JIMMA UNIVERSITY

COLLEGE OF SOCIAL SCIENCE AND HUMANITIES

DEPARTMENT GEOGRAPHY AND ENVIROMENTAL STUDIES

ANALYSIS OF ROAD TRAFFIC ACCIDENT USING GIS AND REMOTE SENSING TECHNOLOGIES: A CASE OF BURAYU TOWN, CENTRAL ETHIOPIA

BY

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A THESIS SUBMITTED TO THE COLLEGE OF SOCIAL SCIENCES AND HUMANITIES DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR MASTERS OF SCIENCE IN GIS AND REMOTE SENSING.

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ABBREVIATIONS AND/ ACRONYMS

BTA	Burayu Town Administration
BTRA	Burayu Town Road Authority
BTTA	Burayu Town Transport Authority
CSA	Central Statistical Agency
EFPR	Ethiopia Federal Police Report
ERA	Ethiopia Road Authority
FAO	Food Organization Authority
GIS	Geographical Information System
GIS-T	Geographic Information Systems for Transportation
GPS	Global Position System
GTP	Gross Transformation Plan
GNP	Gross National Product
OSM	Open Street Map
OSZSF	Oromia Special Zone Surrounding Finfinne
LMBT	Land Management of Burayu Town
ITF	International Transport Forum.
RS	Remote Sensing
RTA	Road Traffic Accidents
TIN	Triangulated Irregular network
WHO	World Health Organization

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Abstract

Road accidents are continuously becoming a major problem in developing countries town and subsequently cause losses of life and properties. This research aims at identifying accident prone sites and evaluated causes and consequences of car accidents. Distributions of hotspots are examined with the help of geospatial techniques to evaluate and delineate road accident hotspot. Assessment of spatial clustering of accidents and hotspots spatial densities was carried out following Moran's I method of spatial autocorrelation, Getis-Ord Gi statistics and point Kernel density functions. The GiZScore for the total accident locations in the study area varies between -1.95936 to 2.065021 and the GiPValues from 0.038921 to 0.875373. Based on GiZScore and GiPValue western and southwestern part of the study area particularly the local place named by Kella, Dirre gujje and Ashewa meda clearly indicate accident hotspots. This study clearly indicate 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 were the major possible causes for Road Traffic Accident (RTA) in Burayu town. Findings from this study also shows that drivers with an age from (18-30) are the most vulnerable, which results a total record of 122 accidents (50.6%) within only four years. Generally, the main reason for road accidents in Burayu Town is mainly attributed to both spatial and non-spatial characteristics. It is suggested that special inspection and priority should be given for those identified black spots sites.*

Key Words: *Black Spot; Road Traffic Accidents; Kernel density*

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

At global level, about 1.3 million people die in road accidents and more than 50 million are injured every year (WHO, 2009). The main cause of death among persons aged 5 to 29 years is represented by car accidents and nearly half of those who die in such tragedies are pedestrians, cyclists or motorcyclists (Stevenson, *et al.,* 2008).

Road Traffic Accident (RTA) is one of the most complicated issues over the world. There are around1.3 million deaths and 50 million injured as results of RTA every year in the world (ITF, 2017). To significantly decrease the number of accidents, it is really necessary to know exactly where and when accidents happen frequently. The locations, which are identified by high accident occurrence compared with the other locations, are known as hotspots or black spots (Dereli and Erdogan, 2017). Past studies show that the occurrences of RTA are not random in space and time. In fact, these locations identified by several key factors such as geometric design, traffic volume, surroundings, or severe weather conditions, etc. (Xia and Yan, 2008). Therefore, in order to effectively build accident preventive plans, it is really vital to determine potential dangerous locations associated with accident occurrence time (Harirforoush, 2017).

Any movement of people for any perseverance using different means is known as transportation. As indicated in Bamford and Robinson (1978),"Transport by definition infers a movement, and each individual from an early age owns his own "built-in" capability to travel, although within a restricted area. It is obvious that, among all modes of transportation, road transport is close to means of conveyance. Road Transport's major advantage compared with others is its elasticity, which permits it to function from door-to-door over short distances at the most competitive prices (Bamford and Robinson, 1978; Wough, 1990). In Africa over 80% of goods and people are transported by roads while in Ethiopia road transport accounts for over 90% of all the inter-urban freight and passenger movements in the country (Kifle, 1996). So as a result of rapid population growth and rural to urban migration in the town the supply and demand of transport network is imbalance, the car accident is increasing from time to time.

