	7
Amstegna Police Tabiya	38	3.62	7
Wabe Shebele Hotel	38	3.62	7
Di Africa Hotel	38	3.62	7
Philips Building	35	3.34	8
Berbere Berenda	35	3.34	8
National Theatre	29	2.79	9
Geja Sefer	29	2.79	9
Balcha Hospital	29	2.79	9
Awash Wein breway Factory	26	2.51	10
Immigiration	26	2.51	10
Sarbet Square	26	2.51	10
Cocka-Cola	26	2.51	10
Cigarette Factory	26	2.51	10
Total	1050	100.00	

Table: Lafto Sub city Accident Record sheet

Major ABSs	Total Road Traffic Accidents		Rank
	No.	%	
Hana Mariam	*300*	*18.31*	*1*
Goffa Gebreal	*277*	*16.90*	*2*
Around Sar-bet	*231*	*14.08*	*3*
Mekanissa School	*208*	*12.68*	*4*
Sarbet Mekanisa	*162*	*9.86*	*5*
Ring road Kebele 15/16	*139*	*8.45*	*6*
Adey Abeba	*116*	*7.04*	*7*
Goffa Camp	*92*	*5.63*	*8*
Around Saris	*69*	*4.23*	*9*
Mekanisa Alcohol Factory	*46*	*2.82*	*10*
Total	*1641*	*100.00*	

Table: Addis Ketema Sub city Accident Record sheet

Major ABSs	Total Road Traffic Accidents		Rank
	No.	%	
Around Bus Station	*93*	*12.58*	*1*
Mesalemiya	*73*	*9.95*	*2*
Gojam Berenda	*63*	*8.54*	*3*
Sebategna Mebrat	*63*	*8.54*	*3*
Cinima Ras	*53*	*7.14*	*4*
Minalesh Tera	*53*	*7.14*	*4*
Near Square	*39*	*5.26*	*5*
Near Amanuel	*39*	*5.26*	*5*
Tekle Haimanot	*39*	*5.26*	*5*
Near Made	*29*	*3.94*	*6*
Kuwas Meda	*22*	*3.00*	*7*
Post Office	*22*	*3.00*	*7*
Adarash	*22*	*3.00*	*7*
Addis Ketema	*20*	*2.72*	*8*
H/Giorgis Bridge	*20*	*2.72*	*8*
Kesel Tera to Chid Tera	*19*	*2.54*	*9*
Sefere Selam	*19*	*2.54*	*9*
Near Tana Tera	*19*	*2.54*	*9*
Chew Berenda	*16*	*2.16*	*10*
Arategna Police Station	*16*	*2.16*	*10*
Total	*737*	*100.00*	

Table: Akaki Sub city Accident Record sheet

Major ABSs	Total Road Traffic Accidents		Rank
	No.	%	
Saris Abo	401	26.83	1
Cheralia Biscuit Factory	292	19.51	2
Around Akaki Bridge	255	17.07	3
Near Gebriel	219	14.63	4
Akaki Health Station	182	12.20	5
Alem (world) Bank	146	9.76	6
Total	1495	100.00	

