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ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

DEPARTMENT OF GEODESY AND GEOMATICS
SPECIALIZATION IN GEOMATICS

GIS Based Road Traffic Accident Black spot Sites Assessment:
A Case Study of Kirkos Sub-city, Addis Ababa, Ethiopia

A Thesis Submitted to Graduate School of Addis Ababa University in Partial Fulfillment of the Requirement for the Degree of Master of Science

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May, 2019

DECLARATION

I, the undersigned, declare that this thesis work is my original work, has not been Presented for a degree in any other universities, and all sources of materials used for the thesis work have been properly acknowledged.

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Name Signature Date

Place: Addis Ababa

This thesis has been submitted for examination with my approval as a university advisor.

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List of Acronyms

AACRA	Addis Ababa City Road Authority
AADT	Annual Average Daily Traffic
AATP	Addis Ababa Traffic Police
AIDS	Acquired Immunodeficiency Syndrome
CS	Collector Straight
CSA	Central Statistics Agency
DALY	Disability Adjusted Life Year
ETB	Ethiopian Birr
ERA	Ethiopian road Authority
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GNP	Gross National Product
GPS	Global Positioning System
HIV	Human Immunodeficiency Virus
IRTAD	International Road Traffic and Accident Database
KDE	Kernel Density Estimation
Km/h	Kilometer per Hour
NMA	National Meteorological Agency
RSDP	Road Sector Development Program
RTA	Road Traffic Accident
RTABs	Road Traffic Accident black spots
RTAs	Road Traffic Accidents
PAS	Principal Arterial Straight
SPSS	Statistical Package for the Social Sciences
TRB	Transport Research Board
UK	United Kingdom
UN	United Nations
USD/US$	United States Dollar
WB	World Bank
WHO	World Health Organization

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ABSTRACT

Road traffic accidents have been recognized as one of those adverse elements which contribute to the suffocation of economic growth in the developing countries, due to the heavy loss related to them, hence causing social and economic concern. Traffic safety is an important key and plays an integral role in sustainable transportation development areas. Now days, the main negative impact of road transportation systems are loss of property, injuries and deaths in road accidents.

The objective of this study is to Assess GIS based Road Traffic Accidents black spot Sites related issues of Kirkos sub-city in terms of frequency, time and space from 2014 to 2018. The pivotal data necessary for the study was collected from the daily Road Traffic Accident records format of the Kirkos Sub city. Besides, point based traffic accident sites were collected using GPS data-logger devices, it was converted in to shape file using ArcGIS 10.2 software by uploading via DNRGPS 6.0.0.8 application software then 'Joins and relates' function. Thesis applied the combination of geo-information technology and spatial-statistical analysis to bring-out the influence of spatial factors in their formation. The results were presented in the form of line graphs, crosstabs, pie charts, figures and black spots maps.

A traffic accident has multi-facet characteristics associated with it. For proper traffic accident black spots identification use of GIS technique has become an inevitable tool. The result of the study revealed that about 1154 people were affected by Road Traffic Accident casualties. In this connection, the road crashes coasted 537,563,785 ETB from 2014/15 to 2017/18. Besides, 54 Road Traffic Accident Black Spots, top 10 as well as 5 consistent Road Traffic Accident Black Spots have been identified and mapped for the sub city. This Study examined the relations between traffic accidents and city characteristics, such as trend, road factors, and spatial factors. In general, the location of traffic accidents is described as an address with text, so they are difficult to display on the map. These are concern with how to utilize the GIS to work-out on spatial analyst to record the traffic accidents, to map and identify road traffic accident black spots. Remedial measures and provisions for traffic safety are suggested for reducing the risk of accidents in black spots.

Key Words: *GIS, GPS, Road Traffic Accident, Road Traffic Accident Black Spots, Road Traffic Accident casualties*

CHAPTHER ONE

1. INTRODUCTION

1.1 Background of the Study

The rapid increase in population of persons and vehicles without proper planning, design and maintenance of the available roads within the city, as well as the improper location of public facilities resulted in an inadequate transportation network. This is because the volume of traffic outweighs the road capacity, resulting in traffic congestion. According to the UN and its Habitat Organizations, five comprehensive problem fields are relevant for the enhancement of living conditions within a city (UN Habitat, 2003) of which transport is a part. These problems or rather challenges can be solved basically by employing surveying techniques and GIS.

The important issue here is that ever increasing trend and spatial pattern of road accidents emerge following the ever increasing demands for fast movements that require faster means of transport. This is because the need to move from place to place along with its own luggage in making a living is a human character. Such a movement of human beings and goods across a unit of geographical space for day to day activities by any means (foot, animal and/or vehicles is known as 'Traffic' (Goodall, 1987; Mayhew, 1997). This has led to gradual shift of transportation from on-foot to animals and then to vehicle; and even from slower vehicle of the first generation to the fastest vehicles of the 21st century generation. Such improvements in the means of transportation services have been accompanied with traffic congestion and in consequence with accidents. The problems of road safety may, therefore, perhaps remain unresolved despite efforts made to reduce through appropriate road designing methods and legal enactment (Goodall, 1987; Mayhew, 1997). Consequently, RTAs are claiming the lives of millions and caused destruction of property leading to what is known as social and economic crisis (Peden et al, 2004). This implies that the impact it has on human, physical and financial capital, is huge posing challenges to national development efforts. In fact, this requires planning for sustainable transport system in general and sustainable urban transport development in particular. A sustainable transport development planning requires the effort of all concerned bodies including transport authority and the community itself (Kennedy et al, 2005).

As road network is the most important component of urban infrastructure and is a key to the quality of life of the societies in that area. Knowing the process of city infrastructure provision and reliable information base is essential for successful infrastructure management and strategic decision making. Lack of information contributes to problems such as ineffective infrastructure provision and management. Hence, there is a strong interest to apply any tool that contributes to prevent such problems. Geographic Information System (GIS) is certainly one of these tools, which serves both as a database and as a toolbox for urban planning (Berry, 1987, Tomlin, 1990). In a database-oriented GIS, spatial and textual data can be stored and linked using the geo-relational model. It is true that, every day planners use geographic information system (GIS) technology to research, develop, implement, and monitor the progress of their plans (Pettit, 2006).GIS provides planners, surveyors, and engineers with the tools they need to design and map their neighborhoods and cities, and they use GIS to facilitate the decision-making process (Pettit, 2006).

However the road network in most developing countries suffers from many problems like; high accident levels, inadequate infrastructures both in capacity and availability, poor quality infrastructure and mismatch between demand and supply. These are caused by high urbanization, city growth and lack of proper transport planning strategies. Even though no transport network can serve all travel demand perfectly, the amount by which it fails to do so can be useful to study existing road network and identify areas with inadequate infrastructure (Davidson and Davidson, 1998).

Surveying is the bedrock of any meaningful development. The end-product of its process, the map, is employed in planning. Prior to the production of the map, data must be acquired using one or a combination of different techniques such as, Remote Sensing, Aerial Photogrammetry, traditional field survey methods, Global Positioning System (GPS). According to Olagbadebo and Dienye (2008), the digital production of maps which aid in improving the legibility, accuracy and updating procedures is achieved using Geographic Information System (GIS). Hence, the development of a GIS based Road Traffic Accident black spots sites identification in Kirkos sub city for solving problems associated with the road network.

1.2 Statement of the problem

Road Traffic Accidents are claiming the lives of millions and caused destruction of property leading to what is known as social and economic crisis (Peden et al, 2004). This implies that the impact it has on human, physical and financial capital, is huge posing challenges to national development efforts (Kennedy et al, 2005).

Accordingly, nearly ½ a million people die and up to 15 million people are injured in urban road accidents in developing countries each year and this is estimated to have a direct economic cost of 1% to 2% of worldwide gross domestic product (Peden et al, 2004). Moreover, in 1999, for instance, of the total 750-880,000 people died prematurely in road traffic crashes, between 35% and 70 % of all crashes occur in urban areas and urban road networks contribute to a significant proportion of countries' national road traffic crash problem (Downing et al, 2000). These and other estimates have indicated that traffic accident as a whole will become the third major killer next to Acquired immunodeficiency syndrome (HIV/AIDS) and Tubercles Bacteria (TB) (Peden et al, 2004).

In Ethiopia, the situation has been worsened as the number of vehicles has increased and consequently due to increased traffic flow and conflicts between vehicles and pedestrians. Despite government efforts in the road development, road crashes remain to be one of the critical problems of the road transport sector in Ethiopia (UNECA, 2009). Every year many lives are lost and much property is destroyed due to road traffic accidents in the country. The country has experienced average annual road accidents of 8115 over the past 11 years (Central Statistical Agency, [CSA, 2007) compared to over 8000 deaths annually in Turkey (Murat, 2009). In financial terms, Ethiopia, one of the poorest countries in the world, looses at least 400 million Birr each year due to road accidents which was 12 million Ethiopian Birr per year on average, 15 years ago and traffic accident is the third human killer phenomenon in Ethiopia (Fanueal, 2006).

According to the police reports, motor vehicle traffic accidents in Kirkos Sub city during the year 2000 – 2005 are about 44,000 and are relatively less compared to more than 50,000 crashes during the period between 1985 and 1997, and an average 3000 crashes are reported to the police each year (Fanueal, 2006). Each year, therefore, there were 300 people killed and 1500 slight and serious injuries in Addis Ababa (Fanuael, 2006).

In the country in general and in Addis Ababa in particular, a study on road traffic accidents, is not new task. However, none of these were devoted to identify hazardous accident sites (road traffic accident black-spots-RTABSs) especially at sub-city level except an attempt made by the National Road Safety Coordination office (NRSCO, 2005) in collaboration with Addis Ababa traffic police office for the city as a whole as cited in Fanueal (2006). For example, while Bitew (2002) studied the causes, temporal and spatial variations and consequences of taxi traffic accident, Tessema et al (2005) focused on developing adaptive regression trees to build a decision support system to handle road traffic accident analysis. Fanuel (2006) on his part tried to identify major causes of traffic crashes, concluding that there is growing problems of road accidents, and forwarded traffic simulation model for network selection. And while Tewolde (2007) tries to identify variable that most cause road accidents, UNECA (2009) analyzes the trends, causes and characteristics of accidents. As could be seen from the above examples, almost all of them are concentrated on assessing usual causes, consequences and spatial and temporal characteristics as well as application of some models. Such studies including RTABSs identified by national road safety coordination office in 2005, haven't dealt with the experiences of Kirkos sub-city in road accident situation. But the identification of RTABSs for Kirkos sub-city is one of the crucial steps in road traffic accident control planning and management for countermeasure. Therefore, the current study aims at investigating the major RTABSs for Kirkos sub-city based available data obtained from Kirkos Sub City traffic police department so as to suggest the right recommendations as a remedy for the road safety problem. This may provide at least baseline information about the current situation of traffic accident in Addis Ababa that may enable concerned bodies to re-examine the overall system of urban transportation networks and traffic flow. Therefore, the basic problem is an identification of those RTABSs in Kirkos sub-city and to assess the RTA considering its relevance to planners, policy makers, stakeholders and the community at large.

1.3 Objective of the Study

1.3.1 General Objective

The General objective of this study was to identify the Road Traffic Accident black spots using Geographic Information System tool in Kirkos sub city as a case study site.

1.3.2 Specific Objectives

More importantly, the specific objectives of the study were:

- Describe the general characteristics of road traffic accident in Kirkos sub city,
- To Identify major causes of road traffic accident occurrence in Kirkos sub city;
- To identify and map the road traffic accident black-spots in Kirkos sub city,
- Examine the trend of road traffic accident in Kirkos sub city, and
- Analyze the socioeconomic impacts of road traffic accident in Kirkos sub city.

1.4 Research Questions

1. What are the characteristics of road traffic accidents in Kirkos sub city?
2. What are the major causes and contributory factors for the occurrence of RTA in Kirkos sub city?
3. Where do frequent road traffic accidents occur in Kirkos sub city?
4. What is the trend of road traffic accident occurrence in Kirkos sub city? And
5. What social and economic costs have been incurred due to road traffic accidents in Kirkos sub city?

1.5 Significance of the Study

Road traffic Accident has been increasing from time to time however; no attention is given to identify the root cause of the problem and its solutions. So, the findings of this study help to:

- Gain valuable data and information about the road traffic accident black spots, trend, cause and impact of road traffic accident in the city, this in turn, could help to develop countermeasures that could reduce the frequency and severity of road traffic accidents.
- The study proposes prevention and protection measure that help policymakers, transport authorities, road engineers, and other concerned stakeholders to minimize road safety problems.
- It will also make GIS technology applicable in mapping high risk areas.
- Offering information regarding the basic cause of road traffic accidents in the Sub-City and on the site of black spots;

- The study will be used as a bench mark information to those scholars who want to conduct future detailed studies on RTA, road safety and other related issues.

1.6 Scope of the Study

The study area which is Kirkos sub-city is located roughly in the central part of the capital city of Ethiopia, Addis Ababa. The study area contains different types of land uses i.e. road network, business districts, administrative area, several educational institutions, residential area and the like. GIS is a spatial technique which is particularly used in this research. This study mainly used Kirkos sub city RTA data and information of 4 years (2014/15 – 2017/18) which is collected from the RTA archives of Kirkos sub city Traffic police department.

1.7 Organization of the Paper

The Study is comprised of five Chapters. The first chapter introduces the study with general introduction, statement of the problem, objective of the study, basic research questions, significance of the study, scope of the study, limitation of the study and standard definition of basic terms. The second chapter discussed about the review of related literatures regarding definition and concepts of RTA, global and regional trend of RTA, causes of RTA occurrences, economic and social impacts of RTA, RTA black spot definition and treatment, GIS for Road Transport and Road traffic Accident in Ethiopia. The third is encompasses research methodology, data source, data collection techniques, Data Processing, Analysis and Presentation and Road Traffic Accident Black Spot Identification. The fourth chapter presents detailed results and discussions of the study while the fifth chapter embraces conclusion and recommendations.

1.8 Definition of Basic Terms

Accident: Involves personal injury occurring on the public highway (including footways) involving at least one road vehicle or a vehicle in collision with a pedestrian and which becomes known to the police within 30 days.

Damage only accident: is the one as a result of which no person is injured only one or more vehicles involved in the accident are damaged.

Disability Adjusted Life Years: The years lost by an individual because he or she is disabled as a result of being involved in a Traffic Accident.

Fatal accident: Accident involving at least one fatal casualty.

Fatal injury/ casualty: Injury causes death within 30 days of the accident.

Injury: Physical damage that results when a human body is suddenly or briefly subjected to intolerable levels of energy. It can be a bodily lesion resulting from acute exposure to excessive energy or impairment of function resulting from lack of vital elements.

Road network: All roads in a given area.

Road traffic accident black spots: Places or cites where frequent road traffic accidents occur.

Road traffic accident spots: Places or cites where even a single RTA has occurred regardless of its frequency or severity level of its consequence in a given specified period.

Road traffic crash: A collision or incident involving at least one road vehicle in motion, on a public road or private road to which the public has right of access. Included are: collisions between road vehicles; between road vehicles and pedestrians; between road vehicles and animals or fixed obstacles and with one road vehicle alone. Included are collisions between road and rail vehicles. Multi-vehicle collisions are counted as only one crash provided that any successive collisions happen within a very short time period.

Road traffic injury (or casualty): A person who has sustained physical damage (i.e. injury) as a result of a road traffic crash.

Road traffic: Any movement of a road vehicle on a given road network.

Road transport: Any movements of goods and/or passengers using a road vehicle on a given road network.

Road user: a person using any part of the road system as a non-motorized or motorized transport user.

Road vehicle: A vehicle running or drawn on wheels intended for use on roads.

Road: Line of communication (travelled way) open to public traffic, primarily for the use of road motor vehicles, using a stabilized base other than rails or air strips. Included are paved roads and other roads with a stabilized base, e.g. gravel roads. Roads also cover streets, bridges, and tunnels, supporting structures, junctions, crossings and interchanges.

Serious accident: Accident in which no one is fatally injured, but at least one casualty received serious injuries.

Slight accident: Accident in which at least one casualty receives slight injuries but no fatal or serious injuries.

Serious injury/ casualty: Injury does not cause death within 30 days of the accident and either results in the casualty being detained in hospital as an in-patient, or any of the following injuries: fractures, concussion, internal injuries, crushing's, severe cuts and lacerations, severe general shock requiring treatment, or any injury which causes death more than 30 days after the accident.

Kirkos sub city: Kirkos sub city in this research refers to the administrative boundary of Kirkos sub city with 11 werdas as per 2018.

Chapter Two

2. Review of Literature

2.1 Conceptual Framework Road Traffic Accident

Road Traffic Accident is any vehicle accident occurring in a public highway. It includes collision between vehicles and animals, vehicles and pedestrians or vehicles and stuck obstacles. Single vehicle accidents, which involve a single vehicle, which means without other road user, are also enclosed (Safecarguide, 2004). In a similar manner Ajit and Ripunjoy (2004), have mentioned that Accident is an occasion, occurring abruptly, unpredictably and inadvertently under unforeseen circumstances. Seemingly, Segni (2007) have also outlined that an accident is a rare, random, multi-factor event always preceded by a situation in which one or more road users have failed to cope with the road environment. Far from the above arguments, Alister and Simon (2011) stated that accident involves personal injury occurring on the public highway (including footways) involving at least one road vehicle or a vehicle in collision with a pedestrian and which becomes known to the police within 30 days.

In this regard, Road Traffic Accident (RTA) can be defined as an accident that occurred on a way or street open to public traffic; resulted in one or more persons being killed or wounded, and at least one stirring vehicle was intricate. Therefore, RTA is a smash between vehicles; between vehicles and pedestrians; between vehicles and animals; or between vehicles and geographical or architectural obstacles.

Transport is the movement of people and goods from one place to another (Peters 1982; Khanna and Justo 1986; Goodall, 1987). However, according to Belachew (1997), transport also comprises movement of information. Similarly, transportation is the conveyance of people, properties and information from one place to another or it is the repositioning of people, properties and information over space Mekete (1997).

The type of transport which exhibits accident that drastically affects the wellbeing of the people and economy of the nations is the one which involves the movement of people and or goods from one place to the other. Several RTA incidences occur throughout the world at every fraction of times in a day. Whatever the reason, where ever the scene and whoever the victim is, RTAs remain as the headache of everyone (Peden et al, 2004).

The manifestations of RTA are sporadic and random in space and time. Nevertheless, road safety and road incident lessening are related to many other fields of activity such as education, motorist or driver training, publicity operations, police enforcement, road traffic policing, the court system, the National Health Service and Vehicle manufacturing and engineering (Berhanu 2000). The most shocking and emerging reality of RTA is that, it will continue affecting the survival of several lives across the planet. Consequently, UN (2009), remains pessimistic in road traffic accident cases where it projected that, road traffic injuries will be the fifth – leading cause of death globally by 2030. However, WHO (2004) projected that, RTA crashes which were ranked at 9th leading cause of burden of disease by 2002 could rank at the 3rd cause of burden of disease by 2020, if the current trend in motorization continues increasing in the same or similar manner for the coming decade.

2.2 Global and Regional Trends of Road Traffic Accidents

According to WHO (2004), road traffic deaths have risen from approximately 999, 000 in 1990 to just over 1.1 million in 2002. Low-income and middle-income countries account for the majority of this figure. Although the number of road traffic injuries has continued to rise in the world as a whole, time series analysis reveals that road traffic fatalities and mortality rates show clear differences in the pattern of growth between high-income countries, on the one hand, and low-income and middle-income countries on the other. In general, since the 1960s and 1970s, there has been a decrease in the numbers and rates of fatalities in high-income countries such as Australia, Canada, Germany, the Netherlands, Sweden, the United Kingdom (UK) and the United States of America. At the same time, there has been a pronounced rise in numbers and rates in many low-income and middle-income countries.

The trends are based on a limited number of countries for which data were available throughout the period and they are therefore influenced by the largest countries in the regional samples. Such regional trends could mask national trends and the data should not be extrapolated to the national level. The regional classifications employed are similar too, but not exactly the same as those defined by The World Health Organization (WHO). There has been an overall downward trend in road traffic deaths in high-income countries, whereas many of the low-income and middle-income countries have shown an increase trend since the late 1980s (WHO 2004). There are, however, some marked regional differences; Central and Eastern Europe witnessed a rapid increase in road traffic deaths during the late 1980s, the rate of increase of which has since declined. The onset of rapid increases in road traffic fatalities occurred later in Latin America and the Caribbean, from 1992 onwards. In contrast, numbers of road traffic deaths have risen steadily since the late 1980s in the Middle East and North Africa and in Asia, particularly in the former (WHO 2004).

The reductions in road traffic fatalities in high-income countries are attributed largely to the implementation of a wide range of road safety actions, including seat-belt use, vehicle crash fortification, traffic-calming interventions and traffic law enforcement. However, the reduction in the reported statistics for road traffic injury does not necessarily mean an improvement in road safety for everyone. According to the International Road Traffic and Accident Database (IRTAD), pedestrian and bicyclist fatalities have decreased more rapidly than have fatalities among vehicle occupants. In fact, between 1970 and 1999, the proportion of pedestrian and bicyclist fatalities fell from 37% to 25% of all traffic fatalities, when averaged across 28 countries that report their data to IRTAD. These reductions could, however, be due, at least in part, to a decrease in exposure rather than an improvement in safety (WHO 2004).

2.3 Causes of Road Traffic Accident

Road traffic crash results from a combination of factors related to the components of the system including roads, the setting, vehicles and road users, and the way they interact (David et al. 2005). Some factors contribute to the occurrence of a collision and are therefore part of crash causation. Other factors aggravate the effects of the collision and thus contribute to trauma severity. Some factors may not appear to be directly related to road traffic injuries. Some causes are immediate, but they may be underpinned by medium-term and long-term structural causes. Identifying the risk factors that contribute to road traffic crashes is important in identifying interventions that can reduce the risks associated with those factors (David et al. 2005).

2.3.1. Human factors:

Human factors are without doubt the most complex and difficult to separate, as they are virtually all very momentary in nature. What existed at the time of the crash may not exist some instants later. Consider sensory capabilities, knowledge, decision making, attitude, attentiveness, and fitness, health, driving skill, age, weight, strength and freedom of movement. Of these, the emotional dynamics are the greatest variable attributes and 14 the most difficult to ascertain. They are also subject to the most adjustment with the least remaining evidence (David et al. 2005). Human factors in vehicle collisions include all factors related to drivers and other road users that may contribute to a crash. Examples include driver comportment, visual and auditory acuity, decision-making ability, and reaction speed. Some of the human related causes of RTA are discussed as follows.

2.3.1.1 Drink Driving

Drink driving is one of the most contributing factors to RTA occurrences in many countries of the world. For instance (WHO 2009; WHO 2010) reveals that, drink driving is responsible for between 10 and 32 % of fatal crashes. As discussed by WHO (2004) drivers and motorcyclists with any blood alcohol content greater than zero are at higher risk of a crash than those whose blood alcohol content is zero. For the overall driving population, as the blood alcohol content escalates from zero, the risk of being involved in a crash starts to upsurge significantly at a blood alcohol content of 0.04 g/dl. Inexperienced young adults driving with a blood alcohol content of 0.05 g/dl have 2.5 times the risk of a crash compared with more experienced drivers. If a blood alcohol content limit is static at 0.10 g/dl, this will upshot in three times the risk of a crash than that at 0.05 g/dl, which is the most common perimeter in high-income countries. If the legal limit stands at 0.08 g/dl, there will still be twice the risk than at 0.05 g/dl. Alcohol ingestion by drivers puts pedestrians and riders of motorized two-wheelers at risk.

2.3.1.2 Non-Use of Seat-Belts

Significant number of lives could be saved every year by using seatbelts. Till these times many drivers are not realizing how much seat belts could save the lives of themselves and the life of their customers. What makes this fact more complex is that, although it is the worst in most of the developing countries of the world, it is a usual phenomenon in some most developed countries to see drivers with no use of seat belts while driving on public roads. WHO (2010) reported that; in France, where the wearing rate is among the highest, it was estimated that, in 2007 if every passenger and driver had worn a seatbelt, 397 lives could have been saved around 9% of total fatalities. Wearing a seat belt reduces the risk of a fatality by 40- 50%. Another study by (David et al. (2005) shows that, not wearing a seatbelt is the most common cause of fatality which contributes to fatality among 63% of all vehicle occupants. In addition to this, WHO (2004) have stated that Rates of seat-belt use vary greatly among different countries, depending upon the existence of laws mandating their fitting and use and the 15 degree to which those laws are enforced. In low-income and middle-income countries, usage rates are generally much lower. Seat-belt usage is substantially lower in fatal crashes than in normal traffic. Correctly used seat-belts reduce the risk of death in a crash by approximately 60%. In absolute similarities, supporting the above studies, WHO (2009) added that if a seatbelt was correctly used, it would reduce the risk of fatality among front seat passengers by 40-50% and among the rear seat car occupants by 25-75%.

2.3.1.3 Choice of Less Safe Forms of Travel

By one or another reason, many passengers use less safe forms of travel. It would be nothing if the passengers could arrive at their destination using any form of transportation. But several studies in different countries of the world showed that, the lesser the safety of travel is accompanied with miserable RTA occurrences. It is claimed by WHO (2004) that "of the four main modes of travel, road travel scores by far the highest risk in most countries – using almost any measure of exposure – compared with rail, air and marine travel."

2.3.1.4 Speed

The speed of motor vehicles is at the core of the road injury problem. Speed affects to both crash jeopardy and crash magnitude. In accordance to this, recent studies have proved that as speeds increase, so do the number and severity of injuries. For instance a study reported at WHO (2004) shows that the higher the impact speed, the greater the likelihood of serious and fatal injury. The same report WHO (2004) proved that the higher the speed of a vehicle, the shorter the time a driver has to stop and escape a crash. A car moving at 50 km/h will usually require 13 meters in which to stopover, while a car moving at 40 km/h will stop in less than 8.5 meters. An average increase in speed of 1 km/h is associated with a 3% higher risk of a crash involving an injury. In severe crashes, the increased risk is even greater. In such cases, an average increase in speed of 1 km/h leads to a 5% higher risk of serious or fatal injury, travelling at 5 km/h above a road speed limit of 65 km/h results in an increase in the relative risk of being involved in a casualty crash. For car occupants in a crash with an impact speed of 80 km/h, the possibility of death is 20 times what it would have been at an impact speed of 30 km/h. Pedestrians have a 90% chance of surviving car crashes at 30 km/h or below, but less than a 50% chance of surviving impacts at 45 km/h or beyond. The likelihood of a pedestrian being killed increases by a factor of 8 as the impact speed of the car increases from 30 km/h to 50 km/h. To this end WHO (2009) summarized that, a 5% increase in average speed leads to an approximately 10% increase in crashes that cause injuries, and a 20% increase in fatal crashes.