Road traffic accidents are the tenth leading cause of death globally; now make up a surprisingly significant portion of the worldwide burden of ill-health. An estimated 1.2 million people and killed in road crashes each year, and as 50 million are injured, occupying 30 percent to 70 percent of orthopedic beds in developing countries hospitals. And if present trends continue, road traffic injuries are predicted to be the third leading contributor to the global of disease and injury by 2020(WHO, 2002)

In case of Ethiopia, according to the latest WHO data published in April 2011, road traffic accident deaths reached 22,786 or 2.77 % of total deaths. The age adjusted death rate is 37.83 per 100,000 of population ranks Ethiopia number 12 in the world. Road traffic accidents are becoming a major public safety and development obstacle. Pundits assumed that the current situation necessitates high level of political dedication and immediate action. Various studies have indicated that Ethiopia has one of the highest fatality rates per vehicle in the world. It is in excess of 100 fatalities per 10,000 vehicles. This should be compared with Kenya and United Kingdom, where the figure is about 19 and 2 per 10,000 vehicles respectively. Ethiopia loses about $65million annually due to traffic accidents. In addition, the victims are mainly public transport travelers in the working age group (18 to 30 years) (Zegabi, 2014).

In Burayu town the road transport traffic accident management is not analyzed using GIS due to lack of knowledge about this technology. So, GIS based analysis of road traffic accident is very important to fill this knowledge. The function of geographical information system can help to facilitate transportation services which are the base for other public services, minimize life and economic loss through traffic accident. Therefore, the purpose of the study was to analyze road traffic accident in order to minimize economic losses and human health in Burayu Town by GIS and RS technologies

1.2. Statement of the Problem

Road transport is one of frequently used mode of transport in most countries of the world. It is relatively cheap (affordable) and convenient mode as compared to other mode of transportation. It is the most vulnerable to traffic accident than any other mode of transport. Today, however, a certain difficulty has settled in the world increasingly, people face difficulties when moving from place to place. Despite the important positive role, the sector, it also is generating social, economic, political and environmental problems (Abrahalign, 2008).

In, Ethiopia the rate of traffic accidents is very high; because of road transport is the major transportation mechanism along with poor road infrastructure, poor enforcement of traffic laws and other factors. In some regional state main cities of Ethiopia, the road traffic accident seem highest in Bahir Dar then at Mekele, Adama, Harar, Dire Dawa, Addis Ababa and Burayu town respectively (FRP, 2007).

Fatalities due to traffic accidents are reported to be among the highest in the world. According to the WHO (2009), global status report on road safety, the road crash fatality rate in Ethiopia was at least 114 deaths per 10,000 vehicles per year, compared to only 10 in the UK and Ireland and 60 across 39 sub-Saharan African countries In addition, the number of people injured or killed in one crash in Ethiopia is about 30 times higher than that in the US Furthermore, it is sad to note that fatalities due to road traffic accidents are higher among pedestrians in countries like Ethiopia than in developed countries (Hailu *et al.,* 2014). For instance, 60% of the fatalities in the US account to the car drivers, while in Ethiopia only about 5% account to drivers. This is also supported by a recent study where the majority of fatalities were pedestrians (87%) followed by passengers (9%) and drivers (4%), among a total of 25,110 accidents and 3415 fatalities during the period 2000-2009 in Addis Ababa (WHO, 2009).

Countries, since deaths due to these causes are highest among the most economically active population (15-59 years) (Persson, 2008). A study has estimated the total health and life-related cost of motor vehicle injuries in Addis Ababa in 2010 to be about 31,692,892 Ethiopian Birr (Tumato *et al.,* 2011), showing the enormity of the problem.

In spite of the fact that road traffic accident is a huge public health development problem in Ethiopia with significant impact on morbidity, mortality as well as devastating economic effects; proportionate measures have not been taken to address the problem. According to the WHO's global status report mentioned above, even though Ethiopia has put in place relevant laws on traffic speed limits, the effectiveness of their overall enforcement was only 2 (in a scale of 0-10) in 2009 (Hailu *et al.,* 2014). There are some laws on road safety management and on major risk factors in the country. However, they seem to be largely nominal, as the country neither strictly enforces speed limits on urban roads nor controls blood alcohol levels in drunk-driving.