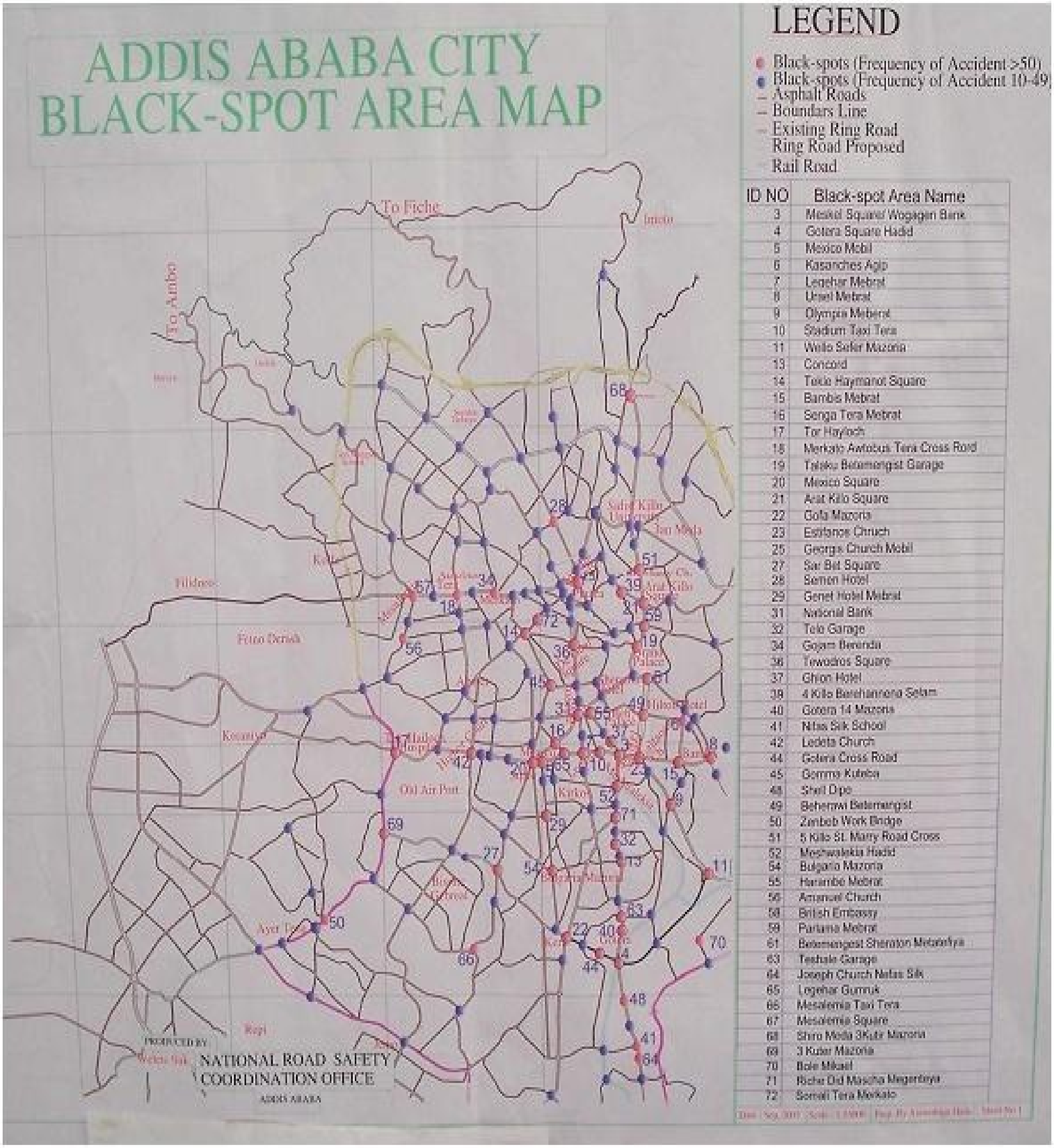
Table: Kolfe Sub city Accident Record sheet

Major ABSs	Total Road Traffic Accidents		Rank
	No.	%	
Zenebe Werk Ring Road	261	21.74	1
Kara Kore	209	17.39	2
Repi Soap Factory	130	10.87	3
Atana Tera Bridge	104	8.70	4
AyerTena	104	8.70	4
Holland Embassy	78	6.52	5
Near Natran Company	78	6.52	5
Koshe Sefer	78	6.52	5
Weyira Sefer	78	6.52	5
Kolfe Keraniyo	78	6.52	5
Total	1200	100.00	

Table: Gulele Sub city Accident Record sheet

Major ABSs	Total Road Traffic Accidents		Rank
	No.	%	
Near Addisu Gebeya	147	23.53	1
Entoto Mariam Church	110	17.65	2
Alem Tsehay Bridge	110	17.65	2
Menen - Shiromeda	110	17.65	2
Medihanialem Church	73	11.76	3
Near Rufael Church	73	11.76	3
Total	624	100.00	