2.3.1.5 Age of Drivers

The age of drivers affects to the behavior of their driving styles and to the level of Driver's attention. In similar sense (WHO 2004); David et al. (2005) argued that Crash rates of male drivers aged 16–20 years were at least three times the estimated crash rate of male drivers aged 25 years and above. Teenagers are significantly more likely to be involved in a fatal crash than older drivers. At almost every blood alcohol level, the risk of crash casualty declines with increasing driver age and experience. In addition to this a study on drivers killed in road crashes estimated that teenage drivers had more than five times the risk of a crash compared with drivers aged 30 and beyond, at all levels.

2.3.1.6 Non-Use of Helmets

The use of helmets has a paramount role in reducing the severity of RTA. However, several riders in different countries of the world are enjoying their journey without using helmets until the worst effect of failing to use helmets come in to their lives. Regarding this WHO (2004); (WHO 2009; WHO 2010) dictates that Non-helmeted users of motorized two-wheelers are three times more likely to sustain head injuries in a crash compared to those wearing helmets. Helmet-wearing rates vary from faintly over zero in some low-income countries to almost 100% in places where laws on helmet use are efficiently enforced. Though helmets have generally been extensively worn in most high-income countries, there is a confirmation of a decline in practice in some countries. More than half of adult riders of motorized two-wheelers in some low-income countries do not wear their helmets appropriately secured. Child passengers rarely wear helmets, or wear adult helmets that do not effectively protect them. Helmet use does not have adverse effects on neck injuries, visibility or the ability to drive safely in traffic. Wearing a motorcycle helmet correctly can reduce the risk of death by almost 40% and the risk of severe injury by over 70% (WHO 2010).

2.3.1.7 The Use of Hand-Held Mobile Telephones

The use of mobile telephones while driving could result in unexpected RTA risks. WHO (2004) suspects that, the use of hand-held mobile telephones can adversely affect driver behavior – as regards physical as well as perceptual and decision-making tasks. The process of dialing influences a driver's ability to keep to the course on the road.

2.3.1.8 Lack of Road User Information and Campaign

Road users ought to acquire the knowledge needed to travel safely by means of formal training and their own experiences. However, inadequate knowledge of traffic regulations, traffic signs, vehicles and other elements may be some of the factors contributing to unsafe behavior and road calamities. Road user information and operations are intended to reduce accidents by promoting safer behavior in traffic, by giving road users better knowledge and more favorable attitudes towards such behavior. Another objective is increased understanding of restrictive measures which are introduced to increase safety, such as speed limits. Elvic, Runee et al. (2005) evaluated a number of studies on the effects of information campaigns on the number of accidents. They reviewed that most campaigns targeted at road accidents in general have not led to statistically significant changes in the number of accidents. On the other hand, campaigns made to specific target group such as use of seat belt, drink-driving campaign and the like have led to a decrease in number of accidents in particular types during the campaign periods.

2.3.2 Road

Some variables regarding the road related causes of RTA firstly, Road environments have impacts on occurrences of road traffic accidents. In developed countries, there are continuous efforts to meet the safety standards of roads through safety audit during the planning, designing, and operation stage. Roadway characters conditions like the quality of pavements, shoulders, traffic control devices and intersections, can be a factor in a crash. Another important road factors include, but are not limited to lighting, view obstructions, signals, surface character, dimension and shielding devices. All factors are subject to adjustments by outside influences such as road surface that become slippery from rainfall. Modifying each of the listed road factors are weather, lighting, roadside devices, activities, surface deposits, damage, deterioration and age (Lisa, David et al. 2005). According to Berhanu (2000) points out features including bridge width, curved bridge, approach roadway alignment and adverse surface condition as the most prevalent factors of bridge accidents. Based on the findings of the cited studies, Berhanu (2000) suggests that at least the bridge shoulder should be 1.8 m wider than the approach traveled way width on rural two-lane highways (i.e. 0.9m shoulder width on each side should be carried across the bridge). Besides, frequency and severity of traffic accident at bridges can be reduced through the provision of adequate visual information to enable the driver control and navigate safely on bridges. Finally, Road lights are intended to provide enough lighting for drivers to travel with comfort and safety during night periods or under low visibility conditions. (Sandra 2000).

2.3.3 Vehicle

While vehicle design can have considerable influence on crash injuries, it must be studied in accordance to its contribution to RTA. Prior studies to this one like WHO (2004) have proved that vehicle related factors contribution to crashes, through vehicle defects, is generally around 3% in high-income countries, about 5% in Kenya and 3% in South Africa. Similarly, Ung (2007) stated that Vehicles have caused road accident because their owners did not properly maintain and regularly inspect the vehicle during the maneuver. So the road accident happened when brake failure, tire blowout, power steering failure, headlight failure. In addition to this defective or under inflated defective brakes, overloaded or poorly loaded vehicle or trailer, defective lights or indicators, defective steering or suspension and defective or missing mirrors are the major factors for the frequent occurrence

2.3.4 Environment

The climatic and environmental conditions can also be a factor in transportation crashes. Supporting this idea (David et al. 2005); Alister and Simon (2011) argued that, Weather on roads can contribute to crashes: for example wet pavement reduces friction and flowing or standing water greater than 1/8”deep can cause the vehicle to hydroplane. Many several crashes have occurred during conditions of smoke or fog, which can reduce visibility.

2.4 Impacts of Road Traffic Accident

All countries in the world are currently affected by RTA. Although the effects of RTA vary from one country to the other, from nation to nation, it should be every body’s concern. Some of the major impacts of RTA discussed by different organizations and scholars are conversed in the following sub-sections.

2.4.1 Economic and Social Impact of Road Traffic Accident

The social and economic impact of road traffic accident is a very sensitive issue. The impact is not only on individual life or his family but also on the government and on the society at large.
Road traffic accidents are currently deteriorating the financial wealth of many nations. In this regard, (WHO 2004); Naci, Chislom et al. (2008) urges that, in economic terms, the cost of road crash injuries is estimated at roughly 1% of Gross National Product (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries. The direct economic costs of global road crashes have been estimated at US$ 518 billion, with the costs in low-income countries – estimated at US$ 65 billion – exceeding the total annual amount received in development assistance. In addition to this, in terms of regional disparities of cost of RTA Naci, Chislom et al. (2008) indicated that, the economic cost of road crashes have been estimated to be as much as US$ 24.5 Billion in Asia, US$ 19 Billion in Latin America and Caribbean, US$

9.9 Billion in Central and East Europe, US$ 7.4 Billion in the Middle East and US$ 3.7 Billion in Africa. When we come to Ethiopia, RTA's economic impact is even worse. As far as the economic impact of RTA in Ethiopia is concerned, Persson (2008) have discussed that, the economic impact of RTAs is substantial for Ethiopians as the annual cost is estimated to be around £40 million.

The RTA impacts are also shown with their influence on the social aspects of the livelihood. To this regard, WHO (2004) claims that, over 50% of the global mortality due to road traffic injury occurs among young adults aged between 15 and 44 years, and the rates for this age group are higher in low-income and middle-income countries. In 2002, males accounted for 73% of all road traffic deaths, with an overall rate almost three times that for females: 27.6 per 100, 000 population and 10.4 per 100, 000 population, correspondingly. Road traffic mortality rates are higher in men than in women in all regions regardless of income level, and also across all age groups. In an absolute similar manner Naci, Chislom et al. (2008) supports this argument by stating that, Road crashes kill and maim the most productive segments of the population; globally, in 1998, 51% of fatalities and 59% of disability-adjusted life years lost as the result of road traffic injuries occurred in the most productive age groups. The report of WHO (2004) added that people with road traffic injuries accounted for 13-31% of all injury-related attendees and 48% of bed occupancy in surgical wards and were the most frequent users of operating theatres and intensive care units. The increased work load in radiology departments and increased demand for physiotherapy and rehabilitation services were largely attributed to road traffic injuries. Regardless of the costs of healthcare and rehabilitation, injured people bear additional costs. Permanent disability, such as paraplegia, quadriplegia, loss of eye sight or brain damage, can deprive an individual the ability to achieve even minor goals and can result in dependence on others for financial support and routine physical care. Less serious injuries can result in chronic physical pain and limit the injured person's physical activity for lengthy periods. Serious burns, contusions or lacerations can lead to emotional trauma associated with permanent disfigurement. WHO (2009) states that, over 90% of the world's fatalities on the roads occur in low and middle income countries, although these countries only have about 48% of the world's registered vehicles.

The WHO anticipates, unless immediate action is taken, that over the next 15 years, the number of people dying annually in the road traffic crashes may rise to 2.4 million. This report also urges that, given these numbers, road traffic injuries have to be seen in low and middle income countries as one of the most important health problems along with diseases such diarrhea, malaria, HIV/AIDS and tuberculosis.

2.5 Black Spots of Road Traffic Accident

2.5.1 Black Spot Definition

Black spot areas in RTA are defined in different ways by different scholars. From the perspective of Rokytova (2000) black spots are defined as locations that are generally classified after an assessment of the level of risk and the likelihood of a crash occurring at a location. In another words, accident black spot on a National Highway in Norway is defined as any place with a maximum length of 100 meters, where at least four injury accidents have been testified to the police in a four year period (Elvic, Runee et al. 2005). Thus, a black spot in the UK may well have only five injury accidents in three years, whereas a city in Bangladesh may have black spot defined as having more than 10 injury accidents in a year (Geurts and Wets 2003). In most developed states, black spots are defined as the locations where there are 12 accidents in 3 years per 0.3 kilometers (Guo, Gao et al. 2003). In Czech Republic, the black spot criterion is that junctions or 250m long road sections that are considered as black spots on condition that at least 3 road accidents with injuries occurred within 1 year or at least 3 road accidents with injuries of the same type occurred within 3 years or at least 5 road accidents of the same type occurred within 1 year (Rokytova 2000).

Study on single carriage way trunk road Walmsley, Summersgill et al. (1998) revealed that the criterion used to delineate road sections for accident analysis are age of opening, carriageway width, curbs, hard strips, and speed of the road sectionElvic, Runee et al. (2005) points out black spots on national highways in Norway have heavy traffic but do not have particularly high accident rates when compared with places which are not classified as accident black spots. Ranking of black-spots were done with various alternatives. Jonnessen and Sakshaug (2006) show three alternative methods of ranking black spots. These are number of accident with personal injury or serious personal injury, accident rates (accident per million vehicle kilometer) and potential for accident reduction. In addition to this, Lisa, David et al. (2005) stated that Black spot areas are sites that have had more than one fatal crash, sites with multiple crashes within a mile from one another.

2.5.2 Criteria for Analyses of Black Spot

Different country can use expected time coverage for black spot analysis in respect to amount of accident exist repeatedly with the specified number and relative severity at specified period. As a result; accident data for the most recent 1 to 3-year period is normally used and is generally sufficient. 2 or 3 year analysis periods are more appropriate at locations with low traffic volumes, where a 1-year period may not provide sufficient information for location with low traffic volume. Accident data should only be used when there are no major changes in facility characteristics or land use. Simple methods for identifying unsafe locations, where the number of crashes or the crash rate per unit exposure exceeds a given threshold, are routine and straightforward (Taylor, Bonsall et al. 2000). From a purely statistical point of view, it is favorable to have as many accidents as possible. If accidents from more than one year are added, the result would be more accidents (Kent Sjölinder and et.al, December 2001).

Various methods for studying spatial patterns of crash data as point events have recently been developed. One of the most widely used is Kernel Density Estimation (KDE). Many recent studies use planar KDE for hot spot analysis, such as the study of high pedestrian crash zones (Vasudevan, Pulugurtha et al. 2007) road crash hot spots (Anderson 2009), and highway crash hot spots (Erdogan 2009). The goal of planar KDE is to develop a continuous surface of density estimates of discrete events such as road crashes by summing the number of events within a search bandwidth. However, planar KDE has been challenged in relation to the fact that road crashes usually happen on the roads and inside road networks that are portions of two-dimensional space.

2.6 GIS for Road Transport

Accordingly, the owner of GIS software ESRI (2011) also described GIS as an integrated hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS technology allows you to view, query, and understand data in many ways. You’ll see relationships, patterns, and trends in the form of GIS-based maps, reports, and charts. Now a day GIS is applied in the transportation as the backbone for Intelligent Transportation System (ITS). ITS, utilizes advanced technologies frequently GIS, to improve both the efficiency and safety of transportation system. GIS-based ITS applications are fed with data from GPS units, video cameras, and road monitoring units.

Yohannes (2005) in his paper describes about the application of Geographic Information System (GIS) in transportation (also called GIS-T). According to his view, GIS in transport has evolved from simple graphic and map-based representation of roads and geographic features to serve specific functions in highway agencies to a more complex and powerful tool for integrating data and decision making within and among agencies. It helps to study, improve, and solve problems related to transportation system (Miller & Shaw, 2001).

Geographic database as such consist of spatial and non-spatial data with complex data structures used to analysis. According to Svante (2001), transport data are spatial in a number of aspects. All spatial data is geographically referenced to a map projection in an earth coordinate system and can be "re-projected" from one coordinate system into another, thus data from various sources can be brought together into a common database and integrated using GIS software.

An important geographic object of transport data is the network, which in a GIS interpretation will be arc (links) and nodes. Data for transport applications often represent flows of people and goods between points or zones (Svante, 2001). Routes and networks are the interconnected features that are used for transportation and include highways, railways, city streets, rivers, transportation routes (transit, school buses), and utility systems. Networks are an important part of our everyday lives and analysis of these networks improves the movement of people, goods, services and the flow of resources.

Roads are main arteries of modern society‟s infrastructure, contributing heavily to the distribution of goods and persons. GIS provides many helpful applications for ensuring a smooth flow, by aiding design, routing, traffic control and real-time navigation (Husdal, 2000). It also provides a valuable tool in the process of planning and designing roads. It can help visualize and communicate the effects of roads on their environment. By collecting significant data for the whole network, repairs and work budgeting would be more reliable and can be calculated in advance. First creating the optimal route between locations and then using GIS to decide how and where to indicate, improve directions and movements in the road network and help avoiding congestion (Marshall, 1995).

2.7 Road Traffic Accident in Ethiopia

Most of the road deaths in developing countries involve vulnerable road users such as pedestrians and cyclists. In Ethiopia, pedestrian injuries account for 84% of all road traffic fatalities compared with 32% in Britain and 15% in the United States of America. In contrary, in the heavily motorized countries, drivers and passengers account for the majority of road deaths involving children (Bunn, Collier et al. 2003). Similarly, Mekonnen (2007) quoted that, RTA in Ethiopia is a serious problem. The RTA death rate is estimated to be 130 per 10,000 vehicles. Of the total victims of RTA who lost their lives, over half are pedestrians, out of whom 30% are children. In Ethiopia, one among five people injured dies due to RTA. Based on a five-year average records, of the personal injury accidents, 81% are caused due to drivers error, 5% due to vehicle defect, 4% due to pedestrian error, 1% due to road defects and 9% due to other problems in Ethiopia. Studies further shows that the professional drivers are involved in 88% of the fatal accidents. Special purpose vehicles and motor bicycles cause 8% of such accidents. On the other hand, automobile drivers have very good safety records with only 4% of the fatal accidents, which is equivalent to a rate of 12 fatal accidents per 10,000 vehicles.

Conferring the National Road Safety Coordination Office of Ethiopia, the main underlying reasons for the frequent RTA occurrences and severe impacts of RTA in Ethiopia are Improper behavior or lower skill of drivers, Poor vehicle technical conditions, Animals and carts using the highways, Pedestrians not taking proper precautions, Poor traffic law enforcement, Poor emergency medical services and Insufficient safety considerations given in road development. In addition to thesis Segni (2007) added another responsible reasons of RTA occurrences in Ethiopia like driving without respecting right-hand rule, failure to give way for vehicles and pedestrians, overtaking in snaky horizontal curves, following too close to the vehicle in front, improper turning and speeding. These causes contribute to 73% of the total accident in the year 2004/05 in Ethiopia but the other possible reasons accounted for less than 27%.

It would be impossible to attach a value to each case of human sacrifice and anguish, add up the values and result a figure that captures the national social cost of road crashes and wounds. Conversely, the economic expenses of road traffic accidents are, obviously, a heavy burden for the national economy. In addition to this UN (2009) added that the economic costs of road crashes and injuries are estimated to be 1% of Gross Domestic Product (GDP) in low-income countries such as Ethiopia.

In another stance , Mohammed (2011) Put his findings of the cost of RTA in Ethiopia on the basis of the Ethiopia's data and economic figure of 2009/10, as the cost of damage only, slight, serious and fatal road traffic crashes were 327.12 million, 204.65 million, 619.38 million, and 716.02 million ETB respectively. This represents the total national economic loss resulting from road accidents to be estimated as ETB 1.867 Billion which is equivalent to 145.07 million United States Dollar (USD) considering the exchange rate of the same year, or approximately 0.49% of the GDP of the country in the same year. Another study conducted by Ethiopian Roads Authority stated that, RTA costs Ethiopian economy between350 - 430 million Birr annually, and loses almost 1860 lives each year with another 8,690 people reported injured (CSA 2007).

Chapter Three

3. RESEARCH METHODOLOGY

3.1. Introduction

Addis Ababa is geographically located at 9˚2' North and 38◦42 East. As a capital city of the Federal Democratic Republic of Ethiopia, it is located almost at the center of the country. The northern borderline runs along the Entoto maintains while its southern borderline runs across a plain land extending towards the Akaki River on to the Debre Zeit road. The eastern limits extend along the road to Debre Berhan and Dessie, while the western boundary runs along Mount Wechecha (EMA, 1988).

Addis Ababa lies at a maximum altitude of 2900 meters above sea level. Because of having the highest altitudinal position, Addis Ababa ranks the fourth highest capital city in the world and takes the first rank from African cities. There is a great variation of height within the city, so that much of it is built on the slope (Tesfaye, 1986).

The city has an expanded area of 540 sq. km and divided into 10 sub-cities and 100 *woreda* for administrative purpose. The city has experienced spatial spread mostly towards the southern, eastern and south western parts. The spatial spread is mainly guided by topography and road network development. The topography of Addis Ababa is not suitable for the transport network development point of view (Tesfaye, 1986). The city's landscape is very sloppy and mostly exposed to flooding.

As per the UN-HABITANT 2007 report, the city had an estimated population of 4 million in 2007. According to Central Statistics Agency of Ethiopia (CSA), the medium population size of the city was 2.7 million in 2007. However, the CSA‟s (2005) estimate for the same year was 3.1million (Abreha, 2007 and Johanson, 2008).The medium population estimate and projection of the agency for years 2010 and 2015 are 3.75 and 4.6 million respectively (Meron, 2007). More than 50% of the city’s residents live under poverty line and 80% of the built up urban area is categorized as slum according to UN criteria (UN-HABITAT, 2008).Addis Ababa is the 4th largest diplomatic center in the world as it is a headquarter of UN Economic Commission for

Africa (UNECA), African Union (AU) and a home of more than 90 embassies and various international organizations (UN -HABITAT, 2007). The city is often referred as the "political capital of Africa" due to its historical, diplomatic and political significance for the continent. Addis Ababa is the hub of social, political, cultural and economic activities of the country and is one of the fastest growing cities in the world. It is a "primate city" in the full sense of the term" (Johnson, 2008).

Addis Ababa City Administration is divided into ten sub-cities: namely, Addis Ketema, Akaki-Kaliti, Arada, Bole, Gulelle, Kirkos, Kolfie-Keraniyo, Lideta, Nefas Silk-Lafto and Yeka Sub-city. The study area is in the Arada sub-city (Figure 3.1).

More specifically, Kirkos sub-city is geographically located at 9˚2′6″N 38˚45′28″E. Kirkos is one of the 10 sub-cities of Addis Ababa, the capital city of Ethiopia. It covers an area of 1464.72 hectares. The sub-city is roughly situated in the central part of Addis Ababa, nearby the center, bounded from the South by Nifase silik lafto, from West by lideta, from East by Bole and from North by Arada sub-cities (Figure 3.1). It is divided into 11 woredas, 31 sub-woredas, 111 sefers, and 316 blocks.

There are several features which makes the sub city differs from other sub city. It is the sub city where the National Palace and international organizations like African Union, which made Ethiopia the seat of Africa, Economic Commission of Africa and 23 embassies are located.

In addition to this, international features like the first National Stadium, the railway station, Addis Ababa museum, Red Terror Martyrs Memorial Museum, Mesqel Square: which is multipurpose square; Exhibition center and National Theater are located in this sub city. Moreover, Filwuha spa which is unique features for the establishment of Addis Ababa, and the Gottera interchange the first modern and sophisticated road section as well as nations and nationalities square are also located in the sub-city. Beside these, Kirkos the is most commercially vibrant subcity with several commercial center centers like 25 Star hotels including Sheraton Addis and Hilton, 161 financial intuitions including commercial bank of Ethiopia head office and Awash international bank and insurance. Minster and government offices such as Minister of Justice and road authority are found in this sub city.

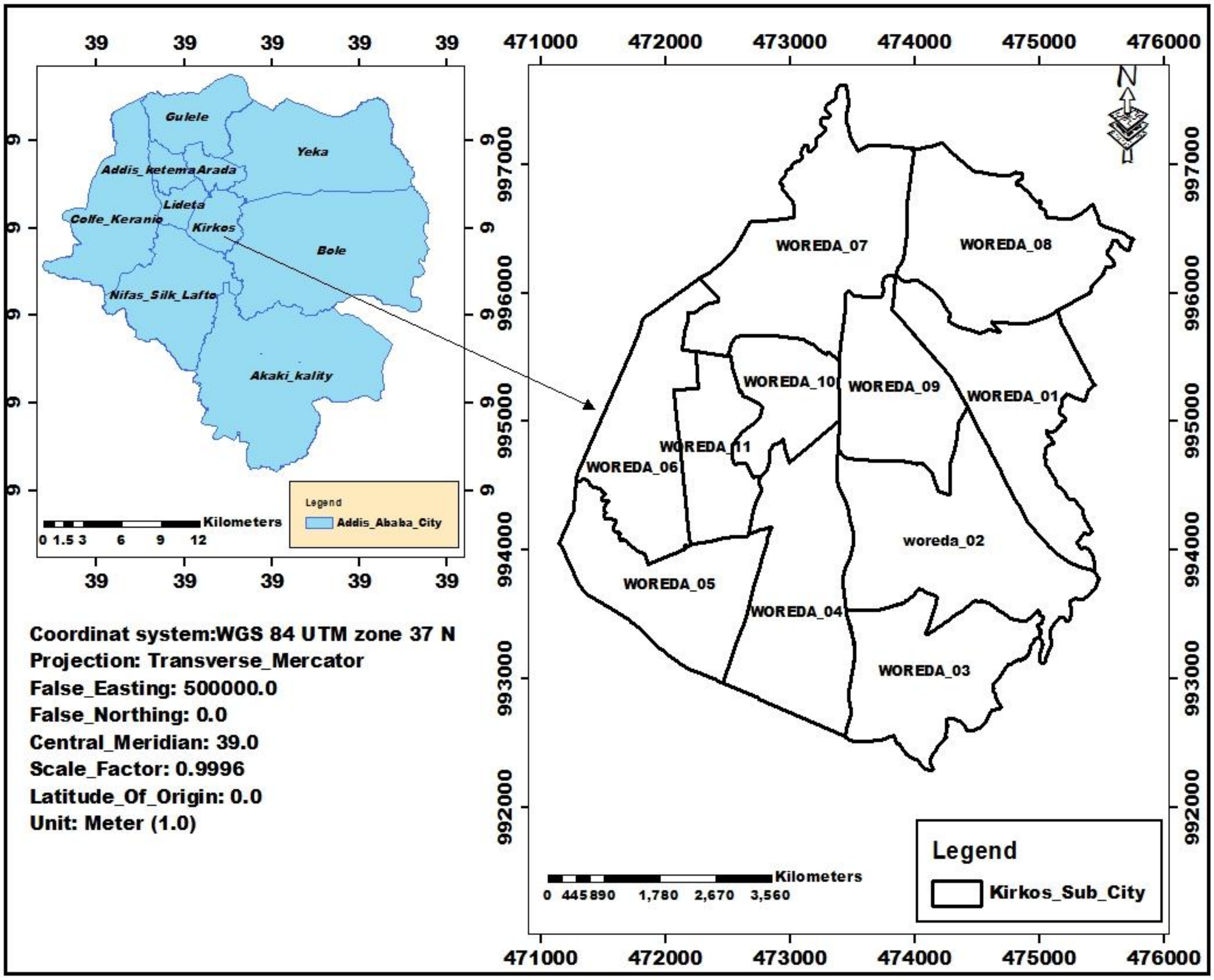

Figure 3.1 Map of the Study Area (Kirkos sub-city)

Source: Adopted from Kirkos sub-city Land Administration.

3.2. Topography

Elevation is an indicator that enables a simple understanding of Topography (relief) for a given area; here it is mapped easily by using raster zed contour map. Conversion of- vector contour map in to raster creates an elevation surface data providing the altitude value of any space measured on small size square or pixels. From the Elevation map we can see that Kirkos sub city is characterized by relatively smooth type of topography with Slight elevation difference and steeply landscape around river gorges. Generally speaking in the sub city, the altitude ranged from 2248 meter to2404 meters above sea level which has a range of 156 meters. The highly elevated land exists in the north while relatively lower elevation exists in South. Elevation is an indicator that enables simple understanding of topography (relief) for an area, here it is mapped easily.

Slope is another means of describing topography for a given area. It is a measure of terrain steepness that is, the degree to which land is not horizontal. The range of slope values in degrees is 0 to 90. For percent rise, the range is 0 for near infinity. A flat surface is 0 percent, a 45 degree surface is 100 percent, and as the surface becomes more vertical, the percent rise becomes increasingly larger."

The categorization of an area in different slope classes can be used for different civic works such as for planning of drainage, road construction, housing and etc. In this slope analysis map, slope is measured as percentage rise classified in to 6different ranges. Kirkos is Flat and Gently Sloping sub city in which 89.37% of its land area comprising less than 10% slope.