Overall, the gravity of the problem is getting worse from time to time, approaching a crisis level and requiring urgent and multi-pronged actions.

In Burayu the road traffic accident is severe that may people lose their life and injuries a large number of people and damage of properties which has relatively high collision record and no day pass without traffic accidents but no enough intervention has been taken.

Many studies have been conducted for analyzing traffic accidents in Addis Ababa. Most previous studies are based on the report data analysis without mapping and identifying the spatial location of the accident site. In the last 10 years, very few studies have applied GIS to understand the case, and hotspot areas of RTA in Addis Ababa but none of all below did not consider Burayu town that are the most traffic accident. For example, Kalu (2016) studied GIS-based spatial analysis & prediction of traffic accidents in Addis Ababa case of Gulele sub-city, Mahlet (2016) studied the assessment of reported road traffic crash in Addis Ababa case of Kolfe Keranyo sub-city, Efrem (2019) investigated about GIS-based road traffic accident black spot assessment in Addis Ababa in case of Kirkos Sub-city. But none of these were devoted to clearly explain the root causes as well as its impact on socio-economic status in Burayu town. So in spite of the growth of road traffic accidents in the town, no research have not yet seriously examined on this problem. Therefore, this study attempted to fill the areal, time and knowledge gap through applying geo-spatial techniques.

1.3. Objective of the study

1.3.1. General Objective of the study

The general objective of the Study is to analyze road transport traffic accident for the last five years (2016-2021) in Burayu Town.

1.3.2. Specific Objective of the study

- To identify the traffic accident hot spots and mapping in Burayu Town;
- To identify major possible causes and consequence of road traffic accident in the study area; and
- To assess the socio-economic impacts of road traffic accidents in Burayu Town

1.4. Research question

- Where could be traffic accident hot spots in Burayu Town?
- What are the causes and consequences of road traffic accident occurrence in Burayu town?
- What are the major socio-economic impacts of traffic accidents in Burayu town?

1.5. Scope of the study

The road transportation traffic accident problem suffering in most of Ethiopian cities by different factor, however to make the study specific and manageable geographically limited to Burayu Town and conceptually focus only identifying the existed road transport network, the major cause and consequences of road traffic accidents including identification of hotspot and mapping traffic accident area.

1.6. Significance of the study

This study was significant by evaluating cause and consequence of road transport traffic accident of Burayu town. In the same manner the study was serve as literature material for the city of road authority, traffic police commission and it will input for the improvement for road traffic and decision-making process in the area.

Furthermore, the findings obtained from the study will be helpful to gain information and knowledge about the patterns of road traffic in the town, which in turn, could help to develop countermeasures that could reduce the related traffic problem in the town

In addition, the result of the study is expected to generate important findings that can help as useful input for further research to refine the conceptual and methodology of the present study.

1.7. Ethical consideration

Validity and reliability in their continuum should be notable in every modern research, as they are ways to establish in multiple ways (Golafshani, 2003). Hence to secure the validity of the research the researcher was review relevant and conceptual and empirical literatures similar to problem under investigation. This enables the researcher incorporate major theme in data generating instruments so as to identify the problem in holistic way. Similarly, the researcher was look in to different methodologies of former research outcome and scholarly articles undertaken in order to select accurate data generation tools and technique.

In case of reliability of research, the researcher was use sample check points using GPS and in addition i was undertake a pilot a survey to actual implementation of questionnaire to prove legibility, formatting and logical sequence of questions for actual survey.

All expected bodies to be included in this study was primarily be informed about the target of the research and their willingness; consent was secured before distributing questionnaire and making interview questions. Regarding the right to privacy of the respondents, the study was being kept confidential of the identity of each participant. Any communication with the expected bodies will accomplished at their voluntarily consent without harming threatening personal institutional well-being. In addition, all information obtained from individual respondents will be kept confidential.