Appendix A-2: - Addis Ababa City Black – Spot Area Map



Appendix A-3: Photo on Post Speed Sign

Figure: posted speed location around Zenebe Work Bridge

Appendix A-4: Capacity and Level of Service

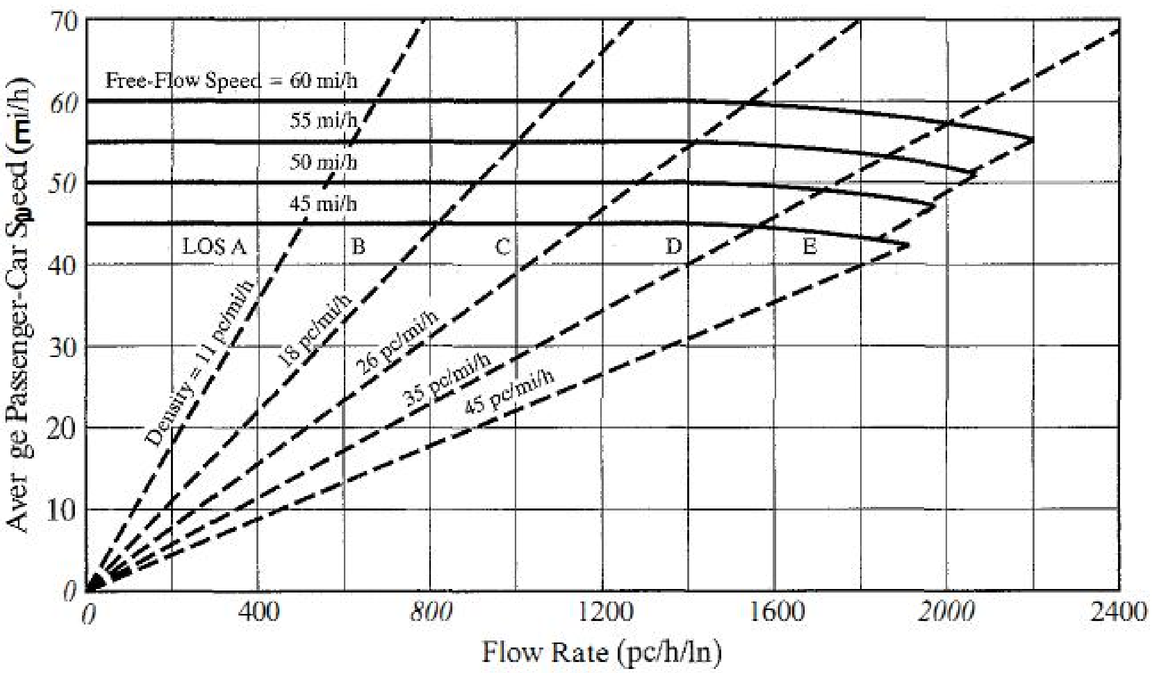


Figure:-Speed-Flow Curves for Multilane Highway Sections (Highway Capacity Manual, Dec 2000)

Appendix A - 5: - KaraKore Daily Traffic data

TRAFFIC COUNT TALLY SHEET Sheet : **-2-**

Name of Road /Street :- **Kara Kore Road** No.: .... Direction From: **Kara Kore (Gate)** To: **Welete Mariam**

Station Name: .... Station No. : .... Date: **18, August , 2015** *(Tuesday)*

Enumerator : **Ato A. Z.** Supervisor: **M. B.**

Hours Counted	Category	Cars	Light	Medium	Heavy	Articulated	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
	Includes	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
6:00 - 7:00 A.M		*38*	*19*	*2*	*12*	*7*	*78*
7:00 - 8:00 A.M		*367*	*37*	*9*	*7*	*9*	*429*
8:00 - 8:15 A.M		*111*	*12*	*3*	*1*	*1*	*128*
8:15 - 8:30 A.M		*103*	*11*	*3*	*1*	*1*	*119*
8:30 - 8:45 A.M		*98*	*10*	*2*	*1*	*1*	*112*
8:45- 9:00 A.M		*81*	*9*	*2*	*1*	*1*	*94*
9:00 - 10:00 A.M		*155*	*17*	*11*	*11*	*14*	*208*
10:00 - 11:00 A.M		*110*	*13*	*12*	*9*	*7*	*151*
11:00 - 12:00A.M		*103*	*11*	*9*	*7*	*5*	*135*
12:00 - 1:00 P.M		*111*	*15*	*9*	*8*	*6*	*149*
1:00 - 2:00 P.M		*99*	*10*	*13*	*2*	*6*	*130*
2:00 - 3:00 P.M		*98*	*3*	*15*	*1*	*2*	*119*
3:00 - 4:00 P.M		*100*	*2*	*11*	*0*	*4*	*117*
4:00 - 5:00 P.M		*343*	*23*	*8*	*7*	*7*	*388*
5:00 - 6:00 P.M		*393*	*10*	*7*	*5*	*1*	*416*
Total		***2310***	***202***	***116***	***73***	***72***	***2773***

TRAFFIC COUNT TALLY SHEET Sheet : **-3-**

Name of Road /Street :- **Kara Kore Road** No.: .... Direction From: **Kara Kore (Gate)** To: **Welete Mariam**