Table 3.1 Slope Description of Kirkos sub-city

Slope Class (%)	Description	Area/Ha/	Percentage
< 2	Flat	196.57	13.41
2-5	Gently sloping	654.69	44.68
5 -10	Sloping	458.30	31.28
10 -15	Strongly sloping	104.78	7.15

15-30	Moderately steep	45.35	3.09
>30	Steep	5.67	0.39
	Total	1464.72	100

Source: Adopted from Kirkos sub-city Land Administration

3.3. Land Coverage in the Sub city

The land with area covered by Kirkos sub city is 1464.72 hectares and this constitutes 2.82% of the total land area of the city which makes Kirkos in 7th place in land area covered from the 10 sub cities. Among the eleven Weredas, the large area is covered by Wereda 02 with 194.78 hectares that is 13.30% of the sub city land area and Wereda 10 covers the smallest land area of 68.37 hectares which is 4.67% of the sub city land area. Generally speaking in the sub city, the altitude ranged from 2248 to 2404 meters above sea level which has a range of 156 meters. I he highly elevated land exists in the north while relatively lower elevation exists in South.

Table 3.2 Land Areal Coverage of Kirkos sub-city

No	**wereda**	**Area (Hectare)**	**Area (%)**
1	01	139.42	9.52
2	02	194.78	13.3
3	03	132.4	9.04
4	04	161.77	11.04
5	05	121.76	8.31
6	06	118.13	8.07
7	07	187.66	12.81
8	08	163.86	11.19
9	09	105.19	7.18
10	10	68.37	4.67
11	11	71.37	4.87
	Total	1464.72	100

Source: Addis Ababa City Administration, 2016

3.4 Population

According to the 2007 census, the total population within this sub city is 220,991 which are 8.07% of the entire population of the city. From the total population 103,314 are males while 117,677are females. Lots of people live in Wereda 04 with population number of 28450-which is 12.87% of the sub city population. And relatively few people live in Wereda 06 with population number of 11,042-which is 5% of the sub city population.

The densely populated Wereda in the sub city is Wereda 10 with population density of 331.83 peoples /hectare and the least dense Wereda is Wereda 07 with population density of 90.6 peoples /hectare. Averages of 150.88 people live in each hectare area of the sub city which makes.

Table 3.3 Population distribution of Kirkos Sub City (2007)

wereda	Total population		Both sexes	% of the tot sub Areas Population	Area/hectare	population Density (#popu/hectare)
	Female	male				
01	9739	8487	18226	8.25	139.42	130.73
02	13515	11476	24991	11.31	194.78	128.30
03	6518	6266	12784	5.78	132.40	96.55
04	15397	13053	28450	12.87	161.77	175.87
05	11058	9867	20925	9.47	121.76	171.85
06	5828	5214	11042	5.00	118.13	93.47
07	8629	8373	17002	7.69	187.66	90.60
08	11732	9752	21484	9.72	163.86	131.11
09	11095	9462	20557	9.30	105.19	195.43
10	11944	10744	22688	10.27	68.37	331.83
11	12222	10620	22842	10.34	71.37	320.06
Total	117677	103314	22099	100.00	1464.71	150.88

Source CSA 2007:

3.5. Land Use

The land use distribution of the study area is indicated in table

Table 3.4 Land use type and Areal Coverage of Kirkos sub-city

N °	Land Use Type	Area (Ha)	Percentage (%)
1	Administration	151.57	10.35
2	Commercial	123.35	8.42
3	Cultural & Social Welfare	14.60	1.00
4	Education	43.44	2.97
5	Health	11.38	0.78
6	Infrastructure and utilities	0.89	0.06
7	Manufacturing & Storage	60.84	4.15
8	Mixed forest	8.30	0.57
9	Mixed Residential	73.60	5.03
10	Municipal Services	13.24	0.90
11	Open space	51.71	3.53
12	Plantation	2.29	0.16
13	Recreation	15.99	1.09
14	Religious Institution	7.64	0.52
15	Residential	519.78	35.49
16	River	17.36	1.19
17	River line	2.96	0.20
18	Road network	296.52	20.24
19	Special use	8.54	0.58
20	Transport terminal	1.54	0.11
21	Under Construction	37.43	2.56
22	Vegetable farm	1.74	0.12
	Total	1464.72	100.00

Source: Addis Ababa city Administration integrated land information center

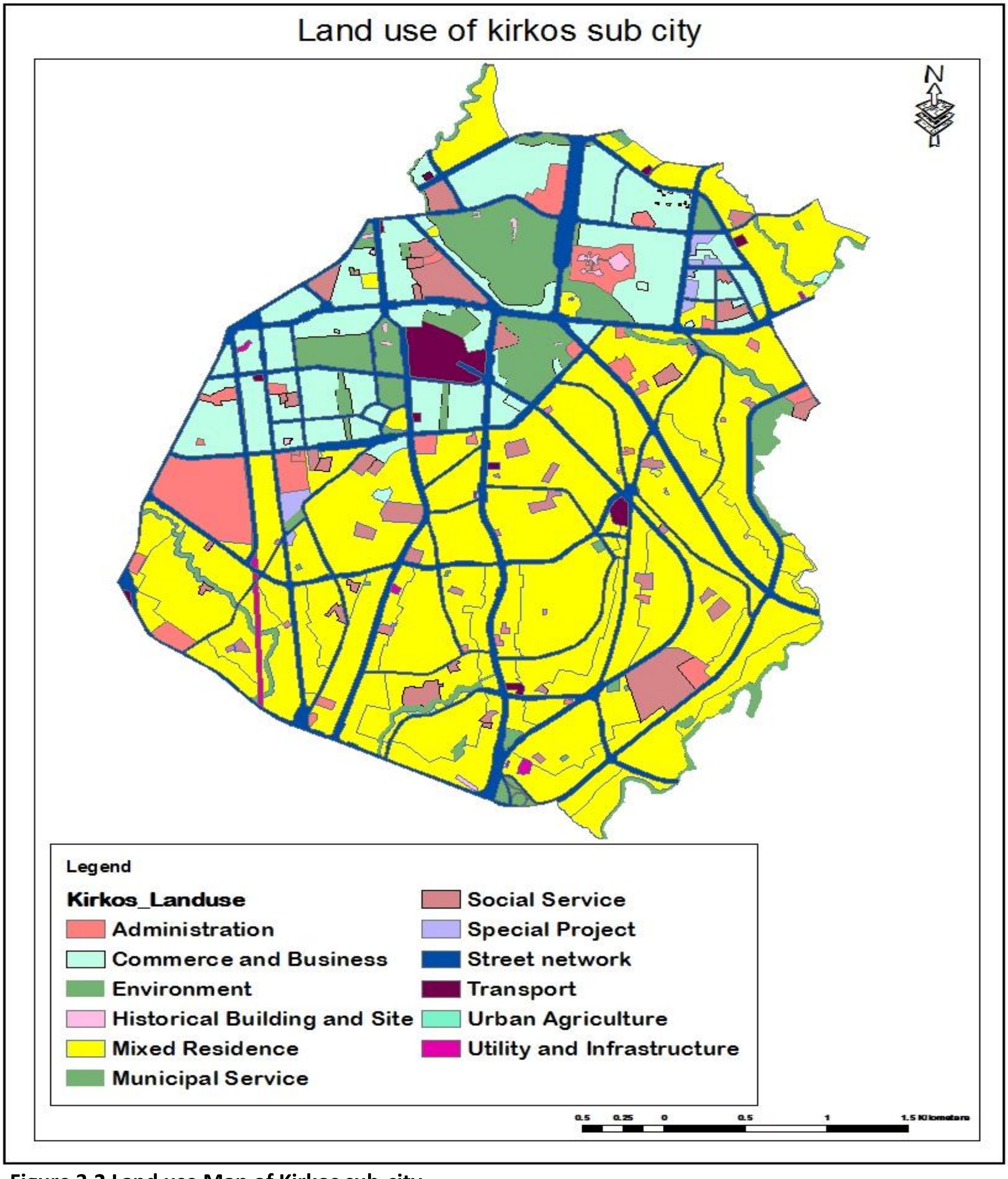

Figure 3.2 Land use Map of Kirkos sub-city

Source: Addis Ababa city Administration integrated land information center, 2018

The land use distribution as identified in table 3.2 and figure 3.4 shows that most of the land use characteristics of Kirkos sub-city is mixed with residential, mixed residential, commercial, educational and administration areas.

3.6. Transport and Existing Road Network

The main components of Addis Ababa transport system in general and Kirkos sub-city in particular are the road network, city buses, minibuses, taxis, small number of private vehicles and large pedestrian. The road network provides the means for travel through the city. Recently, the light railways supplement the intra-city transportation service. The road network of Addis Ababa City has a radial form which is shaped by five regional roads radiating out of Central Business District. There is no well-defined hierarchical system. However, SMEC International (during the development of a pavement management system) divided the road network into the following four categories. The distribution of road network length provided by AACRA is given in table 3.5 and 3.6.

Arterial Roads (PSR): As per the Master plan these roads have varying width ranging from 30m to 60m. These roads provide continuous traffic flow, including intra-urban and inter-urban public transport lines. The ring road is included in this category.

Sub-Arterial Roads (SAR): have a road width ranging from 20m to 25m. These roads include a lower level of intra-urban mobility than the main arterial streets and connect adjoining areas.

Collector Roads (CR): The proposed width of these road categories is 15m and includes minor public streets used to collect and distribute the traffic to and from local streets and provides access to arterials streets.

Local Roads: The proposed width of these types of roads is 10m. Streets that provide access to residential, business areas are included in this category.

Table 3.5 shows the trend of the different hierarchical roads.

Road Hierarchy	**Total Length(km)**	**Area**(Km^2)	Equivalent Length((Km^2)	**No of Bridges**	**Pavement Status**
Arterial Roads	290.39	7.816	1,116.6	171	Very Good
Sub-Arterial Roads	164.36	2.902	414.6	80	Very Good
Collector Roads	214.52	3.066	437.9	34	Good
Local Roads	3,054.98	23.120	3,302.9	430	Good
Total	3724.25	36.904	5272	715	

Source: AACRA, 2018

The following table shows the road type classification in Addis Ababa.

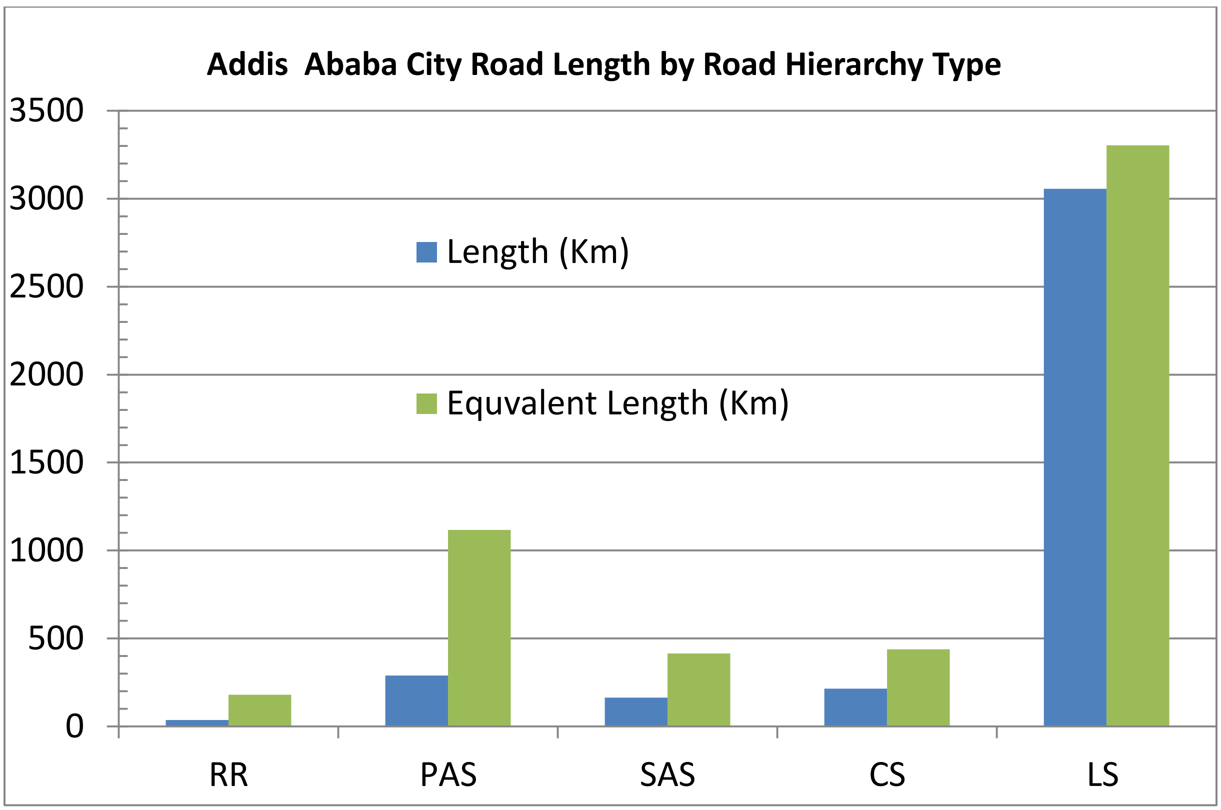

Figure 3.3 show Addis Ababa City Road length by Road Hierarchy type

Source: AACRA, 2018

Table 3.6 Addis Ababa City Road Type Classification

Road Type	**Length(km)**	**Area**(Km^2)	Equivalent Length((Km^2)
Asphalt	990.1000	17.10	2442.86
Cobble	1845.89	13.89	1984.29
Gravel	385.65	3.56	508.57
Care Stone	278.74	1.54	220.00
Earth work	261.21	2.08	297.14
Total	3,761.09	38.14	5,453

Source: AACRA, 2018

As indicated on the table above, the total length of roads in the city has increased to 3,761.09 km 0f which 990.100 km was asphalt road and the rest 1845.89, 385.65, 278.74, 261.21 km was cobble, gravel, care stone and earth work road respectively.

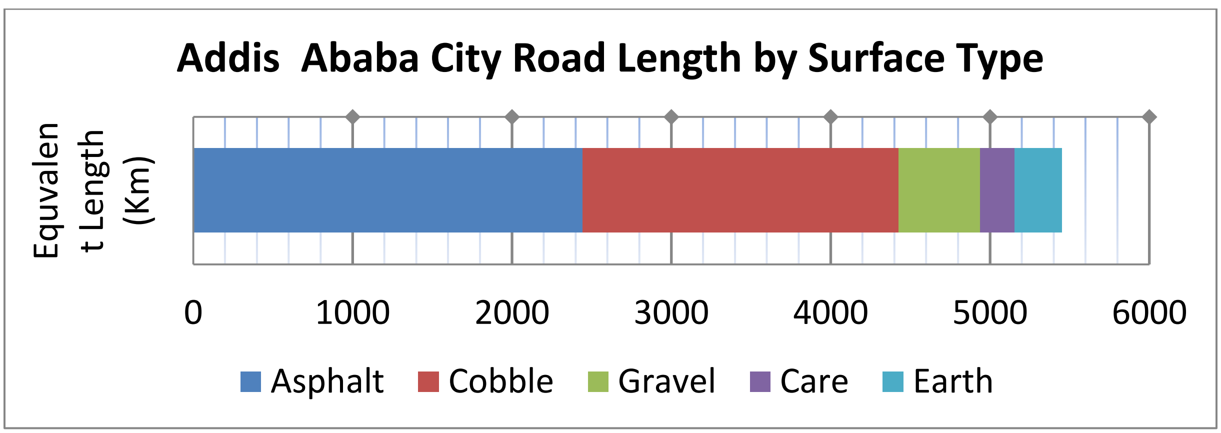

Figure 3.4 shows Addis Ababa city road length by surface type

Source: AACRA, 2018

In Kirkos sub-city more than 25km of the existing road is covered by asphalt/concrete (table 3.5). However, most of the Asphalt roads need maintenance. Currently, the size and the type of road may change a lot, because of the construction of small scale train rail way from *Mixco square* to Nation and Nationality square and continued.

Table 3.7 Kirkos Sub-City Road Classification by Road Type

Sub city	No	Surface Area	Length(m)	Area(m^2)	Equivalent Length((Km^2)
kirkos		Asphalt	75,754.69	1,275,728.55	182,246.94
		Cobble	29,666.00	209,425.50	29,917.93
		Gravel	11,376.00	85,764.00	12,252.00
		Care Stone	24,449.00	130,277.61	18,611.09
		Earth work	134.00	804.00	114.86
		Grand total	141,379.69	1,701,999.66	243,142.81
Grand Total (Km/km^2)			141.38	1.70	243.14

Source: AACRA, 2018

The predominant public transportation in the city in general and in Kirkos sub-city in particular includes: Anbessa City Bus, which serves the majority of the public transport users in the city, blue and white Mini-Bus, Higer Midi-Bus and Star Alliance Bus. There is also a small proportion of private car user. According to studies done before, more than one third of the total population Addis Ababa City is a pedestrian.

This is not only because of the society cannot afford to use the existing facilities, but also because of uncontrolled and rapid horizontal expansion and poor road network of the city (narrowness, limited network extent, almost no pedestrian walk way, etc.). Those are the major contributor for the low level of transport service in the city and in the study area as well.

Table 3.8 Registered Vehicles in Kirokos sub-city

kirkos sub -city vehicle by category			
Major Code	**AM Code**	**Am Service Type**	**total**
1	01AA	Taxi	1853
2	02AA	owner vehicle	17696
3	03AA and 03ET	commercial	22415
4	04AA and 04ET	governmental	6471
5	5	public institution	1121
7	COD	diplomat	2044
8	UN	united nation	1666
9	AAU	Africa union	376
10	EDE	supporting institution	9528
15	LEYU	NULL	123
22	2 long vehicles	NULL long vehicles	2
23	3 Long vehicles	NULL long vehicles	1
24	UN	united nation diplomat	89
25	AAU	Africa Union Diplomat	121
26	ED_COD	supporting institution diplomat	39
35	35	supporting institution	188
91	TELALAFI	NULL	490
		Total	64223

Source: Kirkos sub-city transport office, 2018

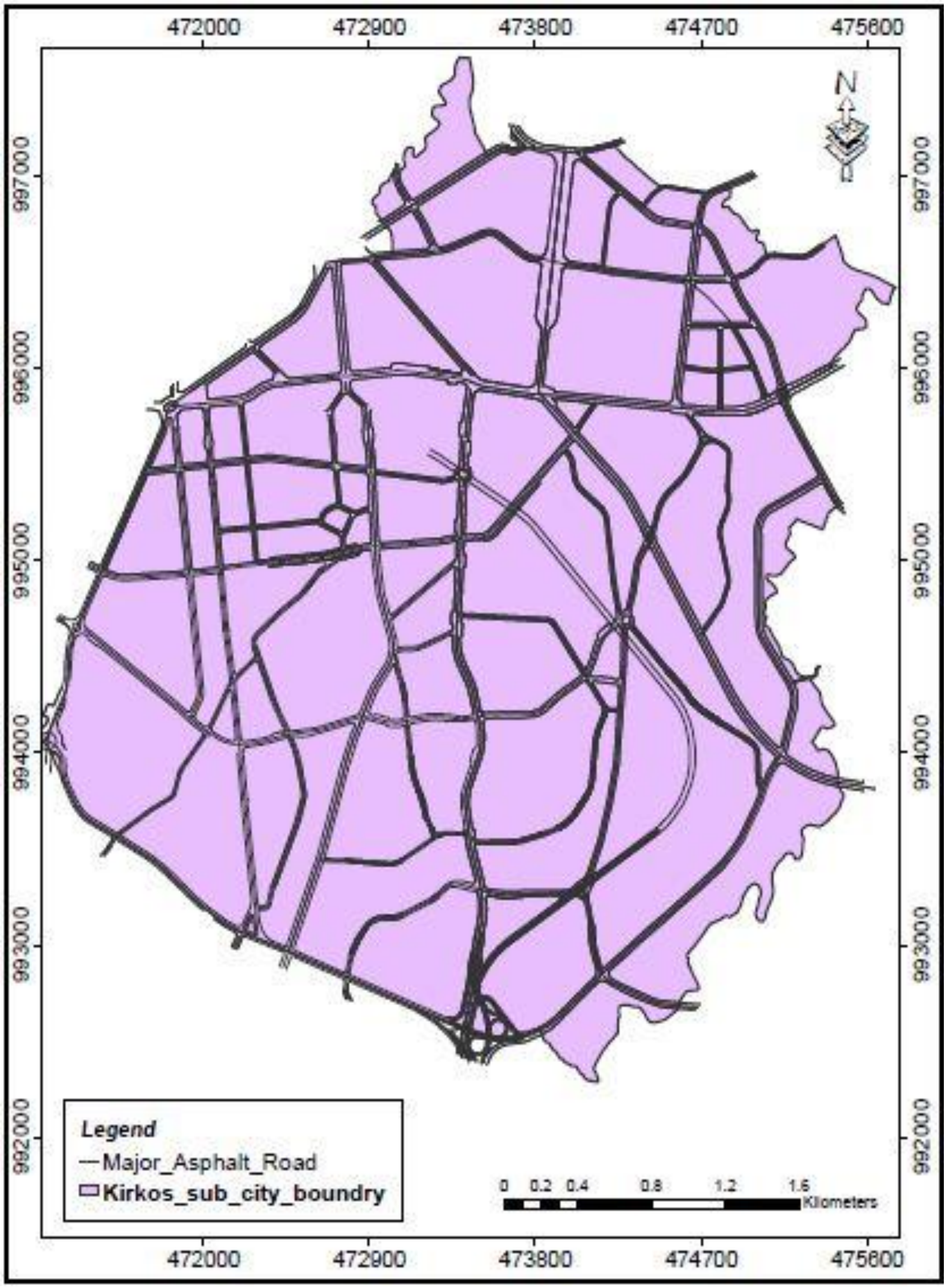

Figure 3.5 Map of Major Asphalt Road Network in Kirkos Sub-City

Source: Adopted from AACRA

3.7. Data Source

The data that are useful, the type of data and the availability of data were evaluated before the field work did commence. The types of data used in this research comprise of two types, i.e. primary data and secondary data

Primary Data: The primary data were obtained by locating the Traffic accident hot-spots of the sub-city using Global Positioning Systems (GPS). In addition, informal interview was conducted for Kirkos sub-city administration and Addis Ababa City Road Authority (AACRA), experts who were working in on the road traffic accident.

Secondary Data: - The RTA data (hard copy) were collected from the daily RTA records file of Kirkos Sub City Traffic Department. Data collection format was prepared in excel document format which enables the researchers to collect, filter and edit the required variables for the study. The summary of types and sources of data which were used in this study are shown in Table 4.1.

Table 3.9 Type and Source of data

Data	**Source**	**Format**	**Remark**
Demographic data Sub-city boundaries	Kirkos Sub-City Administration	Excel Auto CAD	Aggregated at *Woreda* level AutoCAD format and converted to Shape file
Land use data	Addis Ababa city Administration integrated land information center	PDF and Auto CAD	The data contains land use classification of Addis Ababa city and Kirkos sub-city
Current road network	Addis Ababa City Road Authority (AACRA)	Auto CAD	This data is obtained from AACRA in AutoCAD format and converted to Shape file, This data contains the existing road network of the study area with hierarch, length width and conditions

Road Traffic accident (RTA) data.	Kirkos sub-city police Department	Hard copy	Input data sets collected from the daily RTA records file of Kirkos sub-city police commission in paper format and converted to Excel file
Location of RTA Spots	GPS and Google Earth	Map and point data	The data is obtained using GPS and Google Earth.
Transport data.	Addis Ababa City Road Transport office and Kirkos Sub-city Road Transport Office	Hard copy	The data contains information about number of vehicle, It is obtained in paper format and converted into Excel file

3.8. Data Collection Techniques

A combination of the following techniques was employ in the study.

1. **Recorded Document Analysis:** By looking through the existing relevant documents or literature, the researcher tried to analyze the issues related with road traffic accident and traffic black spot identification.
2. **Field survey-** Field survey was conducted to assess the current traffic movement in the sub city and accessibility of the existing road network within the boundary of the sub-city.
3. **Identification of Black Spot Location Using GPS and GIS:** To identify accident blackspot, a method of Joining RTA Database with RTA Spots using GIS. The coordinates of all accident locations were acquired using Hand held GPS and all accident data were collected from Kirkos sub-city police Department .It has been created shape files in three types: point to represent check points, line to draw the road network and polygon to represent the geographical area occupied by study area. Then, these features have been connected by attributes table showing its characteristics. This step has been conducted by ARC GIS 9.2. After that all the processes have been carried out such encoding, coloring, classifying phenomena, analyzing data and output process for maps. This is to show as the different number of black spot location for further identification and final putting all black spot site locating using GPS coordination for further improvements.
4. **The accident site:** Point data was taken by GPS to show the location of traffic accident sites.

3.9. Data Preparation

After collecting the location of RTA places in GPS as point data, it was converted in to shape file using ArcGIS 10.2 software by uploading via DNRGPS 6.0.0.8 Application software. The four years RTA data which was arranged in Excel format was again filtered and rearranged using Pivot table for further application and was saved as CSV (comma delimited) (*.csv) format. After this procedure, the total RTA data was linked to the aforementioned shape file in to the ArcMap using the *'Joins and relates'* function. The *'clip'* functions from the *'Analysis tools'* was manipulated to pin sub-cities from Addis Ababa administration map shape file so as to know the number of RTA Spots included in each part of area in each year. Using input data like RTA Spot special codes, RTA Spot code count, RTA Spot name, RTA year and Kirkos sub-city boundary shape file; spatial RTA point maps of RTA Spots and RTA Black spots of each year and spatio-temporal RTA Black Spot maps were prepared for analysis.

3.10. Data Processing, Analysis and Presentation

The RTA Data collected from Kirkos sub-city Traffic police department were processed using descriptive statistics like crosstabs, frequencies, averages, totals and percentages in Arc Map 10.2 and the Statistical Package for the Social Sciences (SPSS) version 19 software. Accordingly, the data was organized and presented in the form of tables, pie charts, column bar charts and line graphs. The difference and trend in the frequency of RTAs was presented on maps using graduated symbols and bar charts.