1.8. Organization of the study

This thesis has five chapters. Chapter one deals an introduction part which consists of the introduction, statement of the problem, the objectives, research equations, and significance, scope of the study, data validity and reliability, Ethical consideration, and the organization of the study. The second chapter deals with review of related literature obtained from various published and unpublished reference materials. Chapter three describes the study area and the research methodology. Chapter four contains the analysis, results and discussion parts of the study and the fifth chapter presents the conclusion and recommendations of the study.

CHAPTER TWO

2. REVIEW OF RELATED LITERATURES

2.1. Introduction

2.2. The concept and role of road transportation

Road transport network infrastructure plays important role in the economy; especially for third world countries it's open to access for agricultural land, health centers, market schools and different public services. Therefore, it facilitates movement or mobility in urban areas improves quality of life (Gwilliam and Kenneth, 2002).

Accident is defined as an error in driver-vehicle-roadway system and it must be recognized that different types of accidents are caused due to different at any given location namely, rear-end, side-swipes, head-on, night-time, bad-weather, etc. Bad weather accidents can results due to a road pavement which becomes dangerously slippery when wet or it may be due to inadequate signs for inclement weather (Kamal et al., 2008).

Generally, road accidents are evaluated by means of precisely defining the event involving damage to the property and/or injury to the road users, which are recorded first-hand by the police and/or emergency services (Bhat *et al.,* 2013). Accidents are rarely caused by a single factor. Usually, the interaction of the diverse set of factors such as roadway design parameters, road user behavior, environmental conditions, etc., cause accidents; however, one factor can be more responsible than the rest, and can easily be identified.

2.3. Trends of Road Transport Traffic Accidents

Road traffic accidents (RTAs) are one of the serious problems at the global level that results in loss of life and economic damage. Road accident fatalities and injuries are increasing all over the world (Aghajani *et al*., 2017). Due to RTAs about 1.3 million people lose their life, between 20-50 million people disabled and about 518 billion US$ lost annually at global level (Hordofa *et al*., 2018). Dereli and Erdogan (2017) concluded that a traffic accident is a serious problem that threatens human life. Estimation of death-related losses normally includes social and economical losses (Karpova and Julmukhamedova, 2017). Road traffic accidents lead to a large number of fatal incapacitating injuries; the consequences of these accidents are fundamentally reflected in the social sphere (Kontakt, 2017).

According to the World Bank (2012) estimation, road traffic injuries cost 1 percent to 2 percent of the Gross National Product (GNP) of developing countries, or twice the total amount of development aid received worldwide by developing countries. As in developed countries, driver impairment component of road traffic accidents in developing countries. Driving at excess speeds, while under the influence of alcohol or drugs, while sleepy or tired, when visibility is composed, or without protective gear for all vehicle occupants are major factors in crashes, deaths and serious injuries.