Station Name: .... Station No. : .... Date: **19 , August , 2015** *(Wednseday)*

Enumerator : **Ato A. Z.** Supervisor: **M. B.**

Hours Counted	Category	Cars	Light	Medium	Heavy	Articulated	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
	Includes	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
6:00 - 7:00 A.M		*92*	*16*	*13*	*5*	*3*	*129*
7:00 - 8:00 A.M		*234*	*32*	*15*	*2*	*1*	*284*
8:00 - 9:00 A.M		*223*	*25*	*5*	*5*	*5*	*263*
9:00 - 10:00 A.M		*84*	*11*	*10*	*10*	*6*	*121*
10:00 - 11:00 A.M		*63*	*8*	*7*	*7*	*3*	*88*
11:00 - 12:00A.M		*67*	*9*	*3*	*6*	*2*	*87*
12:00 - 1:00 P.M		*67*	*9*	*5*	*5*	*2*	*88*
1:00 - 2:00 P.M		*55*	*10*	*4*	*1*	*2*	*72*
2:00 - 3:00 P.M		*59*	*11*	*7*	*2*	*1*	*80*
3:00 - 4:00 P.M		*71*	*1*	*7*	*0*	*2*	*81*
4:00 - 5:00 P.M		*213*	*24*	*15*	*8*	*3*	*263*
5:00 - 6:00 P.M		*256*	*29*	*5*	*3*	*3*	*296*
6:00 - 7:00 P.M		*247*	*23*	*6*	*4*	*2*	*282*
7:00 - 8:00 P.M		*212*	*22*	*8*	*3*	*2*	*247*
8:00 - 9:00 P.M		*121*	*13*	*7*	*3*	*3*	*147*
9:00 - 10:00 P.M		*50*	*4*	*5*	*2*	*2*	*63*
10:00 - 11:00 P.M		*31*	*1*	*2*	*1*	*2*	*37*
11:00 - 12:00 P.M		*13*		*1*	*0*	*0*	*14*
12:00 - 1:00 A.M		*8*			*0*	*0*	*8*
1:00 - 2:00 A.M		*2*			*0*	*0*	*2*
2:00 - 3:00 A.M					*0*	*0*	*0*

3:00 - 4:00 A.M					*0*	*0*	*0*
4:00 - 5:00 A.M		*5*			*4*	*0*	*9*
5:00 - 6:00 A.M		*7*	*5*	*5*	*3*	*1*	*21*
Total		***2180***	***253***	***130***	***74***	***45***	***2682***

TRAFFIC COUNT TALLY SHEET Sheet : **-4-**

Name of Road /Street :- **Kara Kore Road** No.: .... Direction From: **Kara Kore (Gate)** To: **Welete Mariam**

Station Name: .... Station No. : .... Date: **20, August , 2015** *(Thursday)*

Enumerator : **Ato A. Z.** Supervisor: **M. B.**

Hours Counted	***Category***	***Cars***	***Light***	***Medium***	***Heavy***	***Articulated***	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
	Includes	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
6:00 - 7:00 A.M		*33*	*13*	*3*	*7*	*4*	*60*
7:00 - 8:00 A.M		*318*	*23*	*6*	*4*	*2*	*353*
8:00 - 9:00 A.M		*294*	*21*	*7*	*2*	*4*	*328*
9:00 - 10:00 A.M		*127*	*11*	*8*	*5*	*5*	*156*
10:00 - 11:00 A.M		*98*	*8*	*8*	*4*	*3*	*121*
11:00 - 12:00A.M		*86*	*7*	*5*	*6*	*2*	*106*
12:00 - 1:00P.M		*84*	*7*	*5*	*6*	*2*	*104*
1:00 - 2:00 P.M		*76*	*6*	*8*	*2*	*2*	*94*
2:00 - 3:00 P.M		*86*	*3*	*10*	*1*	*2*	*102*
3:00 - 4:00 P.M		*89*	*3*	*7*	*3*	*2*	*104*
4:00 - 5:00 P.M		*271*	*14*	*3*	*2*	*4*	*294*
5:00 - 6:00 P.M		*316*	*11*	*7*	*4*	*2*	*340*
6:00 - 7:00 P.M		*310*	*16*	*5*	*3*	*2*	*336*
7:00 - 8:00 P.M		*249*	*14*	*5*	*3*	*2*	*273*
8:00 - 9:00 P.M		*151*	*13*	*6*	*2*	*3*	*175*