3.11. Road Traffic Accident Black Spot Identification

Road Traffic Accidents Spot is place where even a single RTA has occurred regardless of its frequency or severity level of its consequence. However, as explained in the prior chapters, the definition of Black spots remains subjective among different scholars and different countries. For instance, Rokytova (2000) have stated that, black spots are generally classified after an assessment of the level of risk and the likelihood of a crash occurring at a location is made. In another stance, David et al. (2005) argued that black spot areas are sites that have had more than one fatal crash, sites with multiple crashes within a mile from one another. In addition to this, Runee et al. (2005) stated that in UK, Black spots are places where only five injury accidents occur in three years. In contrary, Geurts and Wets (2003) explained, from the perspective of Bangladesh, black spots are areas that exhibit more than 10 injury accidents in a year. Runee et al. (2005) added, other developed countries like Norway considers black spots as any place with a maximum length of 100 meters, where at least four injury accidents have been reported to the police during a four year period. The above varied definitions of black spots have dictated that a place to be considered as a black spot should exhibit fatal crash, multiple crash or injury in a defined time and space. Space, time and frequency of RTA occurrences are however considered as major criteria to identify RTA black spots in Kirkos sub-city in this research. Thus, we defined here RTA black spot as a single place that exhibits five or more RTA occurrences in one year. In addition to this, any place which exhibited only one or more RTA scene in the whole study period is hereby considered as RTA Spot. This implies that, all RTA Black Spots are RTA Spots but all RTA Spots may not necessarily be RTA Black Spots. Top 10 RTA Black Spots and consistent RTA Black Spots were identified based on their total RTA Frequency and consistency as RTA Black Spot in the whole study period, respectively.

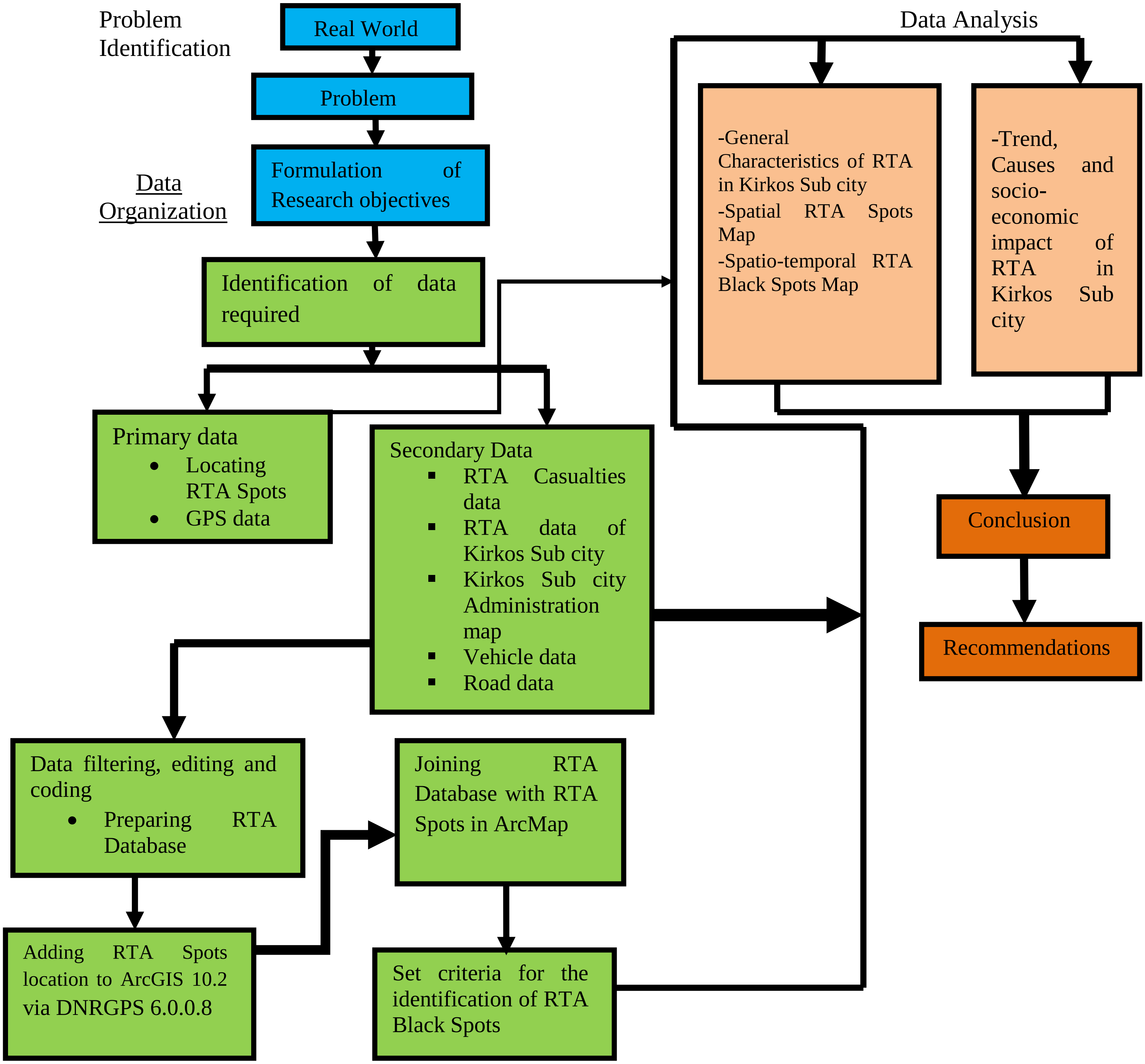

Figure 3.6: Research Design

Chapter Four

4. RESULTS AND DISCUSSION

4. 1 General Characteristics of Road Traffic Accident in Kirkos Subcity

4.1.1 Time and Road Traffic Accidents

4.1.1.1 Temporal Variation of Road Traffic Accidents

The occurrence of RTA can vary within the 24 hours of a day. The environmental factors like the availability of light, the volume of vehicles, the number of pedestrians and the like have a greater impact in the variation of RTA distribution within a day. Table 4.1 specifies the alteration of distribution of RTA occurrences in Kirkos Sub City in terms of the variation of time.

Table 4.1: Temporal variation of RTAs by hours of a day in Kirkos Sub City (2014/15-2018)

Time interval (Military time format)	Accident year				Total	%
	2014/15	2015/16	2016/17	2017/18		
12 A.M – 6 A.M	838	732	951	979	3500	24.80
6 A.M – 12 P.M	679	911	946	995	3531	25.02
12 P.M – 6 P.M	740	1010	941	998	3689	26.14
6 A.M – 12 A.M	756	602	954	1066	3378	23.93
Missing	6	4	2	2	14	0.09
Total	3019	3259	3794	4040	14,112	100

Source: Compiled from Kirkos Sub City Traffic Office (2018)

The variation in the hours of a day exhibits the difference in RTA occurrences in Kirkos Sub City (Table 4.1). The time between 12 p.m to 6 p.m reveals the largest proportion (26.14%) of all the RTA scenes in Kirkos Sub City between the years 2014 to 2018. 3689 (26.14%) accident records were observed in this time interval. The frequency of occurrence of RTAs in this time segment even exhibited a continuous increase from the years 2014 to 2018. Ironically, the time between 12 a.m to 6 a.m contributes only for 3500 (24.80%) of RTA records in the city with in the study time. In nearly similar context, Segni (2007) have discussed that the time between 3 p.m to 6 p.m contributes for the majority of RTA occurrences in the roads found between Addis Ababa and Shashemene. Generally, RTAs in Kirkos Sub City are frequently observed in the day time than in the night time between 6 a.m to 6 p.m. About 7220 (51.16%) of all the accidents recorded in the study period have been observed in the day time. The rest 6878 (48.73%) RTA incidences have been recorded in the night time between 6 p.m to 6 a.m. This means, driving or travelling on the roads of Kirkos Sub City between 12 p.m to 6 p.m is five times more precarious for being engaged in RTAs than driving or travelling between 12 a.m to 6 a.m. This phenomenon is evident mainly due to the fact that the movement and volume of vehicles and pedestrians is more in the day time than in the night time. This result is different from Bahir Dar City. Addis (2003) stated that about 51% RTAs in Bahir Dar City are commonly exhibit during the day time as opposed to 49% in the night time. The difference in the temporal occurrence of RTAs between day and night times in Kirkos Sub City also approves the idea stated by Hoobs (1979) that, night time accident rates are about 50% greater than or proportional daytime accidents.

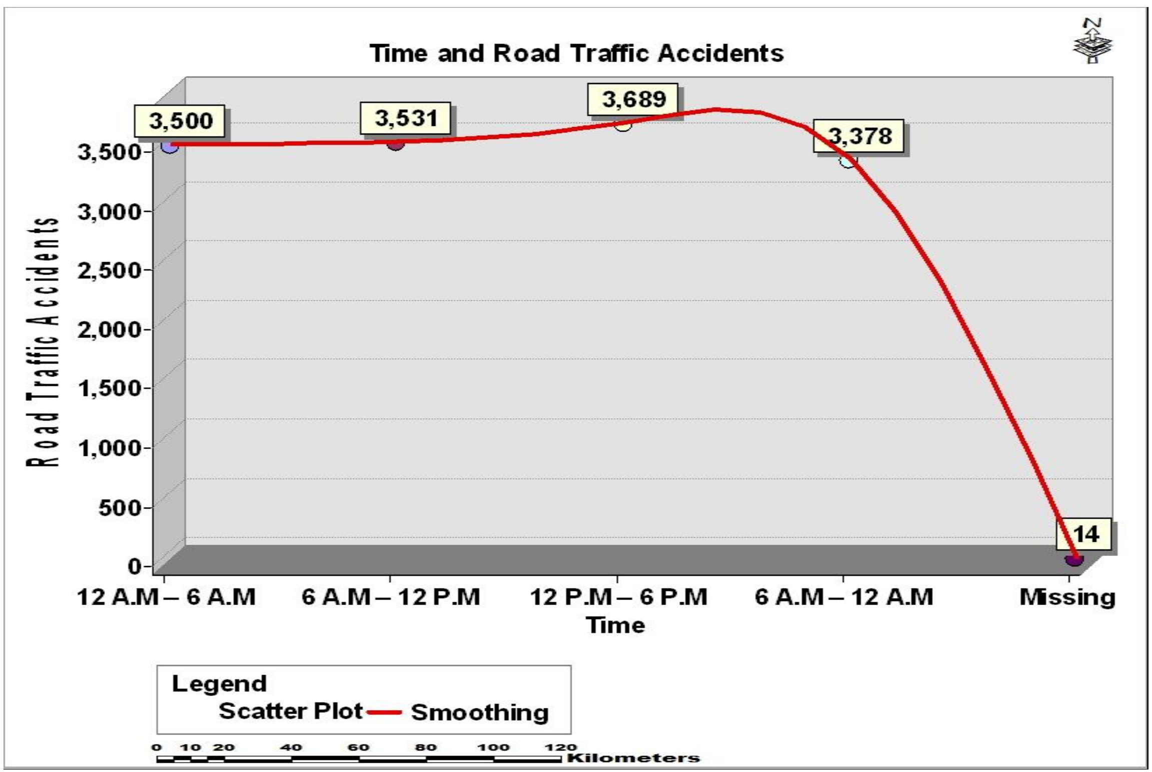

Figure: 4.1.Temporal variation of RTAs by hours of a day in Kirkos Sub City (2014/15-2018)

4.1.1.2 Weekly Temporal Variation of Road Traffic Accidents

Like the variation in the distribution of RTAs within the 24 hours of a day, there is disparity of RTA frequencies between the different days of a week.

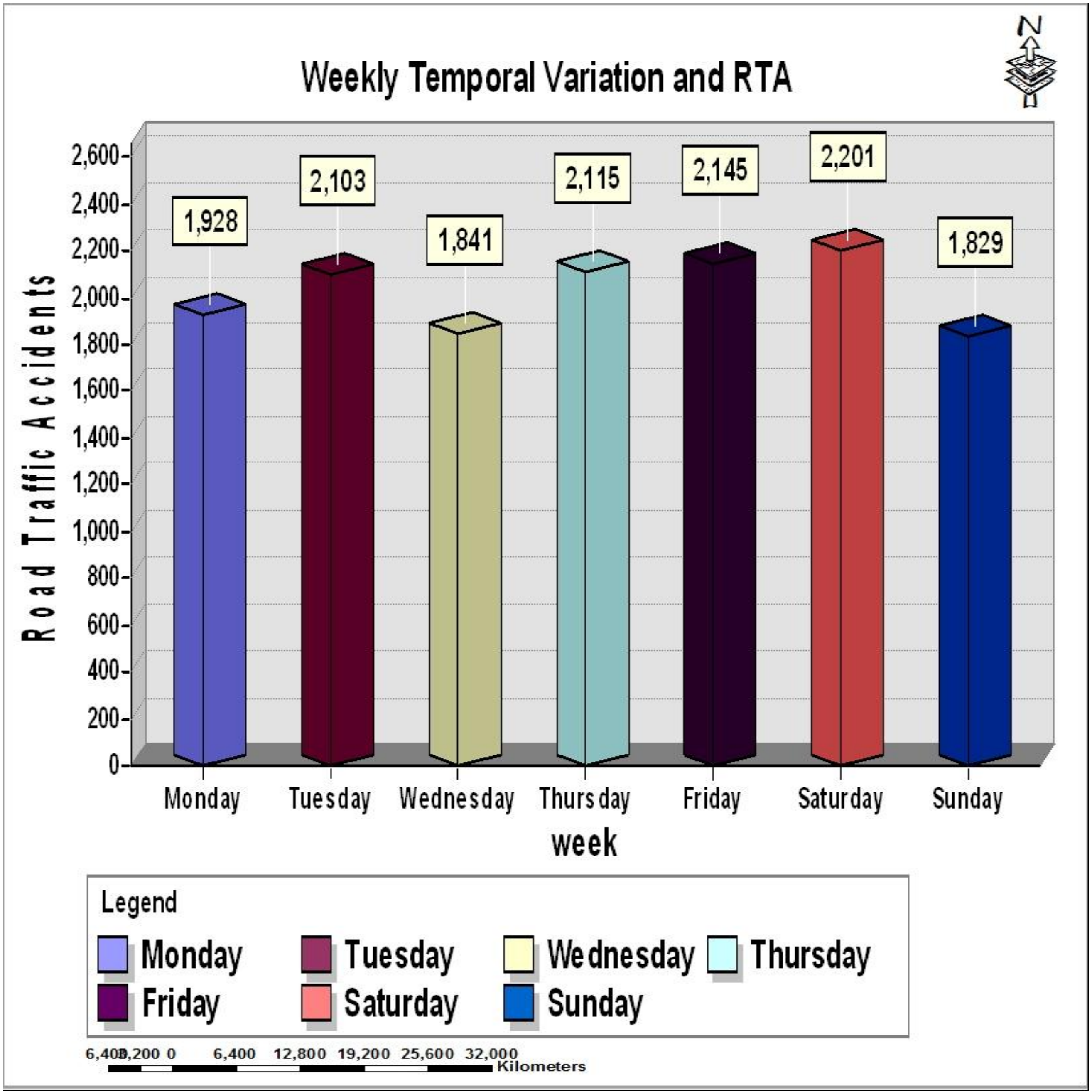

Figure: 4.2. Temporal variation of RTAs in a day by week in Kirkos Sub City (2014-2018)

4.1.2 Drivers Characteristics and Road Traffic Accidents

4.1.2.1 Drivers Age and RTA

Human beings are the primary causes of RTA. Several studies have witnessed that the age of drivers have a greater impact over the occurrence of RTA scenes. This is due to the fact that, the age of drivers affects their driving behavior, concentration, sense of responsibility and patience.

Table 4.2:Drivers age and RTA in Kirkos Sub City (2014 to 2018).

Drivers Age in years	Accident year				Total	%
	2014/15	2015/16	2016/17	2017/18		
18	1	2	-	-	3	0.021
18-30	1135	1334	1663	2032	6164	43.67
31-50	964	961	1286	1222	4433	31.41
>51	822	940	833	764	3359	23.80
Missed	97	23	12	22	154	1.09
Total	3019	3259	3794	4040	14112	100.0

Source: Compiled from Kirkos Sub City Traffic Office (2018)

Drivers between the ages of 18 and 30 are more frequently engaged in road crashes than drivers in the other age groups (Table 4.2). Drivers aged 18 to 30 contribute 6164 (43.67%) of all the RTA crashes in the study period followed by age groups between 31 and 50 which contributes 4433 (31.41%) to the misery. Driver age group above 50 years contributes only 3359 (23.80%) road crashes in Kirkos Sub City during the study period. The underage car drivers/riders contribute for 3 (0.021%) of total crashes during the study period. Drivers found in the age group between 18 and 30 (young drivers) in the city are 1.23 times more frequently involved in RTAs than drivers aged 31 to 50 in Kirkos Sub City.

Likewise, David et al. (2005) suggested that, young drivers are significantly more likely to be involved in a fatal crash than aged drivers. In addition, a study on drivers killed in road crashes estimated that young drivers are five times prone to the risk of crash accidents compared to the drivers aged above 30. This is mainly due to the fact that many exhibit behaviors and attitudes can place young drivers in more hazardous situations than other road users. Older drivers with slower reactions might be expected to cause in more accidents, but this has not been the case as they tend to drive less and, apparently, more cautiously.

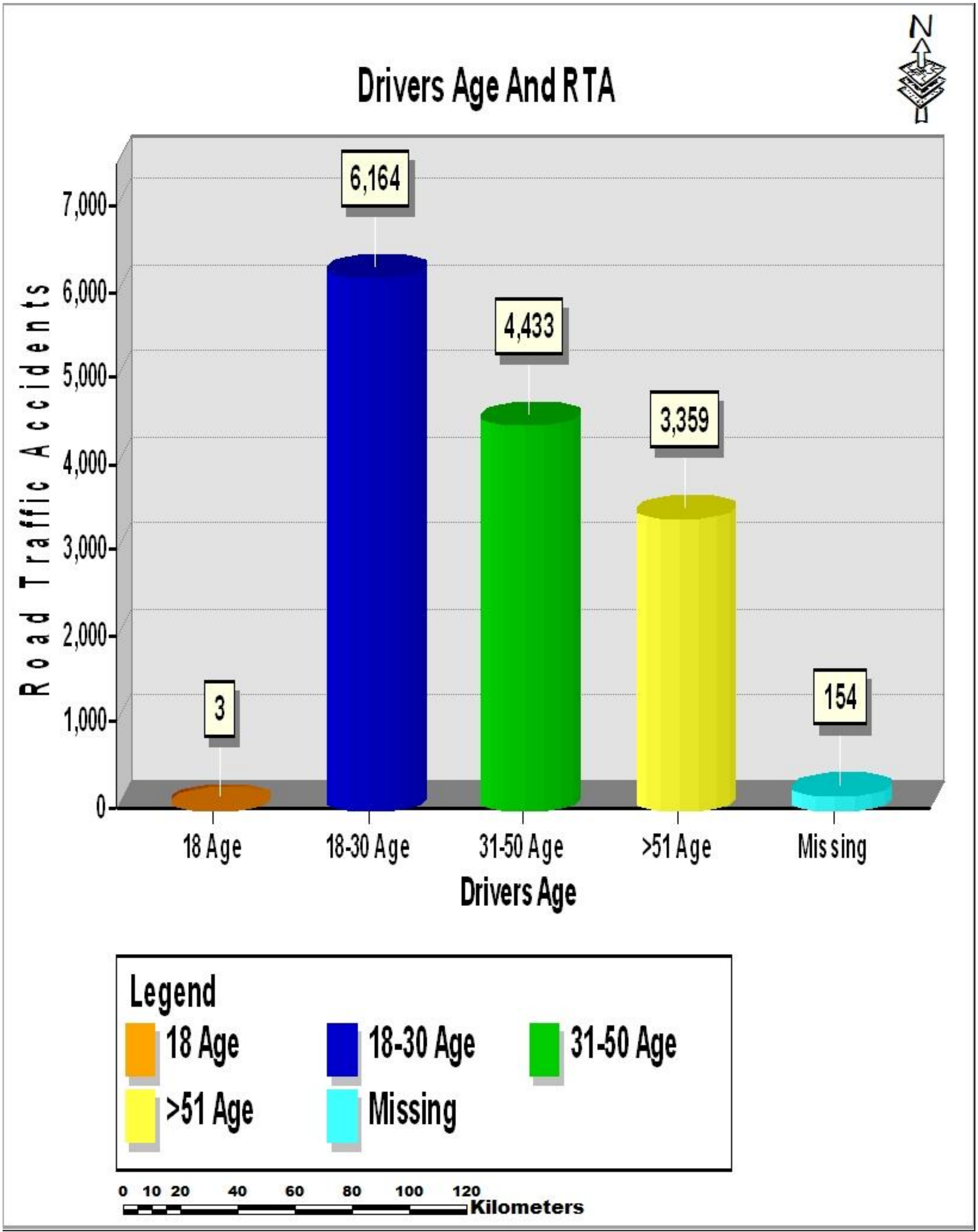

Figure: 4.3.Drivers age and RTA in Kirkos Sub City (2014 to 2018).

4.1.2.2 Drivers Sex and RTA

The occurrence of RTA in Kirkos Sub City shows a greater variation in terms of drivers' sex. As shown in figure 4.4, the number of male driver's involvement in RTAs greatly outnumbers females in Kirkos Sub City. The outstrip number of male drivers could result in more frequencies of engaging in RTA events. From 2014 to 2018 male drivers cause 11563(81.93%) RTAs in Kirkos Sub City. In contrary, female drivers caused 2385 (16.90%) road crashes. In a very similar result Mekonnen (2007) have proved that, male drivers are the main contributors to RTAs than females in Addis Ababa. However, with this, conclusive remarks cannot be made due to the different proportions of male against female drivers.

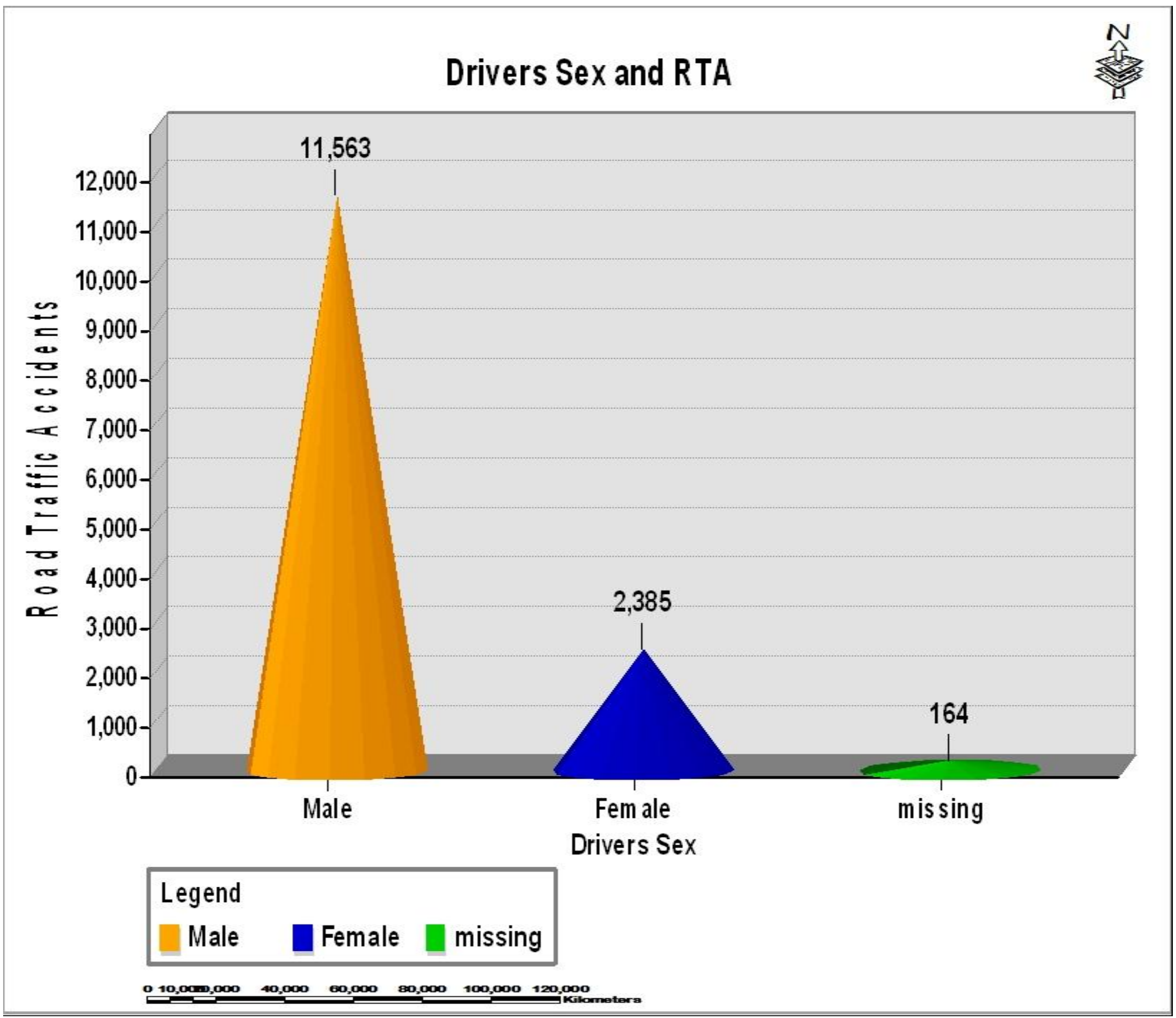

Figure: 4.4: Drivers sex and their contribution to RTA in Kirkos Sub City (2014-2018)

4.1.2.3 Drivers Driving Experience and RTA

It is believed that the experience of drivers play a paramount role in road crashes. The distributions of road crashes in Kirkos Sub City are also affected by the driving experience. Table 4.3 summarizes the difference in RTA occurrences in relation to driving experience.

Table 4.3: Driving experience and RTA in Kirkos Sub City (2014-2018)

Drivers driving experience in years	Accident year				Total	%
	2014/15	2015/16	2016/17	2017/18		
No Driving license	-	120	84	174	378	2.68
<1	461	513	966	659	2599	18.41
1-2	685	745	788	865	3083	21.84
2-5	602	642	851	1000	3095	21.93
5-10	543	563	644	748	2498	17.70
10 year above	631	652	449	572	2304	16.32
Missed	97	24	12	22	155	1.09
Total	3019	3259	3794	4040	14112	100.0

Source: Compiled from Kirkos Sub City Traffic Office (2018)

Table 4.3 illustrates 3083 (21.84%) RTA incidences have been exhibited by drivers whose driving experience is between 1 to 2 years. The drivers with driving experience between 2 and 5 years have caused 3095 (21.93%) road crashes in the study period. In addition to this, with the exception of the drivers in their first year experience, the result shows that the frequencies of RTA occurrences decrease with increasing in driving experience in Kirkos Sub City. Drivers with an experience of 1 to 2 years cause 1.25 times more road crashes than drivers with driving experience between 5 and 10 years. This result in Kirkos Sub City is found conflicting with the correlation between driving experience of drivers and frequency of their involvement in road crashes in Addis Ababa city. This is because, as stated by Mekonnen (2007), the highly experienced drivers are engaged in frequent RTA scenario than the least experienced ones in Addis Ababa.