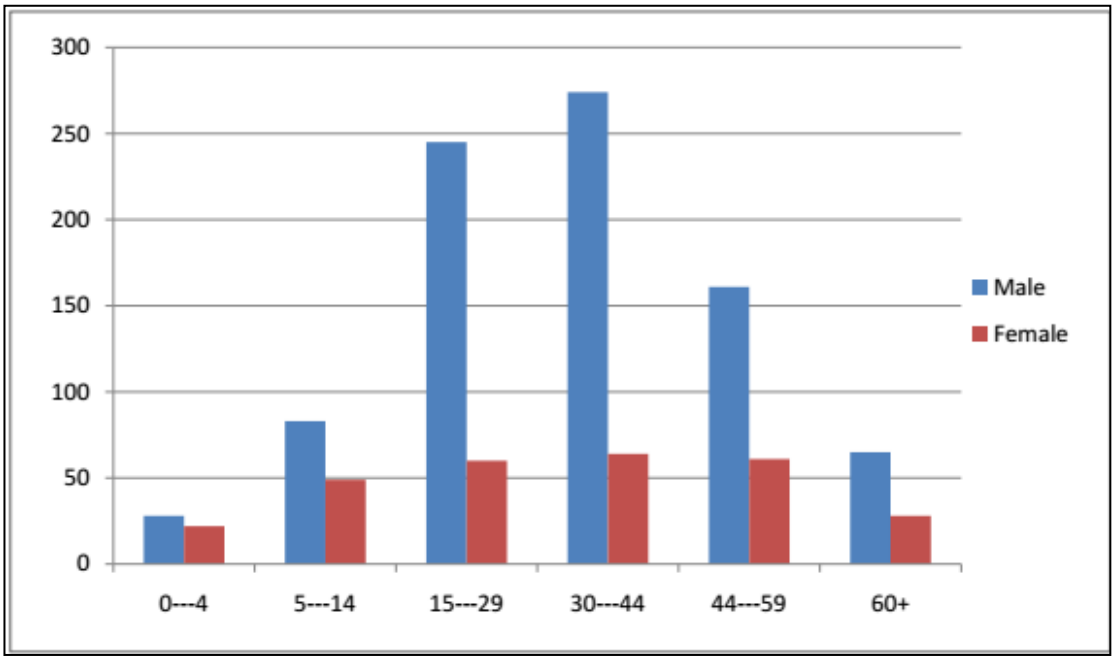


Figure 1: Traffic accident deaths worldwide by sex and age group

*Number of deaths in thousand. Source: WHO, Global Burden of Disease Project, Version 1, 2009

In general, pedestrians, cyclists and moped and motor cycle riders are the most vulnerable road users as well as the heaviest users of roads in poor countries. Most people who use public transportation, bicycles, or mopeds and motor cycles or who habitually walk are poor, illuminating the higher risk bores by those from less privilege. In Asia, for instance, motorized two-and three-wheelers (such as motorized rickshaws) will make up the anticipated growth in numbers of motor vehicles (Dinish, 2002).

Proportion of road users killed in various modes of transport as a percent of all fatalities, selected countries. In general, pedestrians, cyclists, and moped (a motor cycle with a small engine and has also pedal) and motor cycle riders are the most vulnerable road users as well as the heaviest users of roads in poor countries. Most people who use public transportation, bicycles, or mopeds and motor cycles or who habitually walk are poor, illuminating the higher risk bores by those from less privilege. In Asia, for instance, motorized two-and three wheelers (such as motorized rick shawls) will make up the anticipated growth in numbers of motor vehicles (Dinish, 2002).

Table 1: Various mode of transport that killed road users

			Motorized vehicles		
Country	**Pedestrians**	**Bicyclists**	**Two-wheeled**	**Four-wheeled**	**Others**
Thailand	47	6	36	12	-
Malaysia	15	6	57	19	3
United States	13	2	5	79	1

Source: Moha, 2010

Road traffic accidents are one of the significant causes or disability, injury and death in the world. India has the highest road traffic accident rate globally with over 140,000 deaths annually, beating even China. Every hour, nearly 14 lives are lost due to road accidents in India. More than 40% of the deaths are caused by trucks and two-wheelers. Most accidents occur in the afternoons and peak hours (especially in the evening) considered an 'unsafe' or dangerous time to be in the road. In 67% of these accidents there is head injury. Most drivers do not wear seat belts or those on two-wheelers do not wear a helmet though it is compulsory in many states of the country, the rules are broken all the time (WHO, 2012).

This Indian condition is also similar to my study area of Burayu. Most drivers in Burayu do not wear helmet as well as seat belts during my observation. The accident duration is almost similar that in afternoon time is common.

2.3.1. In Africa

According to WHO, 2004 Road traffic accidents kill more people around the world than malaria, and they are the leading cause of death for young and youth aged 5 to 29 especially in developing countries.

The Global Status Report Road Safety (2013) has found that the risk of dying as a result of road traffic injury is highest in African region. The African continent recorded an average of 24.1 out of 100,000 populations dying as a result of road crash in a year. The severity of road traffic crashes is likely to be much greater in Africa than any were else, because many vulnerable road users are involved, poor transport conditions such as lack of seat belts, mobile phoning while driving, and hazardous vehicle environments.

The tendency of road traffic accident to cluster or concentrate at spots on road sections usually known as "black spots" or "accident spots" is very common on roads. These spots can be considered as source of spatial information on road accidents. Identification of such spots helps the enforcement arm of the government, in conjunction with the implementing agencies of the government to put remedial measures to alleviate the occurrences of road traffic accidents. However, more precise information needs to improve the road facility so that driving can be dining safety at these spots (Sauna et al., 1996).