9:00 - 10:00 P.M		*45*	*4*	*4*	*1*	*1*	*55*
10:00 - 11:00 P.M		*34*	*1*	*2*	*0*	*0*	*37*
11:00 - 12:00 P.M		*14*	*0*	*0*	*0*	*0*	*14*
12:00 - 1:00 A.M		*10*	*0*	*0*	*0*	*0*	*10*
1:00 - 2:00 A.M		*2*	*0*	*0*	*0*	*0*	*2*
2:00 - 3:00 A.M		*0*	*0*	*0*	*0*	*0*	*0*
3:00 - 4:00 A.M		*0*	*0*	*0*	*0*	*0*	*0*
4:00 - 5:00 A.M		*6*	*0*	*0*	*0*	*0*	*6*
5:00 - 6:00 A.M		*9*	*5*	*3*	*1*	*2*	*20*
Total		***2708***	***180***	***102***	***56***	***44***	***3090***

Appendix A - 6: - ZenebeWork Daily Traffic data

TRAFFIC COUNT TALLY SHEET

Sheet : -2-

Name of Road /Street :- *Zenebework bridge* No.: .... Direction From: *Total (3kutir Mazoriya)* To: *Alert Hospital*

Station Name: .... Station No. : .... Date: **18, August , 2015** *(Tuesday)*

Enumerator : **Ato Z. M.** Supervisor: **Mr. M. B.**

Hours Counted	Category	Cars	Light	Medium	Heavy	Articulated	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
	Includes	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
6:00 - 7:00 A.M		*543*	*115*	*25*	*8*	*1*	*692*
7:00 - 8:00 A.M		*1001*	*274*	*27*	*14*	*2*	*1318*
8:00 - 9:00 A.M		*1040*	*404*	*32*	*17*	*1*	*1494*
9:00 - 9:15 A.M		*271*	*109*	*7*	*4*	*0*	*391*
9:15 - 9:30 A.M		*269*	*108*	*7*	*4*	*1*	*389*
9:30 - 9:45 A.M		*252*	*101*	*7*	*4*	*0*	*364*
9:45 - 10:00 A.M		*250*	*101*	*6*	*3*	*0*	*360*
10:00 - 11:00 A.M		*931*	*405*	*25*	*14*	*2*	*1377*
11:00 - 12:00A.M		*749*	*360*	*19*	*14*	*0*	*1142*
12:00 - 1:00 P.M		*736*	*280*	*16*	*6*	*0*	*1038*
1:00 - 2:00 P.M		*591*	*179*	*11*	*2*	*0*	*783*
2:00 - 3:00 P.M		*622*	*178*	*10*	*0*	*2*	*812*
3:00 - 4:00 P.M		*568*	*161*	*10*	*1*	*1*	*741*
4:00 - 5:00 P.M		*552*	*211*	*12*	*3*	*1*	*779*
5:00 - 6:00 P.M		*986*	*241*	*7*	*5*	*1*	*1240*
Total		***9361***	***3227***	***221***	***99***	***12***	***12920***

TRAFFIC COUNT TALLY SHEET Sheet : **-3-**

Name of Road /Street :- ***Zenebework bridge*** No.: .... Direction From: ***Total (3kutir Mazoriya)*** To: ***Alert Hospital***

Station Name: .... Station No. : .... Date: **19 , August , 2015 (Wensday)**

(Wednseday)