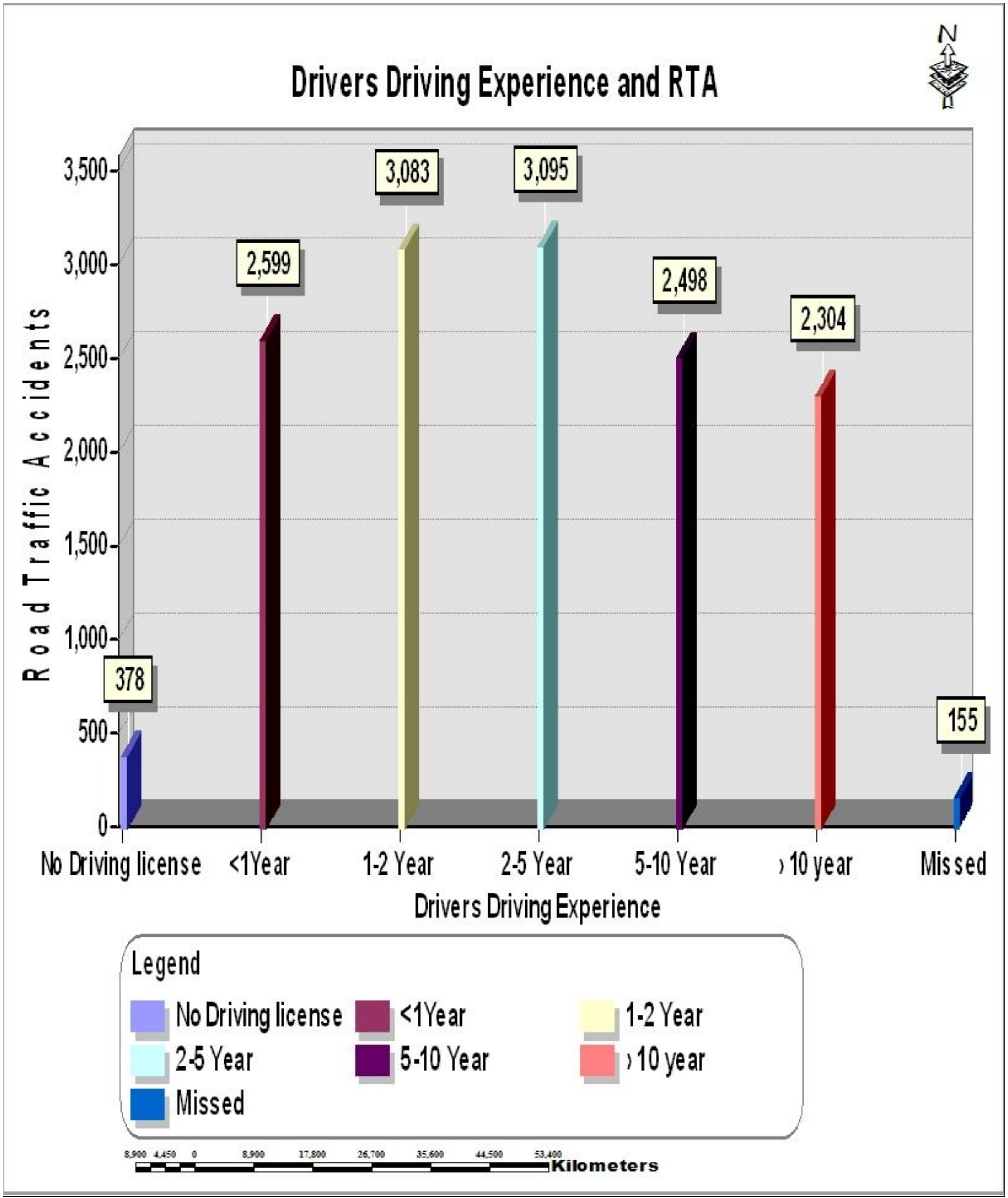

Figure: 4.5: Driving experience and RTA in Kirkos Sub City (2014-2018)

4.1.2.4 Hired Driver – Own drivers vis-à-vis RTA

The incident of RTA was evaluated against driver and vehicle ownership. Figure 4.6 Illustrates how far the drivers – vehicle ownership relationship contributes to RTA occurrences in Kirkos Sub City about 9369 (66%) of RTAs are recorded from hired drivers. Ironically, 4009(29%) of accidents were accompanied by owners of the vehicle while driving their own vehicles. Similar to this finding, Mekonnen (2007) argued that hired drivers were engaged in frequent RTAs in Addis Ababa when compared to the vehicle owners. The low accident caused by own drivers' is mainly attributed to the strong sense of ownership feeling, belongingness and responsibility.

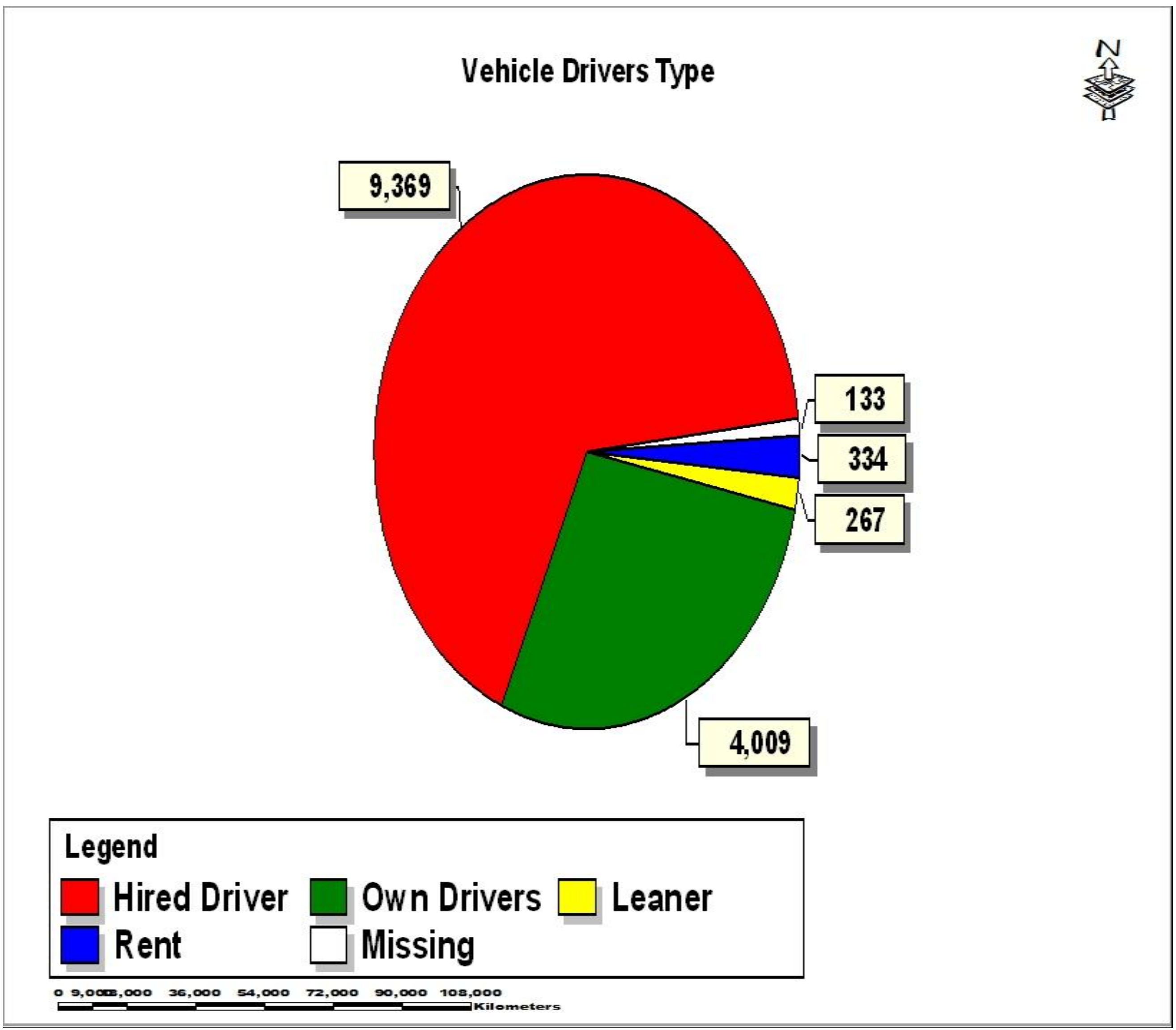

Figure: 4.6 Hired Drivers – own drivers vis-à-vis RTA in Kirkos Sub City (2014-2018)

4.1.3 Vehicle Characteristics and Road Traffic Accidents

4.1.3.1 Vehicle Service Age and RTA

The vehicle service age determines the fate of the vehicle to be engaged in RTA Crashes. The RTA data collected from Kirkos Sub City Traffic office, as shown in table 4.4 reveals that the vehicle service age determines the variation in the distribution of RTA throughout the study period.

Table 4.4: Vehicle service age and RTA in Kirkos Sub City (2014-2018)

Vehicle service age in years	Accident year				Total	%	Average Driving Experience of Drivers in Years
	2014/15	2015/16	2016/17	2017/18			
‹ 1	504	605	681	632	2422	17.16	1
1-2	640	676	1042	948	3306	23.42	1.5
2-5	666	790	762	918	3136	22.2	2.8
5-10	614	650	684	837	2785	19.73	8.9
› 10 year	498	512	613	683	2306	16.34	14
Missed	97	26	12	22	157	1.11	5.30
Total	3019	3259	3794	4040	14112	100.0	

Source: Compiled from Kirkos Sub City Traffic Office (2018)

Vehicles with service age less than 1, and 1 to 2 years caused RTA 2,422 (17.16%) and 3,306 (23.42%), respectively. As the service age of vehicles is high, for example, between 5 and 10 years, the probability of road crashes in the city decreases. This is because: Driving experience: The average driving experience of drivers who drove vehicles with a service age of less than 1and 1 to 2 years was 1 and 1.5 years respectively while vehicles with a service year of 5 to 10 were driven by drivers whose average driving experience was 8.9 years. Speed of the vehicles that vehicles of old age have low speed compared to the new ones.

New vehicles become less familiar to the drivers. Most of the break system, comfort during driving and self-confidence on controlling the vehicles are some of the reasons. The over confidence of drivers on relatively newer vehicles and the lesser attention they gave to the vehicle inspection of new vehicles could result in higher frequency of involvement of new vehicles in RTAs. The probability of vehicles service age contribution to RTA in the city would be a little bit different if the service age of the 1.11% of the vehicles which produced 157crashes was known.

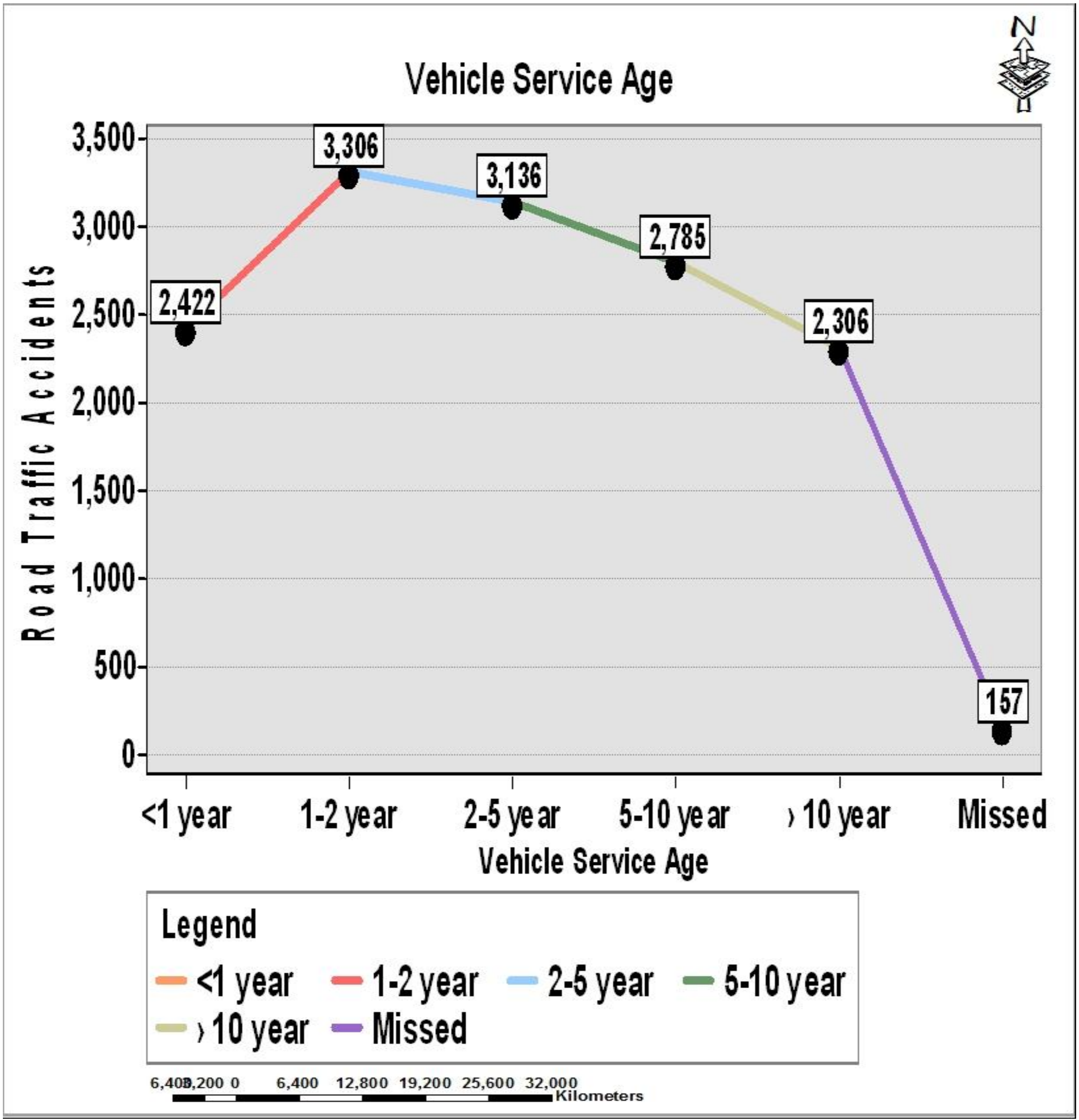

Figure: 4.7: Vehicle service age and RTA in Kirkos Sub City (2014-2018)

4.1.4 Road Characteristics and Road Traffic Accidents

4.1.4.1 Road as a contributor of RTA

Based on the RTA data collected in the study period, the two-way road division types produce 4,795(34%) of all the road crashes, while the one –way roads contribute for 3276 (23%) of RTAs

(Figure 4.8). The frequency of road crashes in two-way roads is by far higher than in the one-way roads. This is because two-way roads host the movement of vehicles from opposite directions in the same stream and are usually characterized by traffic congestion. However, the one-way roads have a divide line which separates vehicles in to two and enables them to move only in one direction and allows vehicles to move in a relatively safe route than in the two-way roads. Due to this reason, two – way roads are more risky to RTA occurrences than one – way roads in Kirkos Sub City. The squares of the city are also places of some RTA occurrences. About 3,730 (26%) of road crashes are recorded at or near the road junction and roundabouts. The remaining 1,049 accidents or (8%) and 1,262 accidents or (9%) happen in cross ways with broken color and cross ways with unbroken color, respectively.

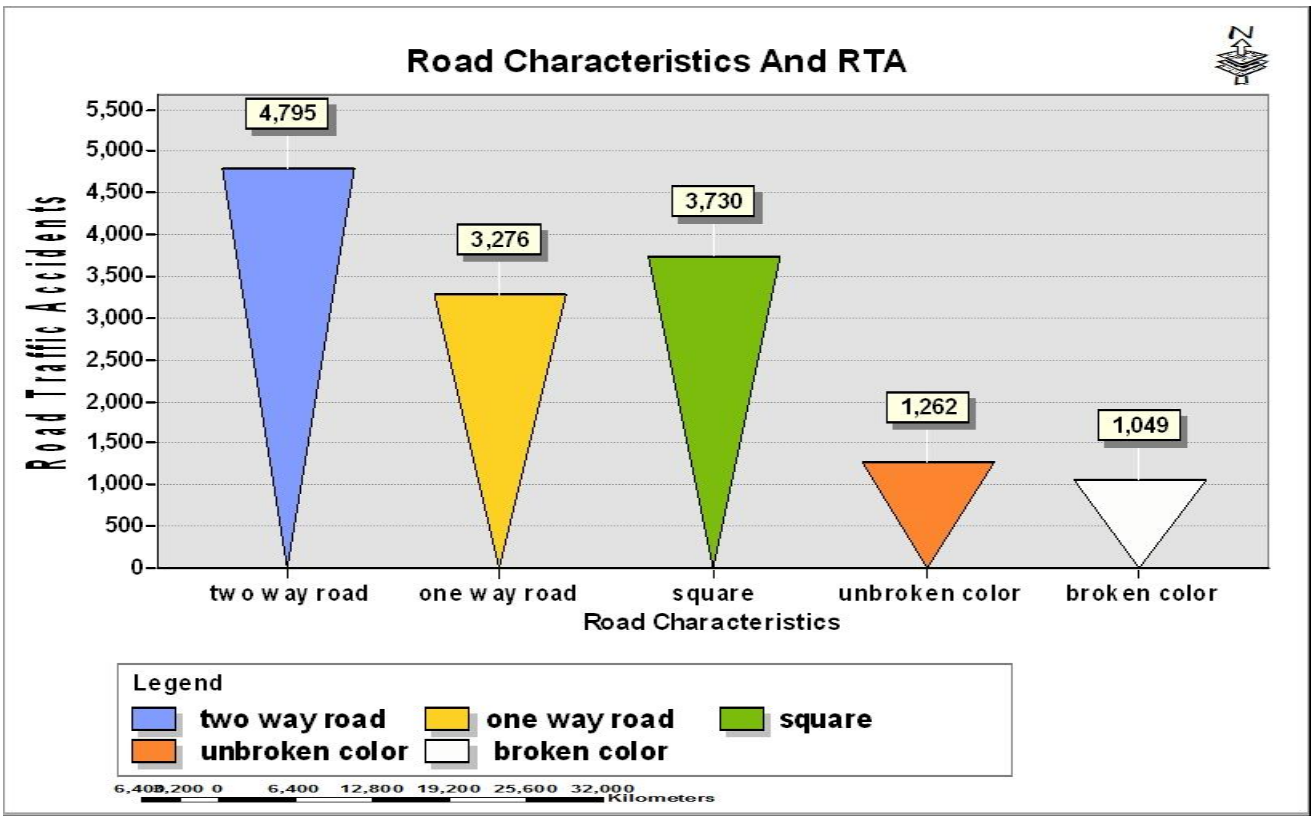

Figure: 4.8 Road divide and RTA in Kirkos Sub City (2014-2018).

4.1.4.2 Road Pavement and RTA

Road's pavement is found as the major contributing variable for the occurrence of RTAs in Kirkos Sub City since it is directly related to the speed of the vehicle. Drivers prefer to drive in higher speeds in smoother road pavements like in asphalt roads. Consequently, about 13,209 (93.6%) of all the accidents has occurred on asphalt roads. Gravel roads and damaged asphalt roads contribute 278 (1.96%) and 365 (2.5%) between the years 2014 to 2018, respectively (Figure 4.9). Drivers have high precaution at hazard locations compared to low hazard locations. This is to mean in places where drivers perceive a location as hazardous, they take more care. Accidents may be more likely to happen when hazardous road or traffic conditions are not obvious at a glance, or where the conditions are too complicated to perceive and react in the time and distance available.

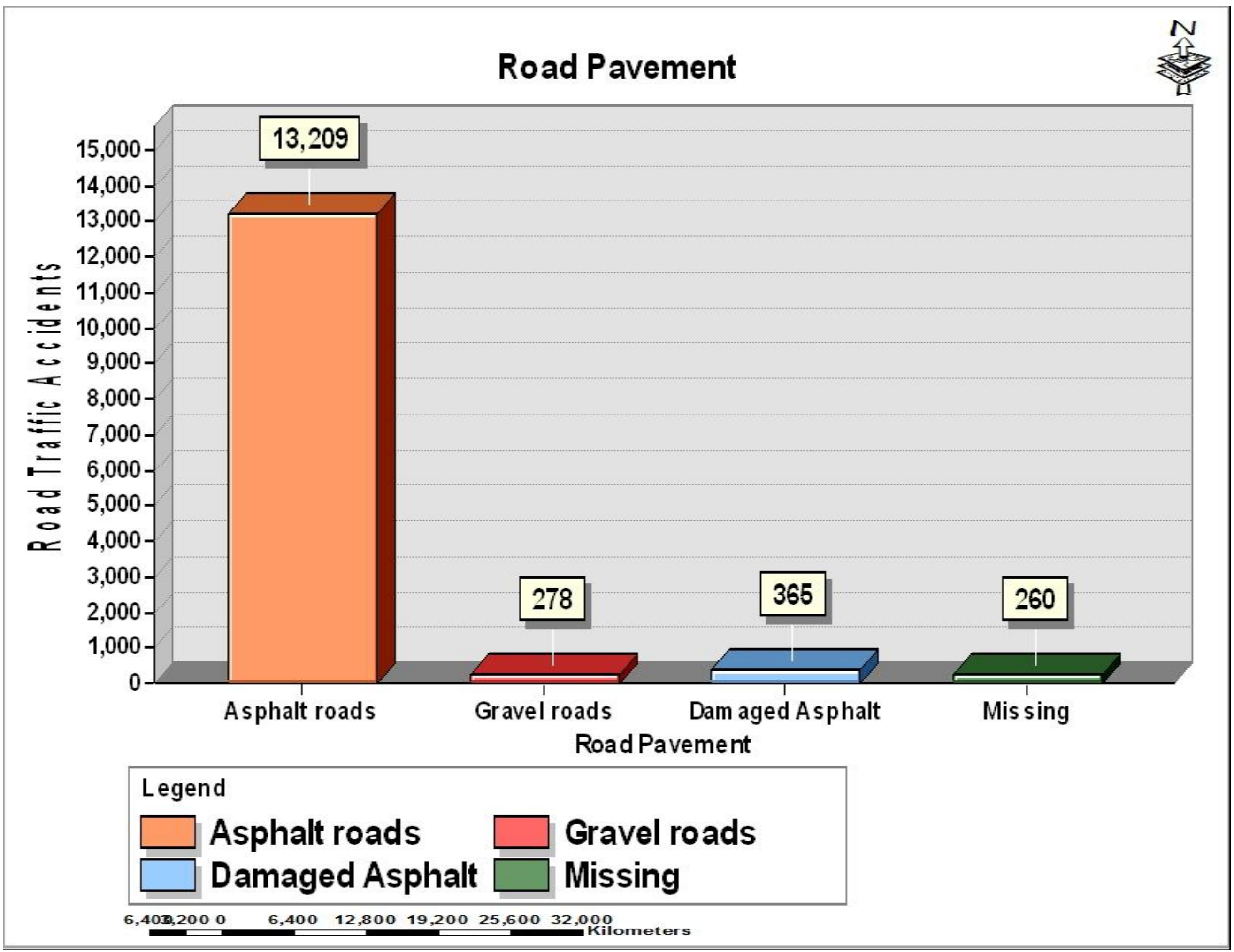

Figure: 4.9 Road Pavements and RTA in Kirkos Sub City (2014-2018)

4.1.4.3 Road Moisture Condition and RTA

As stated by David et al. (2005), the condition of road weather strongly affects the occurrence of RTAs. Similarly, RTA is found to vary according to weather (Figure 4.10). The road condition due to differences in moisture is classified as dry or wet road. Out of the total 14,112 RTA records in the last four years in the city 13,863 (98.23%) have occurred on dry roads while 221(1.56%) on wet and 28(0.19) on muddy roads in Kirkos Sub City. This may be due to the short wet season (little number of rainy days) in a year, the dry season or dry weather which shields the extensive number of days in a year in the city therefore produces greater number of road crashes.