2.3.2. In Ethiopia

Ethiopia is one of the worst countries in the world where road transportation kills and injuries are in large number of road users every year. In Ethiopia, traffic police reports are the official sources of data for road-related incidents. In Ethiopia, the rate of road traffic accidents is very high; because of road transport is the major transportation mechanism along with poor road infrastructure, poor enforcement of traffic laws and other factors (WHO, 2009).In Ethiopia each year more than two thousand people die and ten thousand people injured in road traffic clashes (Ethiopian Federal Police Report, 2010/2011).

Road traffic accident, the 10^{th} most important killer globally, ranked 13^{th} in Ethiopia. According to a study of the Swedish medical university, fatalities related to traffic

accident in the country have a proportion of 70 to 100 for every 10,000 vehicles, which means in every 5 accidents kill 1 person on average (WHO, 2012).

Like other low-income countries, the traffic controlling system is not that much supported by modern technological instruments in Ethiopia. Currently, the country is almost using relatively simple and outdated controlling methods which had been applicable before several decades. It seems that more sophisticated optimization methods are failed for networks. Modern instruments such as traffic speed enforcement hand-held radar and alcohol breath tester, among others, is still not introduced in the country. Of course, according to studies most traffic accidents are the result of speed, poor transport network structure, and lack of road signs and driver's impairment of judgment. Many say that speed, drunk driving and lack of enforcement are said to be the causes of the major failures of the traffic system in Ethiopia. Within a year, over 2,000 people die while over 8,000 are vulnerable to light and heavy injuries are properties worth over 500 million birr get damaged in the country because of road traffic accidents. Most importantly, Oromiya regional state is one of the traffic flow is usually high because of its location obviously vehicles from the 8 states and Dire Dawa City Administration pass through this region to come to the capital city of Addis Ababa (Samuel, 2012).

Ethiopians are more likely to make use of commercial vehicles, minibuses, buses, three tire vehicles (Bajaj) to support mobility needs. Commercial vehicles have a high involvement in crashes, although there is need for exposure data to determine whether they are over represented. It is also highly likely that these vehicles travel more kilometers per annum which contributes to both a high number of crashes and high rate. The observed trends in Ethiopia road crashes provide guidance on their current road safety problems and the challenges, and point to possible areas of counter measures, policies, and program will need to represent low-cost solutions, green economic constraints with in the country (Australian Road Safety Research, 2013).

The Oromiya Regional State is one of the largest states in Ethiopia. This improved road safety policy includes the new road safety laws prohibition of cell phone conversation while behind the wheel, driving without using a seat belt and not using motorcycle helmet and the amendment of an existing road safety laws (excessive speeding, impaired driving with alcohol and chat and unsafe loading) by introducing higher penalty rate including suspension of the

driver license. Seat belt wearing, helmet use and phoning while driving were enforced by using a road side random check up on regular bases; however, speed and alcohol were not well enforced due to lack of radar and breath analyzer (Oromiya Regional State Road Transport Regulation No;96/2007).

The most important modes of transports in the Burayu town are road transport. The road transport is the most proffered because it gives door to door service. On the contrary, it is the most vulnerable to traffic accident than any other mode of transport. The absence of sufficient parking is a problem that observed by the high congestion and traffic accident. Likewise, as far as the number of vehicles in the town is increasing from time to time, the same will happen to the congestion and accident size. Today, the total number of vehicles in the town is over 6367 according to the (Burayu town Transport Agency, 2019)

2.4. Road Environment Contributing for Traffic Accident

Road environments have impacts on occurrences of road traffic accidents. In Addis Ababa - Adama expressway, there are continuous efforts to meet the safety standards of roads through safety audit during the planning, designing, and operation stage.

2.4.1. Road Alignment

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

2.4.2. Horizontal Alignments

Different study shows that road accidents on horizontal curves are causes for concern in all countries. In France, over 20 percent of fatal crashes occur as a result of dangerous curves in rural areas. Crashes on bends are major problems in many developing countries, although the proportion of such crashes is dependent on both topography and demography of each country. A study in Denmark shows that about 20 percent of all personal injuries and 13 percent of all fatalities occur on curves in rural areas (Sweedler, 1995).