Enumerator : **Ato Z. M.** Supervisor: ***Mr. M. B.***

Hours Counted	***Category***	***Cars***	***Light***	***Medium***	***Heavy***	***Articulated***	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
	Includes	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
6:00 - 7:00 A.M		*541*	*54*	*22*	*6*	*1*	*624*
7:00 - 8:00 A.M		*998*	*134*	*25*	*12*	*2*	*1171*
8:00 - 9:00 A.M		*1037*	*199*	*29*	*15*	*1*	*1281*
9:00 - 10:00 A.M		*1039*	*207*	*24*	*13*	*2*	*1285*
10:00 - 11:00 A.M		*928*	*200*	*22*	*12*	*2*	*1164*
11:00 - 12:00A.M		*746*	*177*	*16*	*12*	*0*	*951*
12:00 - 1:00 P.M		*731*	*137*	*13*	*4*	*0*	*885*
1:00 - 2:00 P.M		*587*	*87*	*8*	*2*	*0*	*684*
2:00 - 3:00 P.M		*618*	*86*	*8*	*1*	*2*	*715*
3:00 - 4:00 P.M		*563*	*78*	*8*	*0*	*2*	*651*
4:00 - 5:00 P.M		*548*	*103*	*9*	*3*	*1*	*664*
5:00 - 6:00 P.M		*982*	*117*	*4*	*4*	*1*	*1108*
6:00 - 7:00 P.M		*979*	*108*	*7*	*4*	*1*	*1099*
7:00 - 8:00 P.M		*841*	*105*	*5*	*3*	*1*	*955*
8:00 - 9:00 P.M		*559*	*62*	*5*	*3*	*1*	*630*
9:00 - 10:00 P.M		*403*	*49*	*3*	*3*	*1*	*459*
10:00 - 11:00 P.M		*253*	*34*	*2*	*0*	*0*	*289*
11:00 - 12:00 P.M		*79*	*3*	*1*	*0*	*0*	*83*
12:00 - 1:00 A.M		*16*	*0*	*0*	*0*	*0*	*16*

1:00 - 2:00 A.M		*1*	*0*	*0*	*0*	*0*	*1*
2:00 - 3:00 A.M		*0*	*0*	*0*	*0*	*0*	*0*
3:00 - 4:00 A.M		*0*	*0*	*0*	*0*	*0*	*0*
4:00 - 5:00 A.M		*5*	*0*	*3*	*1*	*0*	*9*
5:00 - 6:00 A.M		*61*	*24*	*8*	*3*	*2*	*98*
Total		***12515***	***1964***	***222***	***101***	***20***	***14822***

TRAFFIC COUNT TALLY SHEET Sheet : **-4-**

Name of Road /Street :- ***Zenebework bridge*** No.: .... Direction From: ***Total (3kutir Mazoriya)*** To: ***Alert Hospital***

Station Name: .... Station No. : .... Date: **20, August , 2015** *(Thursday)*

Enumerator : **Ato Z. M.** Supervisor: ***Mr. M. B.***

Hours Counted	***Category***	***Cars***	***Light***	***Medium***	***Heavy***	***Articulated***	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
	Includes	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
6:00 - 7:00 A.M		*469*	*32*	*20*	*3*	*0*	*524*
7:00 - 8:00 A.M		*1032*	*111*	*22*	*10*	*1*	*1176*
8:00 - 9:00 A.M		*1072*	*176*	*26*	*12*	*1*	*1287*
9:00 - 10:00 A.M		*1073*	*184*	*21*	*11*	*1*	*1290*
10:00 - 11:00 A.M		*962*	*177*	*19*	*10*	*1*	*1169*
11:00 - 12:00A.M		*780*	*154*	*13*	*10*	*0*	*957*
12:00 - 1:00P.M		*767*	*114*	*10*	*2*	*0*	*893*
1:00 - 2:00 P.M		*622*	*64*	*5*	*1*	*0*	*692*
2:00 - 3:00 P.M		*653*	*63*	*4*	*1*	*1*	*722*
3:00 - 4:00 P.M		*599*	*55*	*4*	*1*	*1*	*660*
4:00 - 5:00 P.M		*583*	*80*	*6*	*0*	*1*	*670*
5:00 - 6:00 P.M		*1017*	*95*	*7*	*1*	*1*	*1121*

6:00 - 7:00 P.M		*1007*	*109*	*8*	*4*	*1*	*1129*
7:00 - 8:00 P.M		*838*	*105*	*6*	*4*	*1*	*954*
8:00 - 9:00 P.M		*559*	*62*	*6*	*4*	*1*	*632*
9:00 - 10:00 P.M		*403*	*50*	*2*	*3*	*1*	*459*
10:00 - 11:00 P.M		*133*	*34*	*2*	*2*	*1*	*172*
11:00 - 12:00 P.M		*70*	*5*	*2*	*1*	*0*	*78*
12:00 - 1:00 A.M		*16*	*3*	*1*	*0*	*0*	*20*
1:00 - 2:00 A.M		*1*	*2*	*0*	*0*	*0*	*3*
2:00 - 3:00 A.M		*0*	*0*	*0*	*0*	*0*	*0*
3:00 - 4:00 A.M		*0*	*0*	*2*	*0*	*0*	*2*
4:00 - 5:00 A.M		*67*	*3*	*4*	*0*	*0*	*74*
5:00 - 6:00 A.M		*70*	*26*	*9*	*5*	*2*	*112*
Total		***12793***	***1704***	***199***	***85***	***15***	***14796***