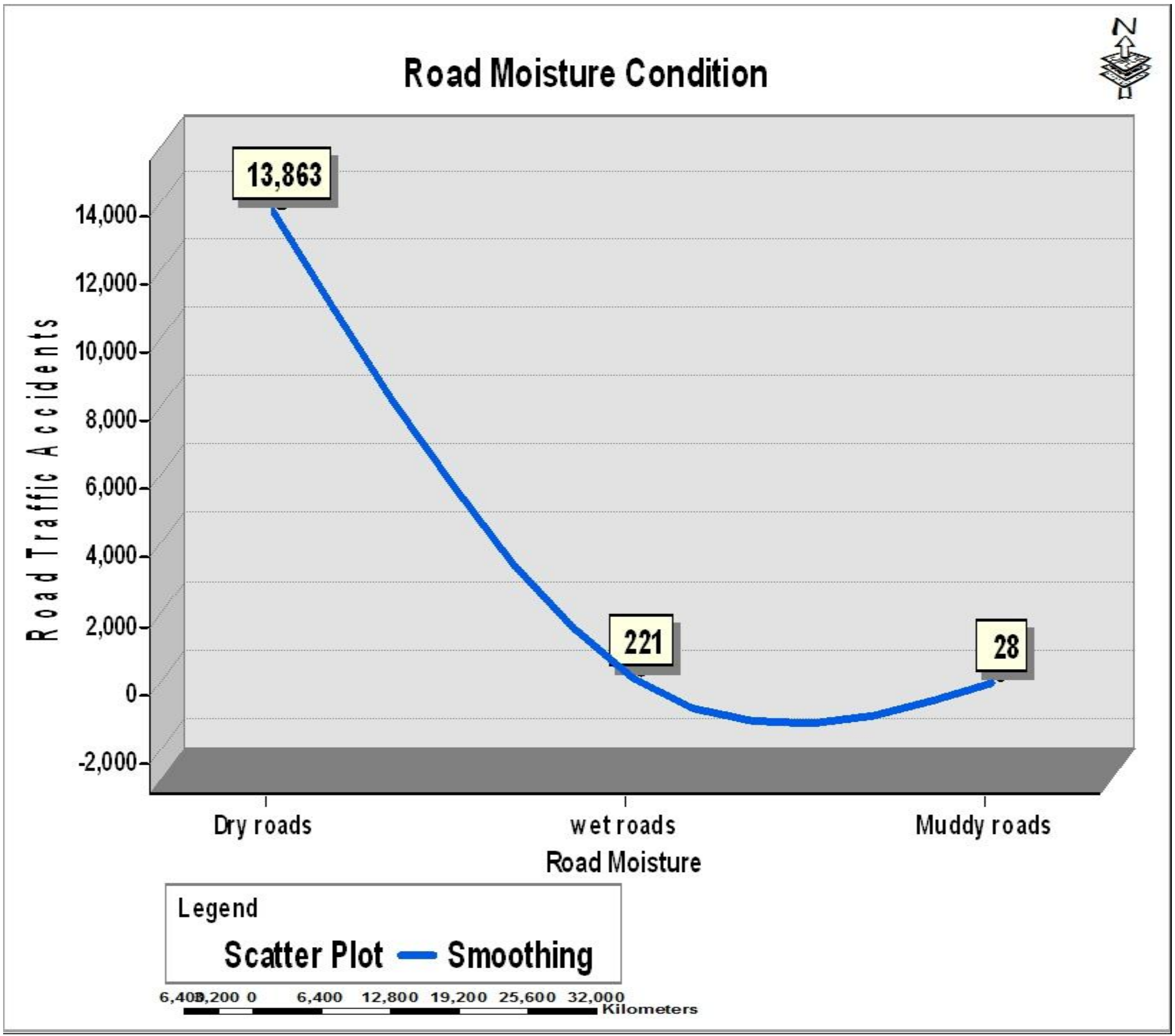

Figure: 4.10 Road moisture condition and RTA in Kirkos Sub City (2014-2018)

4.1.5 Weather Condition and Road Traffic Accidents

The weather condition of the moment in RTAs plays an important role in varying the frequency and risk of road crashes. (David et al. 2005); Alister and Simon (2011) stated that the climatic and environmental conditions can be a factor in RTAs. Experiences show that several crashes occur during conditions of smoke or fog, which reduces visibility. Road Traffic Accidents in Kirkos Sub City frequently occur during good weather conditions than during rainy and drizzle falling events. Accordingly figure 4.11, 13,982(97.7%) RTAs in the city have been recorded in good weather conditions but only 120 (0.85%) and 20(0.14%) accidents recorded in drizzle falling and warm weather conditions respectively. Bright and dry weather of the city which covers the longer days of the year in the city produces greater number of RTAs than the rainy and drizzle falling weather conditions.

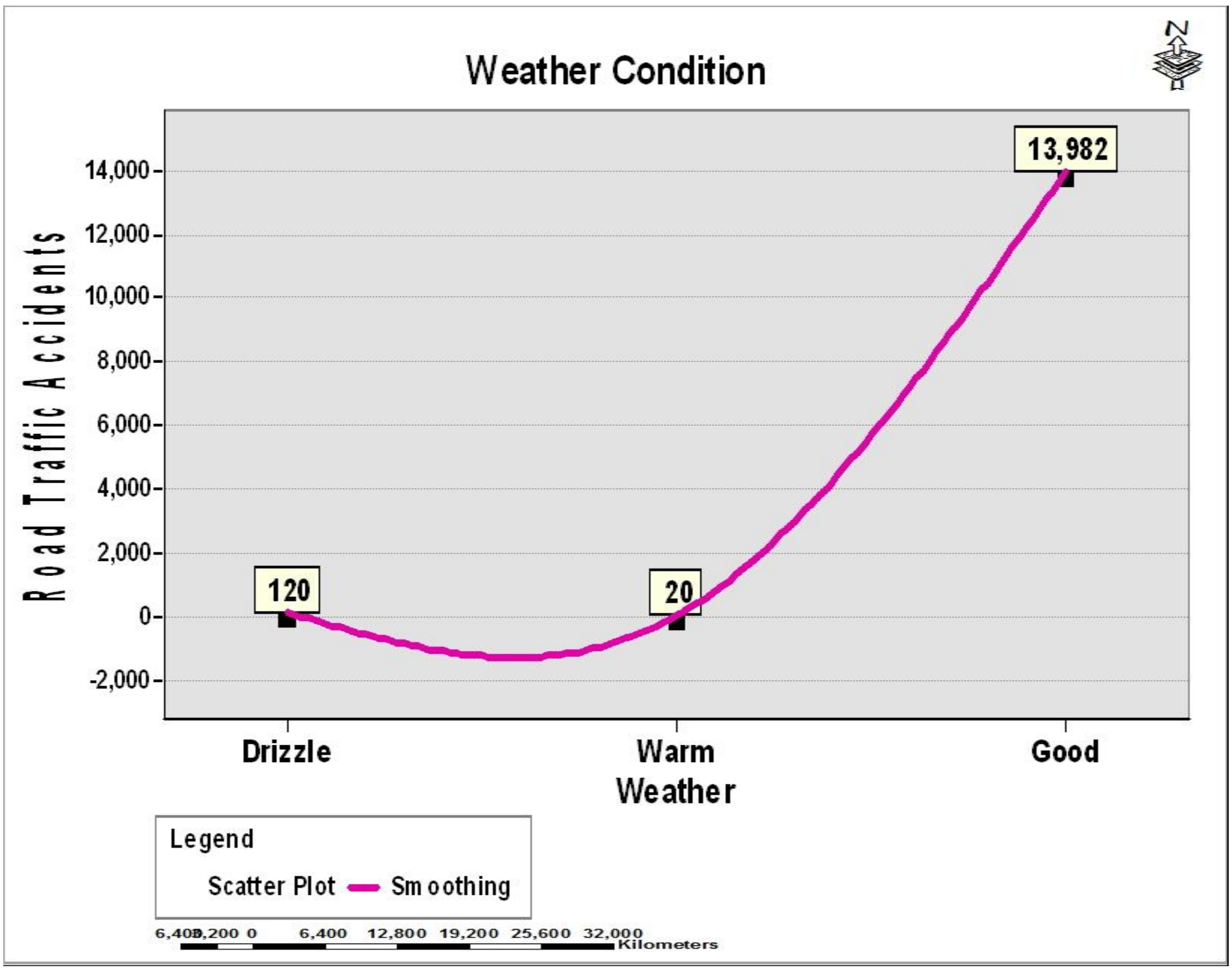

Figure: 4.11 Weather condition and RTA in Kirkos Sub City (2015-2018)

4.1.6 Types of Road Traffic Accidents

Road Traffic Accidents can happen in various ways. Safecarguide (2004) indicated the type of RTA may include collision between vehicles and animals, vehicles and pedestrians or vehicles and fixed obstacles. This shows that RTA can have a varied ways are shown in the blow Figure.

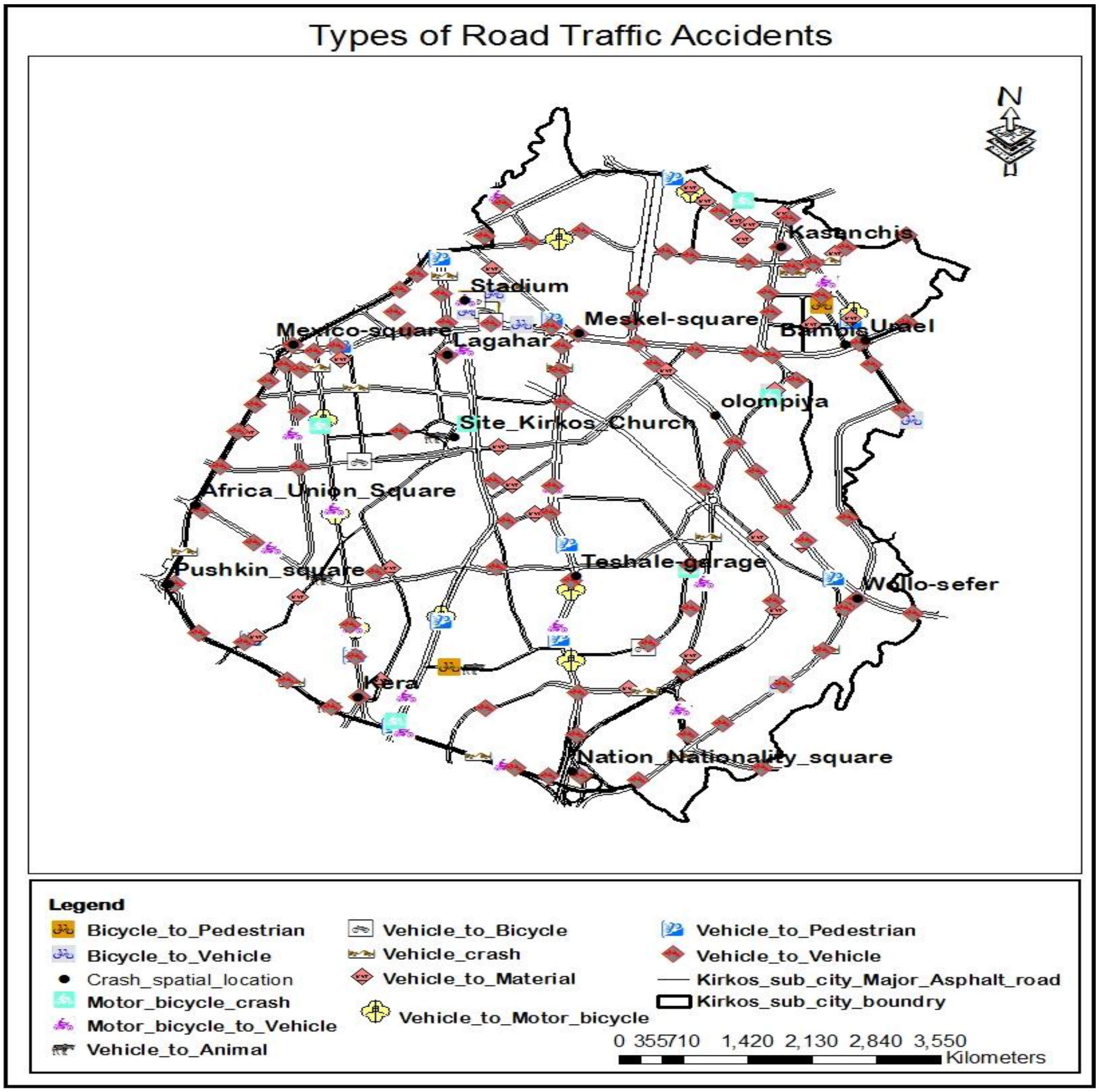

Figure: 4.12. The major types of RTA in Kirkos Sub City

The RTA occurred in the city between the study periods are of varied types and their contribution to the road crashes also vary considerably. The vehicle to vehicle crash gets the biggest proportion i.e. 10340 (73.27%) of RTA crashes of all types of RTAs in the city followed by Vehicle to Material crashes which covers 1906 RTA scenes and 13.50% share of the RTA occurrences from 2014 to 2018 in Kirkos Sub City (Figure: 4.12.). In the remaining cases, with the exception of Vehicle to Pedestrian and vehicle crush types which covers 4.79% and 2.02% of the road crashes, respectively, the rest have relatively insignificant contribution to road crashes in Kirkos Sub City. Pedestrians have been engaged in 730 RTA cases i.e. 676 with vehicles and 54 with bicycle. In addition to this, Motor bicycle to Vehicle and Vehicle to Animal are engaged in 193 and 106 RTA occurrences in the study period, respectively.

4.1.7 Distribution of road accidents by intersection and round about

Figure: 4.13 below show the accident distribution in different sections of a road segment. As the table indicates, there are a large number of accidents on junctions and roundabouts. Contrary to the junctions, straight sections of the road do not have large amounts of accident record. Therefore, much emphasis must be given at junctions and roundabouts to improve geometry of the road category.

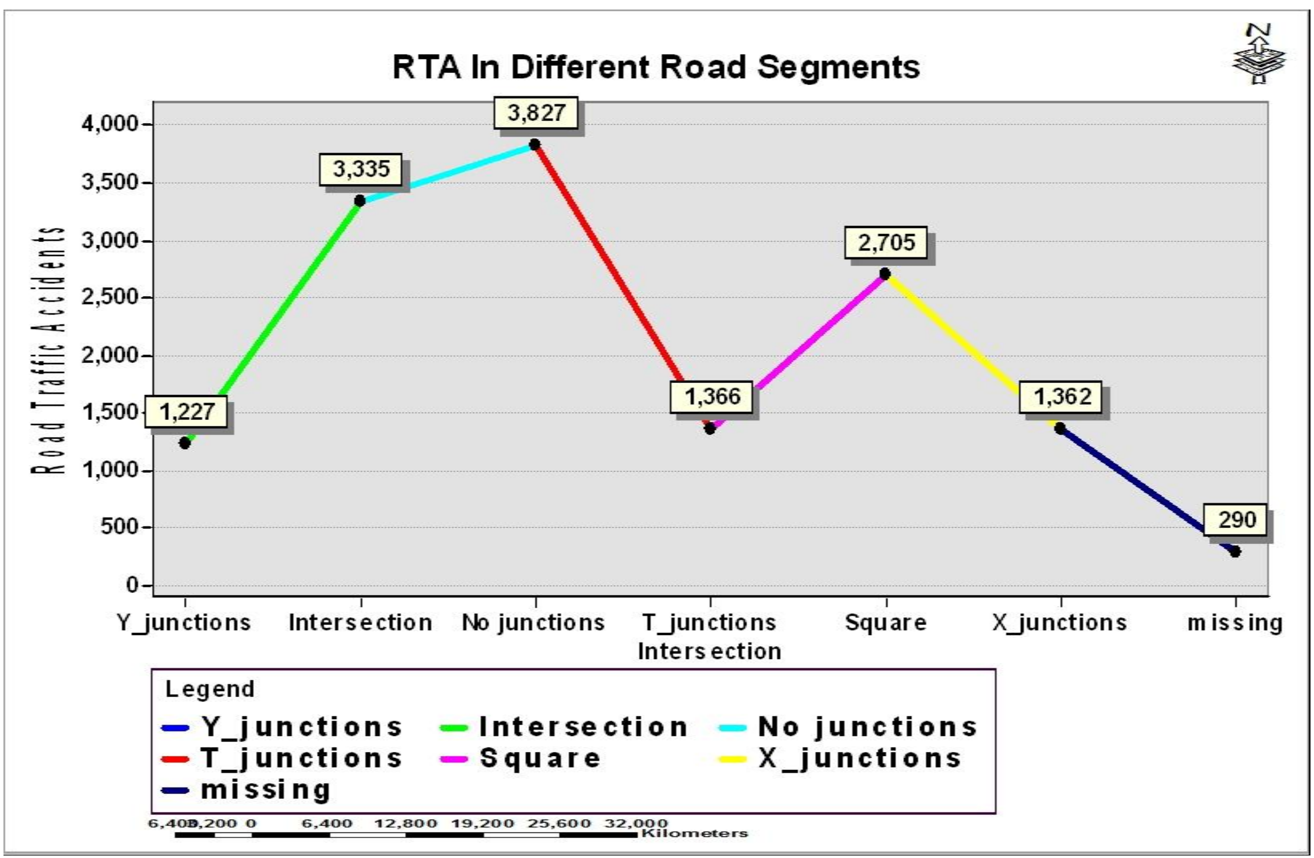

Figure: 4.13. Distribution of traffic accident by road intersection and junction (2014-2018)

4.2 Road Traffic Accident Black Spots in Kirkos Sub City

4.2.1 Spatial Distribution of RTA Black Spots of Kirkos Sub City in 2014/15

According to the criteria set, all places that exhibit five or more than five RTAs were defined as RTA Black spots. Accordingly, as shown in table 4.5 and figure 4.14 places were identified as RTA Black spots in Kirkos City in the year 2014/15.

Table 4.5: Kirkos Sub City RTA Black Spot areas (2014/15)

year	RTA Black Spot area	Number of RTA Spots	No. of RTAs occurred in the Black spot
2014/15	Olompia	8	269
	Kasanchis	5	110
	Wollo-sefer	6	192
	Mexico-square	4	87
	Teshale-garage	2	67
	Meskel-square	5	164
	Bambis	6	55
	Urael	5	51
	Lagahar	4	51
	Stadium	6	49
Total	10	51	1095

Source: Compiled from Kirkos Sub City Traffic Office (2018)

According to table 4.5, a total of 1095 RTAs have been recorded from only 10 RTA black spots in the city in the year 2014/15. This implies that, an average of 109.5RTA incidences have occurred at every single RTA Black spot in the city in the year 2014/15. The highest frequency of RTAs i.e. 269 happened around Olompia area in 2014/15. In addition to this, more of out of the 10 RTA black spots of the city in this year have occurred in the central parts of sub-city and its extension. Urael and its extension Lagahar areas shared 51 and 51 the same RTA Black Spots, respectively. Ironically, Mexico-square, Meskel-square and Stadium exhibited only 87, 164 and 49 RTA black spot area each in the year.

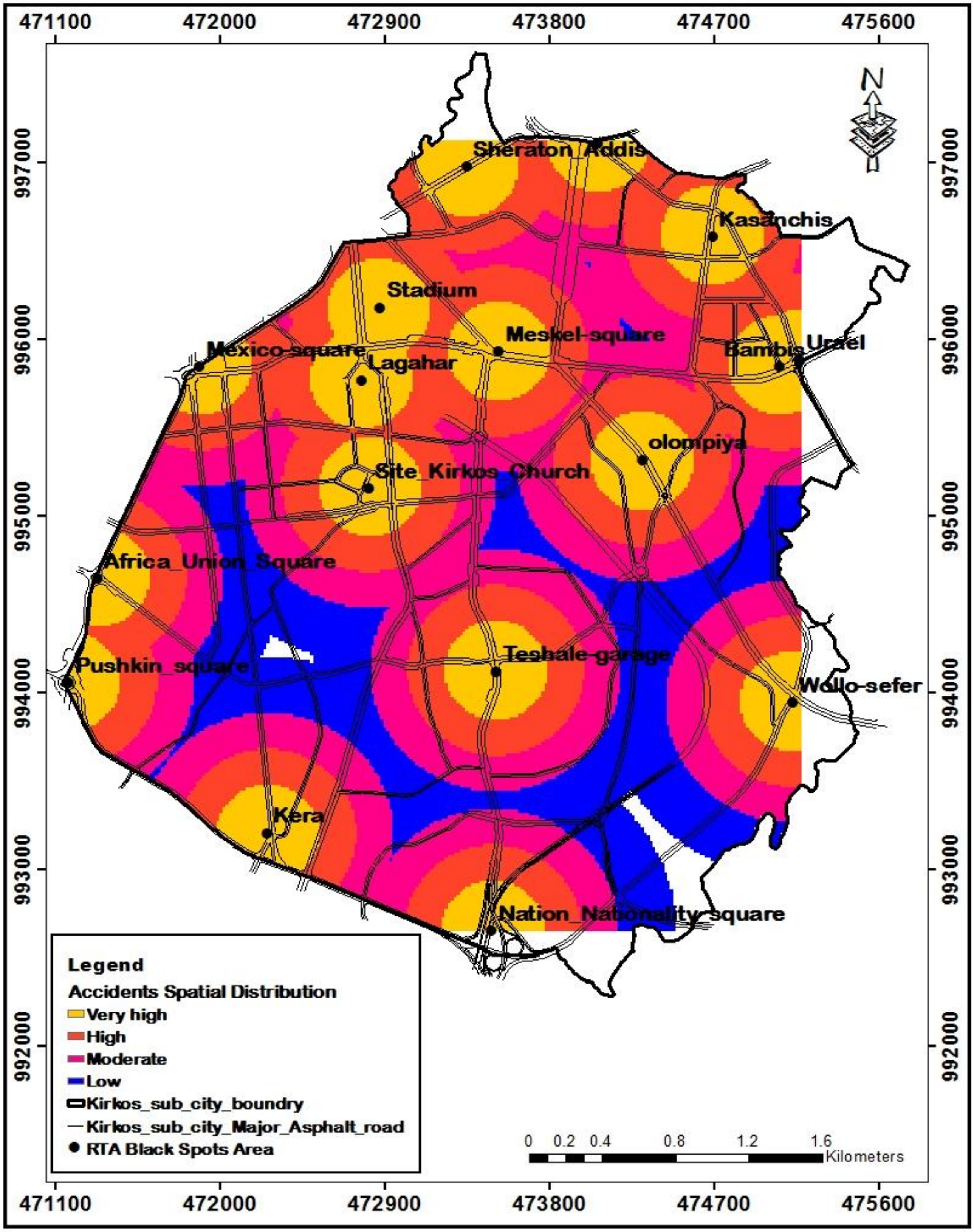

Figure: 4.14. Spatial Distribution of RTA Black Spots of Kirkos Sub City in 2014/15

4.2.2. Spatial Distribution of RTA Black Spots of Kirkos Sub City in 2015/2016

As described in table 4.6 and figure 4.15, places were identified as RTA Black spots in Kirkos Sub City in 2015/16. Compared to 2014/15, the number of RTA Black spots as well as the frequency of RTAs occurred on the black spots have shown an increasing trend by 5 and by 718, respectively.

Table 4.6: Kirkos Sub City RTA Black Spot areas (2015/16)

year	RTA Black Spot area	Number of RTA Spots	No. of RTAs occurred in the Black spot
2015/16	Olompia	8	312
	Kasanchis	5	373
	Wollo-sefer	6	268
	Mexico-square	4	121
	Teshale-garage	7	187
	Meskel-square	5	102
	Bambis	6	32
	Urael	5	38
	Lagahar	4	56
	Stadium	6	78
	Kara	*8*	69
	Tela Garage	5	60
	National Theater	6	34
	Dembel	4	55
	Agona cinema	5	28
Total	15	84	1813

Source: Compiled from Kirkos Sub City Traffic Office (2018)

According to Table 4.6, a total of 1813 RTAs have been recorded from 15 RTA black spots in the city in the year 2015/16. This implies that, an average of 120.86 RTA incidences have occurred at every single RTA Black spot in the city in the year 2015/16. The highest frequency of RTAs i.e. 373 happened in Kasanchis in 2015/16. In addition to this, 312, 268, 187 and102 out of the 15 RTA black spots of the city in this year have occurred in the central part of the sub-city and its extension. In addition to this, all of the RTA Black spots have recorded from the remaining part of sub-cities in this year.

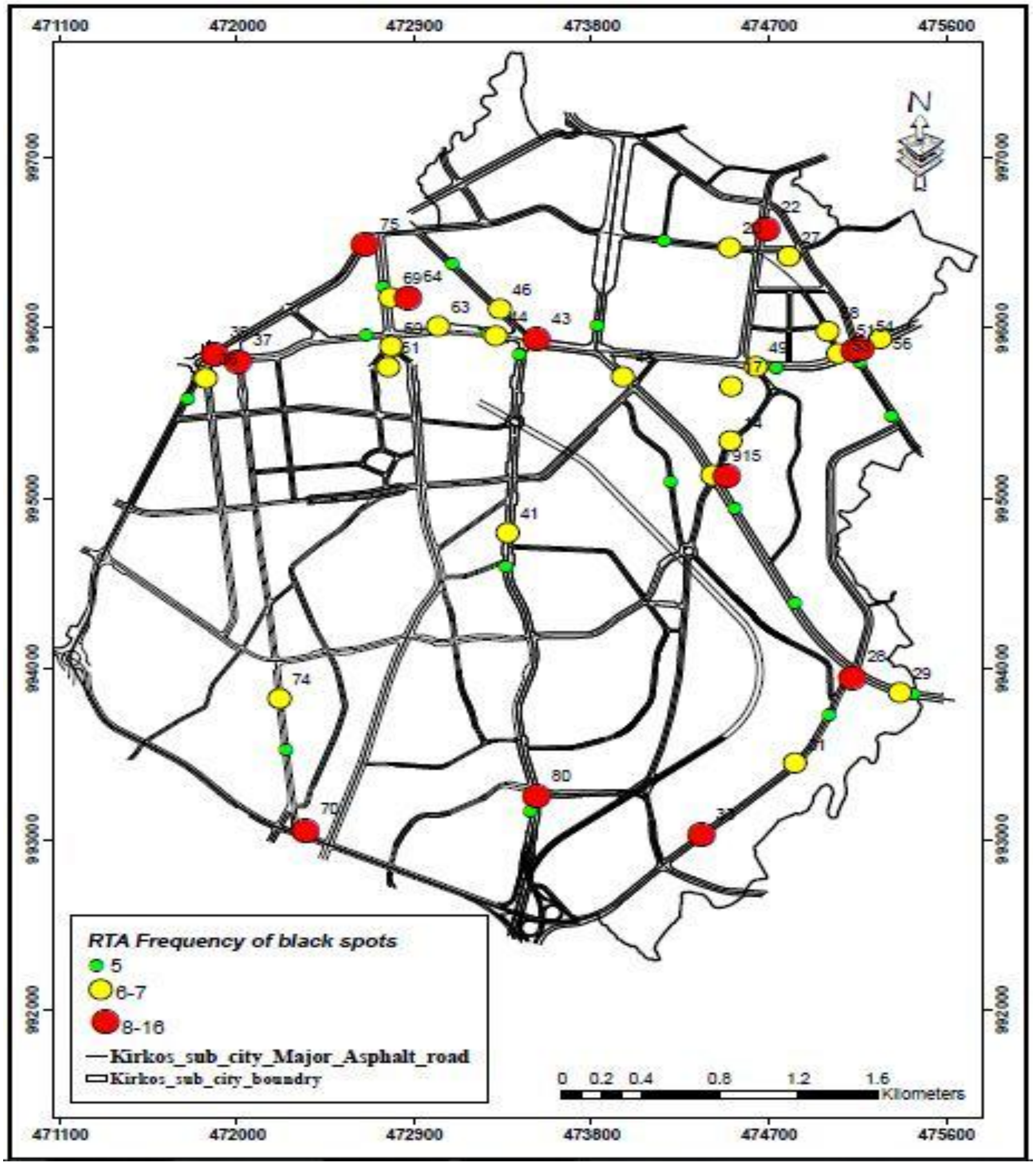

Figure 4.15: Spatial Distribution of RTA Black Spots in Kirkos Sub City (2015/16)

4.2.3. Spatial Distribution of RTA Black Spots of Kirkos Sub City in 2016/2017

As described in table 4.7 and figure 4.16 places are identified as RTA Black spots in Kirkos Sub City in 2016/17. Comparing to 2015/16, the number of RTA Black spots as well as the frequency of RTAs occurred in the black spots have shown an increasing trend by 1 and increasing by 154, respectively. Table 4.7: Kirkos Sub City RTA Black Spot areas (2016/17)

year	RTA Black Spot area	Number of RTA Spots	No. of RTAs occurred in the Black spot
2016/17	Olompia	9	212
	Kasanchis	6	211
	Wollo-sefer	4	178
	Mexico-square	5	169
	Teshale-garage	7	160
	Meskel-square	6	128
	Bambis	4	144
	Urael	6	130
	Lagahar	5	127
	Stadium	9	146
	Dembel	*3*	79
	Agona cinema	5	72
	bulgariya	6	58
	Kara	4	99
	Africa union Square	5	32
	National Theater	3	22
Total	16	87	1967

Source: Compiled from Kirkos Sub City Traffic Office (2018)

According to table 4.7, a total of 1967 RTAs have been recorded from 16 RTA black spots in the Sub city in the year 2016/17. This implies that, an average of 122.93 RTA incidences have occurred at every single RTA Black spot in the city in the year 2016/17. The highest frequency of RTAs i.e. 212 happened in Olompia area in 2016/17. In addition to this, 10 out of the 16 RTA black spots of the city in this year have occurred in the central sub-city and its extension. In woreda level ,Woreda 7 and woreda 8 shared 3 and 4 RTA Black Spots, respectively while Woreda 01 and Woreda 05 sub-cities comprise 1and 2 RTA Black Spot each in the year, respectively .