Appendix A - 7: - Torhailoch - Bethel Daily Traffic data

TRAFFIC COUNT TALLY SHEET Sheet : -2-

Name of Road /Street :- ***Tor Hayiloch*** No.: .... Direction From: ***Tor Hayiloch*** To: ***Ashewa Meda /Bethel/***

Station Name: .... Station No. : .... Date: **18, August , 2015** *(Tuesday)*

Enumerator : ***Ato T. K.*** Supervisor: ***Mr. M. B.***

Hours Counted	Category	Cars	Light	Medium	Heavy	Articulated	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
	Includes	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
6:00 - 7:00 A.M		*409*	*31*	*22*	*9*	*1*	*472*
7:00 - 8:00 A.M		*866*	*125*	*24*	*15*	*2*	*1032*
8:00 - 9:00 A.M		*905*	*203*	*28*	*17*	*1*	*1154*
9:00 - 10:00 A.M		*907*	*212*	*23*	*17*	*2*	*1161*
10:00 - 11:00 A.M		*796*	*204*	*21*	*15*	*2*	*1038*
11:00 - 12:00A.M		*614*	*178*	*15*	*13*	*0*	*820*
12:00 - 1:00 P.M		*586*	*129*	*14*	*6*	*0*	*735*
1:00 - 2:00 P.M		*441*	*68*	*9*	*2*	*0*	*520*
2:00 - 3:00 P.M		*473*	*68*	*8*	*1*	*2*	*552*
3:00 - 4:00 P.M		*418*	*59*	*8*	*1*	*1*	*487*
4:00 - 5:00 P.M		*402*	*88*	*10*	*3*	*1*	*504*
5:00 - 6:00 P.M		*836*	*98*	*5*	*5*	*1*	*945*
Total		***7653***	***1463***	***187***	***104***	***13***	***9420***

TRAFFIC COUNT TALLY SHEET Sheet : -3-

Name of Road /Street :- ***Tor Hayiloch*** No.: .... Direction From: ***Tor Hayiloch*** To: ***Ashewa Meda /Bethel/***

Station Name: .... Station No. : .... Date: **19 , August , 2015** *(Wednseday)*

Enumerator : ***Ato T. K.*** Supervisor: ***Mr. M. B.***

Hours Counted	***Category***	***Cars***	***Light***	***Medium***	***Heavy***	***Articulated***	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
	Includes	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
6:00 - 7:00 A.M		*404*	*37*	*20*	*4*	*1*	*466*
7:00 - 8:00 A.M		*857*	*135*	*21*	*12*	*2*	*1027*
8:00 - 9:00 A.M		*896*	*213*	*26*	*16*	*1*	*1152*
9:00 - 10:00 A.M		*898*	*222*	*21*	*14*	*1*	*1156*
10:00 - 11:00 A.M		*787*	*214*	*19*	*13*	*2*	*1035*
11:00 - 12:00A.M		*605*	*187*	*13*	*12*	*1*	*818*
12:00 - 1:00 P.M		*590*	*137*	*10*	*3*	*0*	*740*
1:00 - 2:00 P.M		*446*	*78*	*5*	*1*	*0*	*530*
2:00 - 3:00 P.M		*477*	*77*	*4*	*0*	*1*	*559*
3:00 - 4:00 P.M		*422*	*67*	*4*	*0*	*1*	*494*
4:00 - 5:00 P.M		*407*	*97*	*6*	*2*	*1*	*513*
5:00 - 6:00 P.M		*841*	*115*	*3*	*3*	*1*	*963*
6:00 - 7:00 P.M		*838*	*98*	*5*	*4*	*1*	*946*
7:00 - 8:00 P.M		*694*	*86*	*4*	*3*	*0*	*787*
8:00 - 9:00 P.M		*418*	*49*	*3*	*3*	*0*	*473*
9:00 - 10:00 P.M		*262*	*33*	*2*	*2*	*0*	*299*
10:00 - 11:00 P.M		*112*	*14*	*1*	*0*	*0*	*127*
11:00 - 12:00 P.M		*45*	*2*	*1*	*1*	*0*	*49*
12:00 - 1:00 A.M		*8*	*0*	*0*	*0*	*0*	*8*

1:00 - 2:00 A.M		1	0	0	0	0	1
2:00 - 3:00 A.M		0	0	0	0	0	0
3:00 - 4:00 A.M		0	0	0	0	0	0
4:00 - 5:00 A.M		3	0	0	0	1	4
5:00 - 6:00 A.M		21	14	5	4	2	46
Total		**10032**	**1875**	**173**	**97**	**16**	**12193**

TRAFFIC COUNT TALLY SHEET

Sheet : -4-

Name of Road /Street :- *Tor Hayiloch* No.: .... Direction From: *Tor Hayiloch* To: *Ashewa Meda /Bethel/*

Station Name: .... Station No. : .... Date: 20, August , 2015 *(Thursday)*

Enumerator : *Ato T.K.* Supervisor: *Mr. M. B.*

Hours Counted	*Category*	*Cars*	*Light*	*Medium*	*Heavy*	*Articulated*	Total
	Axles	2	2	3	4	> 4	
	Tyres	4	6	10	14	> 14	
	Length	< 3m	3m - 7.5m	3m - 7.5m	>7.5m	> 7.5m	
	GVW	< 3.5T	3.5T -12T	>12T	> 12T	> 12T	
	Includes	Cars	Bus	2 Rear axle Truck	4 Axle Truck	Large Truck	
6:00 - 7:00 A.M		423	47	20	5	1	496
7:00 - 8:00 A.M		879	142	22	13	1	1057
8:00 - 9:00 A.M		919	221	27	17	1	1185
9:00 - 9:15A.M		265	66	6	4	0	341
9:15 - 9:30A.M		253	63	6	4	0	326
9:30 - 9:45A.M		244	61	6	4	0	315
9:45 - 10:00A.M		158	40	4	3	1	206
10:00 - 11:00 A.M		809	221	20	14	1	1065
11:00 - 12:00A.M		628	194	14	13	0	849
12:00 - 1:00P.M		613	146	11	2	0	772
1:00 - 2:00 P.M		468	86	7	2	0	563
2:00 - 3:00 P.M		499	85	5	1	1	591
3:00 - 4:00 P.M		443	76	5	1	1	526

4:00 - 5:00 P.M		*429*	*105*	*7*	*3*	*1*	*545*
5:00 - 6:00 P.M		*863*	*122*	*4*	*4*	*1*	*994*
6:00 - 7:00 P.M		*860*	*111*	*6*	*5*	*1*	*983*
7:00 - 8:00 P.M		*722*	*107*	*5*	*4*	*1*	*839*
8:00 - 9:00 P.M		*439*	*56*	*4*	*4*	*0*	*503*
9:00 - 10:00 P.M		*248*	*38*	*3*	*2*	*0*	*291*
10:00 - 11:00 P.M		*106*	*20*	*2*	*1*	*0*	*129*
11:00 - 12:00 P.M		*40*	*4*	*1*	*0*	*0*	*45*
12:00 - 1:00 A.M		*10*	*2*	*1*	*0*	*0*	*13*
1:00 - 2:00 A.M		*0*	*0*	*0*	*0*	*0*	*0*
2:00 - 3:00 A.M		*0*	*0*	*0*	*0*	*0*	*0*
3:00 - 4:00 A.M		*0*	*0*	*0*	*0*	*0*	*0*
4:00 - 5:00 A.M		*7*	*3*	*1*	*0*	*1*	*12*
5:00 - 6:00 A.M		*19*	*10*	*4*	*4*	*2*	*39*
Total		***10344***	***2026***	***191***	***110***	***14***	***12685***

APPENDIX A-9: Interview question

Questions that raised for RTAs Investigators (AAC Traffic Police, drivers, eye witness)

Name ....

Age : *Please mark "X"*

18-25	26-35	36-45	46-50	51-60	>60

Sex: - **Work experience:-.......................**

Male	Female

Work Address:-.. (Sub-city, Wereda, Kebele,)

Duty Station:-... Position:-............................

1. What is your technical background or set of skills about RTAs?
2. How are you connected with others involved in the accident?
3. When /where did you see the accident happen?
4. What was he/she doing during the accident?
5. What attracted your attention to the accident?
6. When you first saw the accident, where was the vehicle or equipment? Where was the individual involved in the accident?
7. What was the direction of travel of the vehicle or equipment involved in the accident? Where was the final resting place of the vehicle or equipment? (Draw a diagram, if appropriate.)
8. What do you recommend to minimize Road Traffic Accidents (RTAs)?
9. Would you like to provide any additional information?

Thank you very much!

Meron Befekadu