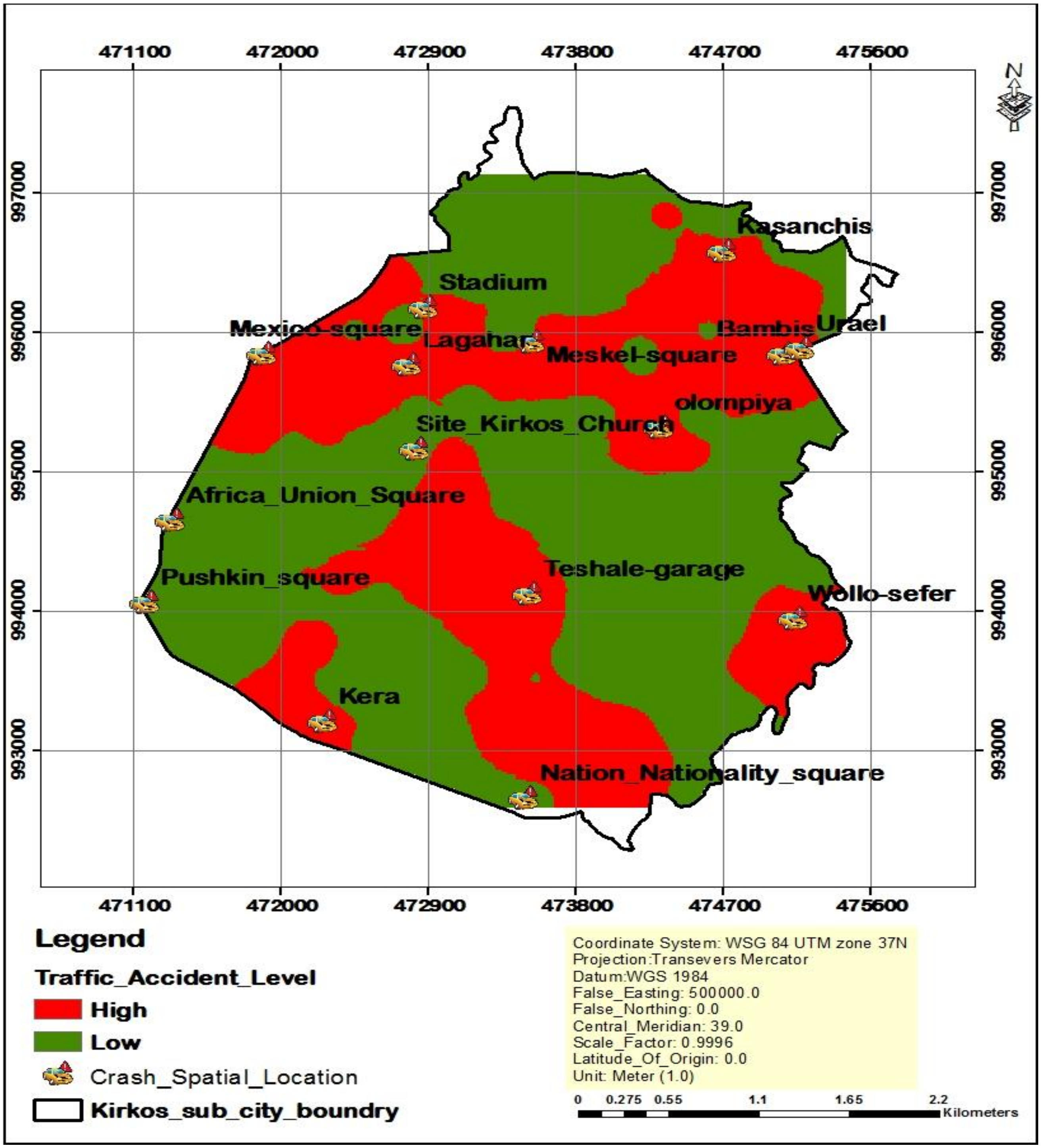

Figure 4.16: Spatial Distribution of RTA Black Spots in Kirkos Sub City (2016/17)

4.2.4. Spatial Distribution of RTA Black Spots of Kirkos Sub City in 2017/2018

As described in table 4.8 and figure 4.17 places are identified as RTA Black spots in Kirkos Sub City in the year 2017/18. Comparing to 2016/17, the number of RTA Black spots have decrease by three and also by 139 frequencies of RTAs occurred in the black spots increase.

Table 4.8 Kirkos Sub City RTA Black Spot areas (2017/18)

year	RTA Black Spot area	Number of RTA Spots	No. of RTAs occurred in the Black spot
2017/18	Olompia	8	219
	Kasanchis	7	291
	Wollo-sefer	5	278
	Mexico-square	6	239
	Dembel	4	187
	Meskel-square	5	182
	Bambis	4	178
	Teshale-garage	6	167
	Urael	5	177
	Lagahar	8	98
	Stadium	*6*	90
Total	13	64	2106

Source: Compiled from Kirkos Sub City Traffic Office (2018)

According to table 4.8, a total of 2106 RTAs have been recorded from 13 RTA black spots in the city in the year 2017/18. This infers that, an average of 162 RTA occurrences has been fallen at every single RTA Black spot in the city in the year 2017/18. Like in 2016/17, the highest frequency of RTAs i.e. 212 RTAs occurred in Olompia area while in 2017/18 Kasanchis area occurred 291 RTAs which is the highest frequency. In addition to this, half of the RTA Black spots of the city in this year have occurred in the central sub-city and its extension. As Woreda 07, woreda 08 and Woreda 09 and its extension shared the most part of RTA Black Spots each in 2017/18.

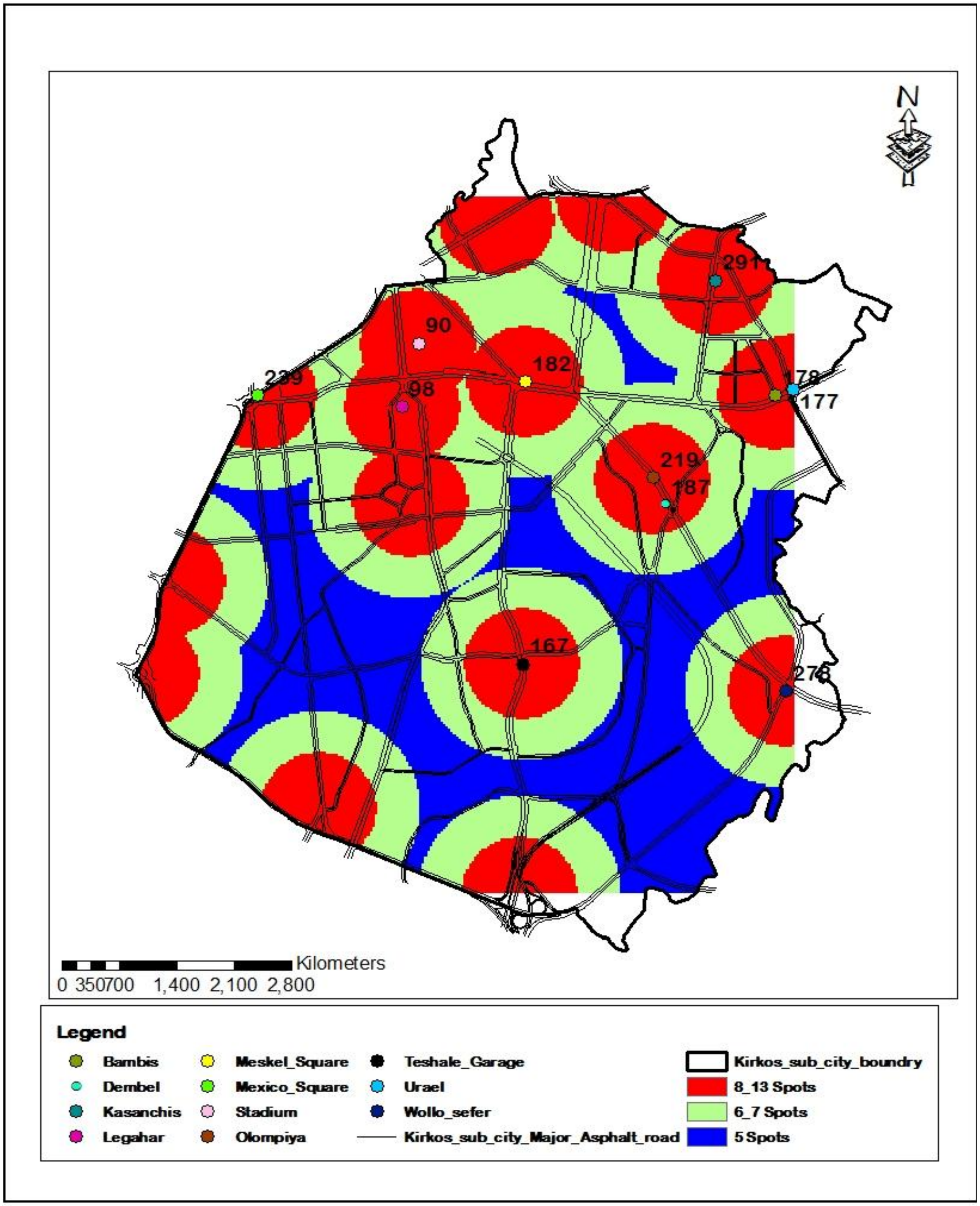

Figure 4.17: Spatial Distribution of RTA Black Spots in Kirkos Sub City (2017/18)

4.3 Trends of Road Traffic Accident in Kirkos Sub City

The occurrence of RTAs vary with time as attributed by the variation in the number and quality of vehicles, quality of roads, physical characteristics of roads, weather condition, population size, level of awareness of road users. The frequencies of occurrence of RTAs in Kirkos Sub City also exhibit such fluctuations in this decade due to either of these reasons. As shown in figure 4.12, more than 10,000 RTA occurrences have been recorded on the roads of Kirkos Sub City from 2015 to 2018. However, according to our findings, the years from 2014 to 2018 revealed the incidence of 14,112 road crashes and property damage. This means the occurrence of RTAs in Kirkos Sub City in the last four years from 2014 to 2018 is 5.48 times much higher than the RTAs occurred in the first ten years from 2008 to 2018. At an average, about 103.2 RTAs have occurred every year in the city between 2015 and 2018 but the occurrence of RTAs have increased to an average of 318.75 incidences per year from 2015 to 2018. The gradual growth in vehicle and human population in the city contributed much to the increasing trend of RTA frequency in Kirkos Sub City especially from the year 2015 to 2018.

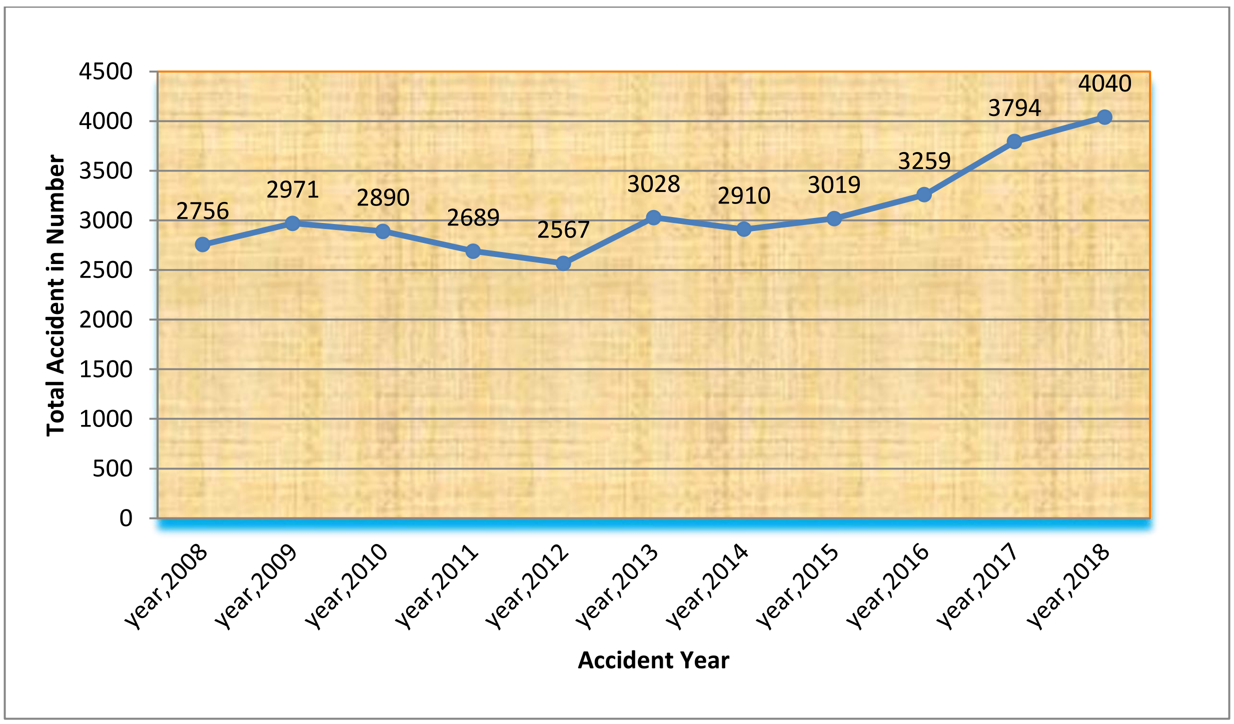

Figure 4.18: Trend of RTA Occurrences in Kirkos Sub City (2015-2018)
Source: Kirkos Sub City Traffic Department (2018)

4.3.1. Top 10 RTA Black Spots of Kirkos Sub City

It is discussed in the previous part that, about 17 RTA Black Spots have been identified in the city from 2014 to 2018. This part however focused only on the Top 10 most severe RTA Black Spots identified in the city in the whole study period from 2014 to 2018. Out of 6981 RTAs recorded from all 17 RTA Black Spots of Kirkos Sub City in the study period, 6595 (94.47%) have occurred in the Top 10 RTA Black Spots (Table 4.9, Figure 4.19). In addition to this, 8 out of the top 10 RTA Black Spots are found in the central parts of the sub city. The remaining 2 are found in Wollo-sefer and in Teshale-garage.

Table 4.9: Top 10 RTA Black Spots and Frequency of RTAs in Kirkos Sub City (2014 – 2018)

Black Spot Code	Major ABSs	Calendar year				%	Rank
		2014/15	2015/16	2016/17	2017/18		
238	Olompia	269	312	212	291	1084	1
245	Kasanchis	116	373	211	219	919	2
137	Wollo-sefer	192	268	178	278	916	3
172	Mexico-square	87	121	169	239	616	5
61	Teshale-garage	67	187	160	167	581	6
163	Meskel-square	164	102	128	239	633	4
158	Bambis	55	32	144	187	418	7
69	Urael	51	38	130	177	396	8
74	Lagahar	45	56	127	98	326	10
165	Stadium	49	78	146	90	363	9
Total	10	1095	1567	1605	1985	6252	100

Source: Compiled from Kirkos Sub City Traffic Office (2018)

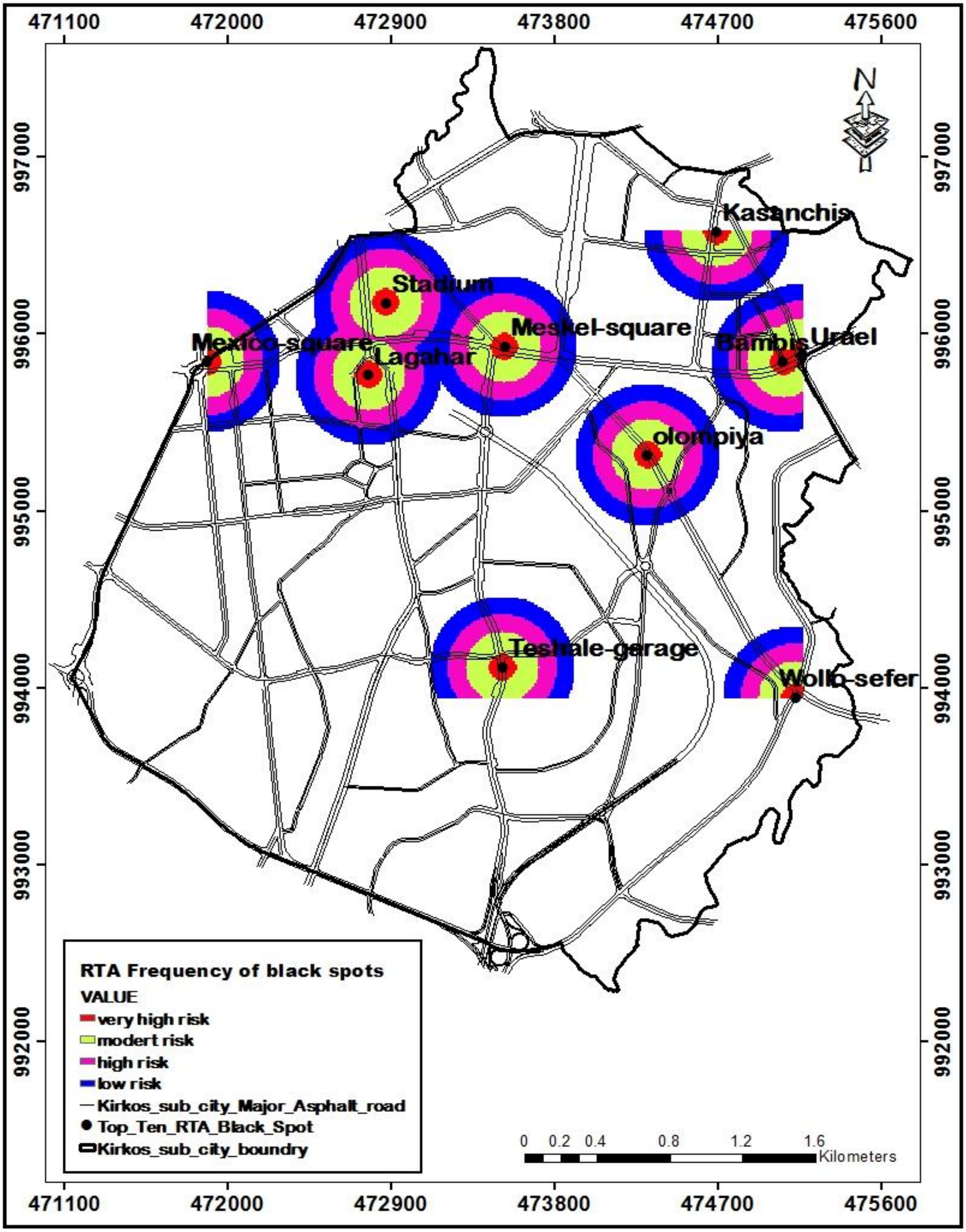

Figure 4.19: Top 10 RTA Black Spots of Kirkos Sub City (2014 – 2018)

4.3.2. Trend of RTA Frequency in the Consistent RTA Black Spots of Kirkos Sub City

Consistent RTA Black spots are RTA Spots which continues as RTA Black Spots in every study period. In this context, consistent RTA Black Spots of Kirkos Sub City are identified based on their consistency as RTA Black spot in every year in the study period from 2014 to 2018. Accordingly, only five RTA Black spots are found as consistent RTA Black spots in the city within the study period.

Table 4.10: Consistent RTA Black Spots and frequency of RTAs in Kirkos Sub City (2014 – 2018)

RTA Black Spot Code	RTA Black Spot	Accidents year				Total RTAs	%
		2014/15	2015/16	2016/17	2017/18		
238	Olompia	269	312	212	291	1084	26.33
137	Wollo-sefer	192	268	178	278	916	22.25
61	Teshale-garage	67	187	160	167	581	14.11
245	Kasanchis	116	373	211	219	919	22.32
172	Mexico-square	87	121	169	239	616	14.96
Total	5	731	1261	930	1194	4116	100.0

Source: Compiled from Kirkos Sub City Traffic Office (2018)

Table 4.10 indicated that, Olompia, Wollo-sefer, Teshale-garage, Kasanchis and Mexico-square are found as RTA Black spots in all years from 2014 to 2018 in the city and are designated as consistent RTA Black Spots of Kirkos Sub City in this study. Olompia, is an area where central location, high congestion, roundabout, park and get maintenance along the road. Wollo-sefer is a steep and curvy road and, drivers will have less control of their vehicles when coupled with speed. Teshale-garage several trucks move, park and get maintenance along the road. Kasanchis is a two way narrow asphalt road which serves as the way to the North of Addis Ababa for the incoming and outgoing vehicles of all types. Mexico-square is also characterized by high congestion, steep terrain with short curves. When this is again coupled with speed of the drivers, it increases the frequency of RTAs.

These all features make the identified RTA Black spots to be consistent and frequent RTA Spots in the city. The Consistent RTA Black spots and their RTA variation is shown in figure 4.20.

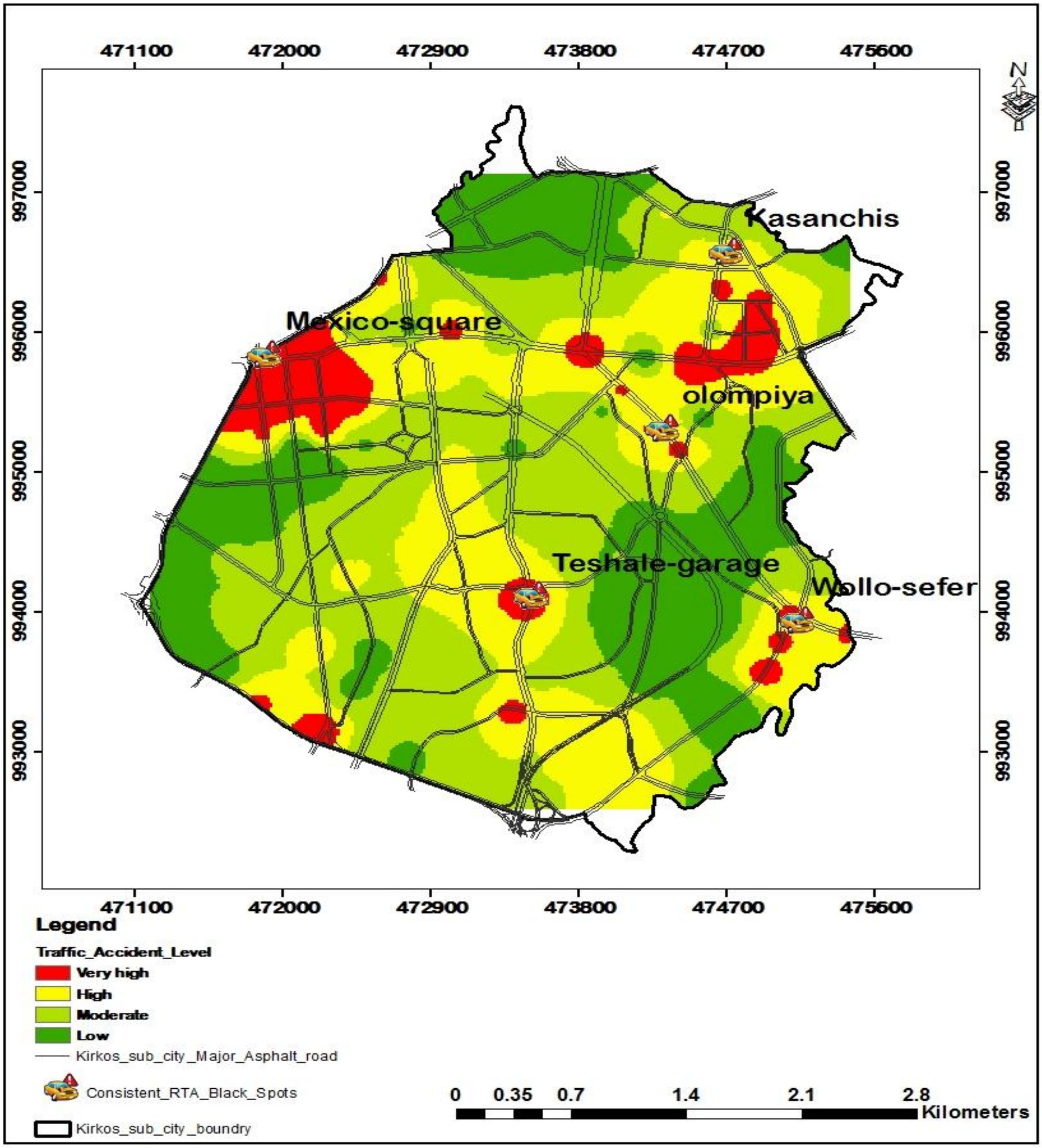

Figure 4.20: Trend of RTA Frequency in the consistent RTA Black Spots of Kirkos Sub City (2014–2018)

4.4. Causes of Road Traffic Accidents in Kirkos Sub City

There are several causes that result RTAs across all roads in the world. According to Mebrahtu (2002); Addis (2003); Segni (2007) the major causes of RTA in Ethiopia and its cities include lack of driving skills, poor knowledge of drivers and pedestrians over traffic rules and regulations, violating speed limits by drivers, insufficient traffic law enforcements, lack of timely vehicle maintenance, driving under the influence of drugs and alcohol, failure to observe and respect road traffic signs, failure to give way for pedestrians, failure to give way for vehicles, lack of sidewalks, lack of road traffic signs, improper overtaking, improper turning and excessive loading.

In addition to this, the common and frequently observed causes of RTAs in Kirkos Sub City are also similar to the aforementioned reasons. Seemingly, with some additional variables of causes of RTA, table 4.11 as shown below describes the current staple reasons of RTA occurrences in Kirkos Sub City.

Table 4.11: Causes of RTA in Kirkos Sub City (2014-2018)

Causes of Accidents	Accidents year				Total RTAs	%
	2014/15	2015/16	2016/17	2017/18		
Missing	12	15	11	22	60	0.42
Brake failure	0	12	23	2	37	0.26
Following too closely	417	626	913	547	2503	17.73
Failure to give way for vehicle	530	823	1307	632	3292	23.32
Failure to give way for pedestrian	430	340	354	235	1359	9.63
Failure to respect the right-hand rule	214	156	126	126	622	4.40
Improper Parking	0	13	20	18	51	0.36
Improper Turning	125	128	147	110	510	3.61
Improper driving	311	276	55	461	1103	7.81
Influence of drug	0	29	30	53	112	0.79
Speed Driving	152	142	0	273	567	4.01
Influence of alcohol	0	80	94	145	319	2.26
Un Safe Driving & Driving without attention	560	198	516	507	1781	12.62
Failure to respect traffic light	133	137	74	204	548	3.88
Failure to respect stop rule	107	100	44	146	397	2.81
Exploding the car rubber	0	158	0	474	632	4.47
Other	28	36	45	85	194	1.37
Total	3019	3259	3759	4040	14112	100.0

Source: Compiled from Kirkos Sub City Traffic Office (2018)

Failure to give way for vehicles, speed driving, and failure to give way for pedestrians, improper turning and failure to respect the right-hand rule are the major causes of RTAs in Kirkos Sub City in the study period (Table 4.11). Failure to give way for vehicle 3292 (23.32%) were RTAs in the study period. In addition, following too closely , Un safe driving and driving without attention ,failure to give way for pedestrian, improper driving , failure to respect the right-hand rule and speed driving contributed to 2503 (17.73 %), 1781 (12.62%), 1359 (9.63%) ,1103(7.81%),622(4.40) and 567 (4.01%) accidents, respectively. This shows that the RTAs in the city are mainly characterized with the involvement of vehicles and pedestrians. This phenomenon results in a huge property damages and severe consequences in the life of Kirkos Sub City.

In addition to this, information collected from some Traffic officers (key informants in this study) have added that, drivers' negligence, failure of pedestrians in using zebra crosses while crossing ways and lesser awareness of the society about RTAs are the major causes of RTA occurrences in the city. Besides, the officers have further identified that, lack of road traffic lights, insufficient number of road traffic signs, limited number and size of side walkways and lower quality of roads played critical role in aggravating the occurrence of RTAs in the city.

4.5. Impacts of Road Traffic Accidents in Kirkos Sub City

4.5.1 Social Impacts of Road Traffic Accident

It is obvious that, the sex of casualties as being male or female by itself does not have any implication to the destiny of prevalence to RTA incidents. However, other human made factors built blocks of differences among sexes incidence to RTAs. The following Table portrays the distinction among sexes prevalence to RTA in Kirkos Sub City.

Table 4.12: RTA by sex and accident severity class in Kirkos Sub City (2014-2018)

Accident Severity class	Accidents year												Total			%
	2014/15			2015/16			2016/17			2017/18						
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	Total
Fatal Accident	29	6	35	27	9	36	33	8	41	32	20	52	121	43	164	1.16
Serious injury	73	29	102	90	37	127	110	13	123	147	*8*	155	420	67	507	3.59
Slight injury	110	28	138	123	13	136	104	5	109	94	6	100	431	52	463	3.28
Property damage	2123	621	2744	2328	652	2980	2974	527	3521	2867	866	3733	10292	2686	12978	91.96
Total	2341	678	3019	2891	702	3259	3249	535	3794	3080	880	4040	11264	2848	14112	100

Source: Kirkos Sub City Traffic Office (2018)

The number of persons who lost their lives, lost either of parts of their body and visits a hospital due to RTAs were 164, 507 and 463 respectively (Table 4.12). The data in the table also proves that, males are more frequently vulnerable to road crashes than females in the city. According to the data, 11264 (79.81%) males and 2848 (20.18%) females were victims of RTAs in the city from 2014 to 2018. This indicates that, males are 3.98 times more prevalent to RTAs than females in Kirkos Sub City. More specifically, males are 3.8 times, 6.3 times and 8.29 times much vulnerable than females to fatal accidents, serious injury and slight injury in Kirkos Sub City, respectively. In addition to this, males are more victims of RTAs than females in all accident severity classes and in all years from 2014to 2018. Such amount of difference among sexes in their prevalence to RTA in Kirkos Sub City is a manifestation of various factors. Since majority of the drivers are males and are the main sources of economies, they are found to be the most victims of RTAs. This gender based difference in RTAs of Kirkos Sub City is similar to the findings of (WHO, 2004). A study by WHO (2004) conducted across WHO member countries specified that in 2002, males accounted for 73% of all road traffic deaths, with an overall rate almost three times that for females: 27.6 per 100, 000 for male population and 10.4 per 100, 000 for female population, respectively. Road traffic mortality rates are higher in men than in women in all regions regardless of income level, and also across all age groups. At an average, males in the low-income and middle-income countries of the WHO Africa Region and the WHO Eastern Mediterranean Region have the highest road traffic injury mortality rates worldwide. The gender difference in mortality rates is probably related to both exposure and risk-taking behavior (WHO 2004). In addition to this Addis (2003) have stated that the risk of males to be involved in RTAs is three to four times higher than females in Bahir Dar City.

4.5.2 RTA by Accident Severity Classes and by age of casualties in Kirkos Sub City

All age segments may not be equally exposed to RTAs. The economic role and responsibility of the age groups in the community could contribute to the fatality of age groups in road crashes. Table 4.13, shows RTA by accident severity classes in Kirkos Sub City between the years 2014 to 2018.

Table 4.13: RTA by accident severity class in Kirkos Sub City (2014-2018)

Accident Severity class	Accidents year				Total RTAs	%
	2014/15	2015/1 6	2016/17	2017/18		
atal Accident	35	36	41	52	164	14.21
Serious injury	102	127	123	155	507	43.93
Slight injury	138	136	109	100	483	41.85
Total	275	299	273	307	1154	100

Source: Kirkos Sub City Traffic Office (2018)

Out of every 100 RTA casualties in Kirkos Sub City, 14.21% have the probability of death, 43.93% the fate of serious injury and the rest 41.85% the possibility of suffering from slight injury due to RTAs (Table 4.13). The highest frequency of serious injuries and slight injuries in the city have been exhibited in the years of 2014/15 and 2015/16 while the most shocking fatal accidents of road crashes have been unveiled in 2016/17 and 2017/18 in the city. In general, 1154 road users in the city became victims of RTAs every year from 2014/15 to 2017/18. More specifically, 164.507, and 483 people suffer fatal accidents, serious injury and slight injury every year in the city between 2014 and 2018. This disaster shows that victims of fatal road accidents died on the scene or in hospitals. Survivors also suffer from different types of injuries and disabilities which can affect their quality of life. The victims can be passengers, pedestrians, drivers; they can even be the cause of the accident themselves. As these victims suffer, their families and communities will suffer too; they must sometimes carry the burden of caring for the victims. The prevalence of people to RTAs can be a cause for social insecurity and social crisis. Road Traffic Accidents affect the physical and psychological wellbeing of an individual or groups. In terms of physical injury for instance, the victims of head and spinal injury may be unable to return to their normal lives. They may even require full care at all times. Usually, these conditions are permanent and there are no actual treatments or cures because of the direct injury to the brain and spine, although, there are some rare cases that show physical improvements with limited movement. Often, these patients stay at the hospital for a long time. As for partial injury, there are many examples, for instance, fractures of bones, loss of limbs, abrasions, lacerations and blunt injuries. In addition to this, another serious consequence of road traffic accidents is psychological problems which can have a substantial impact on the survivors of road traffic accidents and their families. Many studies focus on psychiatric disorders that result from RTAs. Some of these studies discuss the short and the long term consequences for those survivors. One study by Blanchard and Veazey (2001) shows that one-third of young survivors experience a psychological disorder in the early stages and about 25% manifest symptoms for up to 1 year later. Families also suffer from their children's involvement in RTAs. They are considered another hidden victim of RTAs, and need care and support just like other RTA victims or survivors. Families can be affected psychologically and socially. High levels of anxiety, depression, irritability and mood disturbances are the most common psychological symptoms among victims' relatives (Livingston and Brooks 1988).

The distributions of RTAs among different age groups have a serious social impact. All age groups are not equally vulnerable to road crashes in Kirkos Sub City. The data which shows the prevalence of different age categories via accident severity class is only available for the years 2014 and 2018 in the Kirkos Sub City Traffic Office. The analysis is therefore made based on the existing data.

Adults found between the ages of 18 to 30 and 31 to 50 are the most susceptible age groups to RTA in Kirkos Sub City. Adults between 18 to 30 years of age contribute for 6164, (43.67%) of road crashes occurred in the city between 2014 and 2018. The severity rate of RTA in all severity classes is much higher in the age groups of 18 to 30 than the others in the last two years. In addition to this, 4,433 (31.41%) adults aged 31 to 50 years had RTAs in the city during the four years period. Children whose age is below 18 years are also the victims of road crashes in the city. The numbers of children who become victims of RTAs in the city in the last four years are 3 (0.021%). In addition to this, 3359 (23.80%) people whose age is more than 50 also suffered from road crashes in Kirkos

Sub City. This panorama which results in the sufferings of children under the age of 18 and productive population between the ages of 18 to 50 drastically affects the wellbeing of the society in the city. This is because; the RTA is obscuring the future of children and complicating the life of the adult in the city. The situation of children and adults as being the frequent victims of RTA in Kirkos Sub City is found to be similar with the case studied by WHO across the globe. WHO (2004) stated that, over 50% of the global mortality due to road traffic injury occurs among young adults aged between 15 and 44 years, and the rates for this age group are higher in low-income and middle-income countries.

4.5.3 Economic Impacts of Road Traffic Accident

Road Traffic Accidents have multifaceted impacts over the economy of a nation. In addition to the social impacts of RTAs, Kirkos Sub City is also suffering huge economic loss from road crashes. Some of the impacts of RTA have direct economic impact when it is manifested over a property and have indirect influence when it is exhibited on pedestrians, drivers and/or passengers.

Table 4.14: Estimated cost of RTA in Kirkos Sub City (2014-2018)

Accident Year	Number of accidents resulting property damage	RTA Estimated cost (ETB)	Average cost (ETB)	%
2014/15	2744	55,251,725	27,625,862.5	10.27
2015/16	2980	134,390,946	67,195,473	25
2016/17	3521	153,507,670	76,753,835	28.55
2017/18	3733	194,413,444	97,206,722	36.16
Total	12978	537,563,785	268,781,892.5	100.0

Source: Compiled from Kirkos Sub City Traffic Office (2018)

The estimated total cost of RTA in Kirkos Sub City from 2014 to 2018 reaches ETB 537,563,785 (Table 4.14). The highest estimated RTA cost has been recorded at ETB 194,413,444 (36.16 %) in 2017/18 while the lowest at ETB 55,251,725 (10.27%) in 2015/16 in the sub city. The years 2015/16 and 2016/17 exhibited ETB 134,390,946 (25 %) and ETB 153,507,670 (28.55%) RTA cost respectively. This means, the city has lost ETB 537,563,785 in the last four years only due to RTAs. Out of 14112 RTA occurrences in the city in the last four years, 12978 (91.96%) of the accidents have been accompanied with property damages. Accordingly, every single accident complemented with property damage has led to an average financial loss of ETB 268,781,892.5 in Kirkos Sub City in the study period. In the other way round, out of every 100 RTAs occurred in Kirkos Sub City, 91.96 of road crash incidences have been involved in property damages and results a financial loss of an average ETB 268,781,892.5 each from 2014 to 2018. The highest frequency of RTAs resulting property damages i.e. 3733, have been recorded in 2017/18 while the lowest which is 2744 incidences in 2014/15. Kirkos Sub City which is yet struggling to fulfill the needs of its inhabitants due to financial constraints is exhibiting a loss of an average ETB 134,390,946.25every year only due to RTAs.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The use of GIS enables relevant accident data to be quickly processed and displayed on a map. GIS has also been used as a tool to identify hazardous locations on the road depending on the historical road accident data. The study was an attempt to identify GIS based RTABs, describe the characteristics of RTAs, map places of frequent RTABs, examine the trend of RTA, identify major causes of RTAs, and identify the most vulnerable accident black spots in the Kirkos sub city.

The RTA Black Spots exhibit the highest frequency of RTA occurrences. The study implied the existence of large difference in road traffic victims among drivers, passengers and pedestrians in respect of sexes and ages. That is, male drivers, passengers, and pedestrians were the most affected compared to their female counterparts.

Using the Geographical Information System (GIS) is useful in displaying of the crash locations on the map and can be utilized efficiently for the analysis, prioritization and representation of black spots. Road Traffic Accidents are affecting the dwellers of the city in various aspects. Some casualties have lost their lives, others have got serious or slightly injuries due to RTAs. At the same time, a GIS can be effectively used to identify accident black spots on roads in Kirkos sub city. In this situation, it is very important to identify and forecast the probability of the occurrence of accidents.

The assessment of RTABSs Using GIS technique and road traffic accident data revealed that there were 17 RTA hazardous black-spots in kirkos sub-cities have been identified in the city from 2014 to 2018. Out of 17 top 10 most severe RTA Black Spots identified are Olompia, Kasanchis, Wollo-sefer, Mexico-square, Teshale-garage, Meskel-square, Bambis, Urael, Lagahar and Stadium from these Olompia, Wollo-sefer, Teshale-garage, Kasanchis and Mexico-square are consistent RTA black spots which exist consistently as RTA Black Spots in every study period.

Thus, this study contributes much to those who need to understand the general characteristics of RTAs in Kirkos Sub City in terms of identifying critical black spot area using GIS tools and inspire other stakeholders to conduct further studies in the field and also tries to introduce the application of GIS in tools for black spot area identification.

5.2 Recommendations

Based on the core findings of this study, the following are recommended.

- ❖ Appropriate traffic control system should be designed and implemented at each RTABS in Kirkos sub-city if the incidence of accident is to be reduced significantly.
- ❖ Majority of the RTAs in Kirkos Sub City are occurring in the day time especially between 12 pm to 6 pm. Hence, Traffic polices should be assigned in the major roads and RTA Black Spots of the city to ease the volume of vehicles and pedestrians. Vehicle parking across main roads of the city at this specific time which results in traffic congestion needs attention.
- ❖ Since two-way roads are more than one-way roads in Kirkos Sub City, the city administration should focus on widening the existing two-way roads and the newly constructed roads should preferably be one-way types. In addition, short junctions and curves were found to be contributing to RTA hence special attention to new road designs is required.
- ❖ Speed limits must be placed in shorter distances across asphalt roads since about (93.6%) of all the RTAs in the city are exhibited in asphalt pavements and, special follow-up and fine mechanisms should be put in place.
- ❖ In order to enable traffic polices control the traffic flow efficiently; road traffic lights should be placed in the major road junctions so that traffic polices could control traffic flow of other roads other than mere in the junctions and, special attention should be given to the RTA black spots already identified.
- ❖ The prevalence of road casualties is increasing in terms of number and severity form time to time in the city. Therefore, it is recommended that hospitals be more equipped with an emergency vehicle /Ambulances/ to safeguard the destiny of survival of RTA casualties.
- ❖ An effort has to be made to compile and organize RTA data of the city in database software or at least in application software programs like Microsoft office Access or Microsoft office Excel for data retrieval and analysis.
- ❖ The concerned government offices for transport infrastructure have to work together using monolithic data which helps to improve the road system.

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Appendix: A Black Spots GPS Coordinate Data

FID	Shape *	pt	RTA_Black_Name	Black_Spot_coad	x	y	frequency
0	Point	1	olompiya	11	474342	995252	5
1	Point	2	olompiya	12	474422	995115	6–7
2	Point	3	olompiya	13	474306	995318	8–10
3	Point	4	olompiya	14	474507	995335	6–7
4	Point	5	olompiya	15	474489	995128	8–10
5	Point	6	olompiya	16	474526	994944	5
6	Point	7	olompiya	17	474510	995654	6–7
7	Point	8	olompiya	18	474202	995095	5
8	Point	9	Kasanchis	19	474166	996514	5
9	Point	10	Kasanchis	20	474503	996470	6–7
10	Point	11	Kasanchis	21	474754	996369	8–10
11	Point	12	Kasanchis	22	474688	996581	8–10
12	Point	13	Kasanchis	23	474877	996467	6–7
13	Point	14	Kasanchis	24	474384	996849	5
14	Point	15	Kasanchis	25	475105	996028	6–7
15	Point	16	Kasanchis	26	474617	996239	5
16	Point	17	Kasanchis	27	474803	996418	6–7
17	Point	18	Wollo-sefer	28	475124	993948	8–10
18	Point	19	Wollo-sefer	29	475367	993858	6–7
19	Point	20	Wollo-sefer	30	475006	993729	5
20	Point	21	Wollo-sefer	31	474835	993446	6–7
21	Point	22	Wollo-sefer	32	474830	994386	5
22	Point	23	Wollo-sefer	33	474357	993024	8–10
23	Point	24	Wollo-sefer	34	475430	993853	5
24	Point	25	Mexico-square	35	471888	995846	8–10
25	Point	26	Mexico-square	36	471843	995702	6–7
26	Point	27	Mexico-square	37	472007	995805	8–10
27	Point	28	Mexico-square	38	471749	995583	5
28	Point	29	Mexico-square	39	471573	995204	5
29	Point	30	Teshale-garage	40	473363	994593	5
30	Point	31	Teshale-garage	41	473376	994797	6–7
31	Point	32	Teshale-garage	42	473509	994121	8–10
32	Point	33	Meskel-square	43	473523	995932	8–10
33	Point	34	Meskel-square	44	473317	995952	6–7
34	Point	35	Meskel-square	45	473830	996014	5
35	Point	36	Meskel-square	46	473336	996110	6–7
36	Point	37	Meskel-square	47	473432	995840	5
37	Point	38	Meskel-square	48	473961	995711	6–7

38	Point	39	Bambis	49	474637	995771	6–7
39	Point	40	Bambis	50	475055	995830	5
40	Point	41	Bambis	51	475137	995864	8–10
41	Point	42	Bambis	52	474739	995763	5
42	Point	43	Bambis	53	475054	995847	6–7
43	Point	44	Urael	54	475166	995882	8–10
44	Point	45	Urael	55	475160	995794	5
45	Point	46	Urael	56	475267	995935	6–7
46	Point	47	Urael	57	475321	995482	5
47	Point	48	Urael	58	475000	995978	6–7
48	Point	49	Lagahar	59	472786	995891	6–7
49	Point	50	Lagahar	60	472655	995953	5
50	Point	51	Lagahar	61	472770	995770	6–7
51	Point	52	Lagahar	62	472792	995866	5
52	Point	53	Stadium	63	473024	996008	6–7
53	Point	54	Stadium	64	472871	996178	8–10
54	Point	55	Stadium	65	473156	996294	8–10
55	Point	56	Stadium	66	473360	996047	6–7
56	Point	57	Stadium	67	473093	996376	5
57	Point	58	Stadium	68	473275	995961	5
58	Point	59	Stadium	69	472781	996176	6–7
59	Point	60	kara	70	472350	993051	8–10
60	Point	61	kara	71	472271	993219	6–7
61	Point	62	kara	72	472200	993080	5
62	Point	63	kara	73	472250	993521	5
63	Point	64	kara	74	472219	993824	6–7
64	Point	65	National Theater	75	472653	996488	8–10
65	Point	66	National Theater	76	472741	996236	5
66	Point	67	National Theater	77	472505	996262	8–10
67	Point	68	National Theater	78	472470	996098	6–7
68	Point	69	Dembel	79	474415	995135	6–7
69	Point	70	Agona Cinema	80	473524	993251	8–10
70	Point	71	Agona Cinema	81	473489	993160	5

Appendix B: Road Traffic Accident Recording Form

የትራፊክ አደጋ መ/ቁጥር

አደጋ የተፈጸመበት ሰዓት ዕለት ዓ/ም

የተከሳሽ ስም ከነአያቱ ዕድሜ ጾታ

የተከሳሾች ብዛት ወንድ ሴት ዕድሜ የትምህርት ደረጃ

የአሽ/ተሽከ/ግንኙነት የማሽከርከር ልምድ የተሽከ/ዓይነት

የሠሌዳ ቁጥር ንብረትነት የአገልግሎት ዘመን

የተሽከ/ጉድለት መንገድ አካባቢ

የመንገድ አከፋፈል የመንገዱ አቀማመጥ

የመንገዱ መጋጠሚያ የመንገዱ ንጣፍ የመንገዱ ሁኔታ

የብርሃን ሁኔታ የአየር ሁኔታ የተሽከ/እንቅስቃሴ

የአደጋው ዓይነት የደረሰው ጉዳት

የተጎዱ ተሽከ/ብዛት የንብረት ጉዳት ግምት ብር

የከሳሽ ስም ዕድሜ ጾታ

የከሳሾች ብዛት ወንድ ሴት ዕድሜ

ሥራ የአካል ብቃት የከሳሽ እንቅስቃሴ

የአደጋው ምክንያት

የመርማሪው ስም ክስ የቀረበበት ፍ/ቤት

የፍ/ቤት መ.ቁጥር የፍርዱ ውሳኔ

Appendix C: Road Traffic Accident statistics Form

ሐ. የትራፊክ አደጋ ስታትስቲክስ

1. በዕለት የደረሱ አደጋዎች

ተ.ቁ	ዕለት	ብዛት
1	ሰኞ	
2	ማክሰኞ	
3	ረቡዕ	
4	ሐሙስ	
5	ዓርብ	
6	ቅዳሜ	
7	እሁድ	
	ድምር	

2. በሰዓት የደረሱ አደጋዎች

ተ.ቁ	ሰዓት	ብዛት	ተ.ቁ	ሰዓት	ብዛት	ተ.ቁ	ሰዓት	ብዛት
1	0100-0200		9	0900-1000		17	1700-1800	
2	0200-0300		10	1000-1100		18	1800-1900	
3	0300-0400		11	1100-1200		19	1900-2000	
4	0400-0500		12	1200-1300		20	2000-2100	
5	0500-0600		13	1300-1400		21	2100-2200	
6	0600-0700		14	1400-1500		22	2200-2300	
7	0700-0800		15	1500-1600		23	2300-2400	
8	0800-0900		16	1600-1700		24	2400-0100	
							ጠቅላላ ድምር	

3. አደጋ የፈጸሙ አሽከርካሪዎች ዕድሜ

ተራ ቁጥር	ዕድሜ	አደጋው ያስከተለው ጉዳት				ድምር
		ሞት	ከባድ የአካል ጉዳት	ቀላል የአካል ጉዳት	የንብረት ጉዳት	
1	ከ18 ዓመት በታች					
2	ከ18-30 ዓመት					
3	ከ31-50 ዓመት					
4	ከ51 ዓመት በላይ					
5	ያልታወቀ					
	ድምር					

4. የአሽከርካሪዎች ፆታ

ተራ ቁጥር	ፆታ	አደጋው ያስከተለው ጉዳት				ድምር
		ሞት	ከባድ የአካል ጉዳት	ቀላል የአካል ጉዳት	የንብረት ጉዳት	
1	ወንድ					
2	ሴት					
3	ያልታወቀ					
	ድምር					

5. አደጋ የፈጸሙ አሽከርካሪዎች የትምህርት ደረጃ

ተራ ቁጥር	የትምህርት ደረጃ	አደጋው ያስከተለው ጉዳት				ድምር
		ሞት	ከባድ የአካል ጉዳት	ቀላል የአካል ጉዳት	የንብረት ጉዳት	
1	መሀይም					
2	መሠረተ ትምህርት					
3	1ኛ. መ ደ.ት/ቤት					
4	መ 2ኛ ደ. ት/ቤት					
5	ከፍ 2ኛ. ደ. ት/ቤት					
6	ከከፍ 2ኛ.ደ. ት/ቤት በላይ					
7	ያልታወቀ					
	ድምር					

6. የአሽከርካሪና የተሽከርካሪ ግንኙነት

ተራ ቁጥር	ግንኙነት	አደጋው ያስከተለው ጉዳት				ድምር
		ሞት	ከባድ የአካል ጉዳት	ቀላል የአካል ጉዳት	የንብረት ጉዳት	
1	የተሽከርካሪ ባለቤት					
2	ተቀጣሪ					
3	ሌላ					
4	ያልታወቀ					
	ድምር					

7. የአሽከርካሪው የማሽከርከር ልምድ

ተራ ቁጥር	የማሽከርከር ልምድ	አደጋው ያስከተለው ጉዳት				ድምር
		ሞት	ከባድ የአካል ጉዳት	ቀላል የአካል ጉዳት	የንብረት ጉዳት	
1	መንጃ ፈቃድ የሌለው					
2	ከ1 ዓመት በታች					
3	ከ1-2 ዓመት					
4	ከ2-5 ዓመት					
5	ከ5-10 ዓመት					
6	ከ10 ዓመት በላይ					
7	ያልታወቀ					
	ድምር					

7.1. አደጋ የፈጸሙ አሽከርካሪዎች የመንጃ ፈቃድ ደረጃ

ብዛት	የመንጃ ፈቃድ ደረጃ								ድምር
	1ኛ	2ኛ	3ኛ	4ኛ	5ኛ	ልዩ ተንቀሳቃሽ	ፈቃድ የሌለው	ያልታወቀ	

8. የተሽከርካሪው የአገልግሎት ዘመን

ተራ ቁጥር	የአገልግሎት ዘመን	አደጋው ያስከተለው ጉዳት				ድምር
		ሞት	ከባድ የአካል ጉዳት	ቀላል የአካል ጉዳት	የንብረት ጉዳት	
1	እስከ 1 ዓመት					
2	ከ1-2 ዓመት					
3	ከ2-5 ዓመት					
4	ከ5-10 ዓመት					
5	ከ10 ዓመት በላይ					
6	ያልታወቀ					
	ድምር					