2.4.3. Vertical Alignments

There are three main effects of vertical road alignments. These effects are closely associated with the occurrence of traffic accidents. These are excessive speeds and out-of-control vehicles on down grades, differential speed between vehicles created on both down and upgrades, and low range of visibility that often occurs in the immediate vicinity of steep grades at the crest of vertical curves (Kamal et al., 2008). Researchers indicated that it may be difficult for driver to appreciate the sight distance available on crust curve and he may overtake when it is insufficient for him to do so safely. This can be extremely expensive to provide safe overtaking sight distances on crust curves. However, a complete ban on overtaking would be difficult to enforce because of the presence of very slow-moving vehicles, the lack of driver discipline in selecting places, poor maintenance of road marking and signs. Successive short vertical curves on straight section of road may produce misleading forward visibility (Ross silcock partnership, 1994).

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

This is the ability to see ahead in order to stop safely or overtake vehicle or view approach intersection. Sight obstructions on the road, generally occur due to the presence of deep cuts, embankments, vegetation, walls and the like on the inside of the horizontal curves and intersection quadrants, and sharp crest vertical curves. Types of sight distances are: stopping, passing, intersection, and decision sight distance (Kamal et al., 2008). These sight distances vary with design or operational speeds of road section, perception/reaction time, eye, height, object height and pavement friction. Study made in Sweden indicated that there is a decrease of accident rates with increasing sight distance; especially for single-vehicle accidents at night Study made in British reported that on rural roads sight distances shorter that 200m were

relatively more likely to be found at accidents sites through their association with horizontal curves (Berhanu, 2000).

2.4.4. Road Cross-Sectional Elements

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

2.4.5. Lane and Shoulder Width

Numerous studies revealed that lane and shoulder width affects run off the road and opposite direction accidents. The rates of these accidents decrease with both increasing lane and shoulder width, but the marginal effect of increasing width on accident rates decrease as either the base lane width or the base shoulder width increases. Lane width of 3.4 to 3.7 meters has the lowest accident rate and represents the balance between safety and traffic flow. The research revealed that for 3.0 meters lane it is recommendable a shoulder of 1.5 meters or greater, and for 3.3 to 3.6 meters lanes shoulders of 0.9 or greater reduces the accident rate significantly. Generally, lane width has greater effect on accident rates than shoulder width (Berhanu, 2000).

2.4.6. Road Side Features and Side Slopes

Roadside encroachments begin when the vehicle inadvertently leaves the travel lanes, veering toward the roadside. Most encroachments are quite harmless: the driver is able to regain control of the vehicle on the shoulder and safely return to the travel lanes. When coupled with nearby roadside hazards, however, encroachments can result in roadside accidents (Transport Research Board, 1987).

2.4.7. Vehicle Factors Contributing for Traffic Accident

It is not only the improvement in the standards and design of vehicles that matters, but also adequate maintenance of the vehicle during its working life. Older vehicles with mechanical defects and poor maintenance cause higher fatal injuries and property damage. For instance, studies in Britain show that about 20-30 percent of personal injury crashes involve a vehicle

having some deficiency (Sweedler, 1995). In most cases, defects associated with the break, tire, light and other mechanical defects are associated with crash. Size difference between colliding vehicles also affects the severity of injury, particularly in cases when heavy vehicles impact light vehicles.

2.5. Driver Factors Contributing for Traffic Accident

Study made by OECD on its member countries indicated that driver behaviors are the major contributing factor for traffic accidents. Studies in these countries show that about 80-90% of the road traffic accidents were attributed to the fault of the driver. Similarly, negligence of drivers is the main feature of traffic accident in Addis Ababa. Assessment made on the traffic accident data from the traffic police between 1993/94 - 1999/00, it is learned that driver faults account for 98%of the causes. Drivers in the age group between 18 and 30 are responsible for 39, 36, 27 and 32 percent of the fatal, serious, and slight injuries and damage to property respectively during the specified period (Kamal et al., 2008).

Another study made on traffic accident shows that male drivers were responsible for 84, 79, 60 and 78 percent of the fatal, serious, slight and total traffic accidents respectively. Drivers having driving experience of 2-5, 5-10 and above 10 years are responsible for 22, 20 and 28 percent of the casualties respectively. This condition negates the inverse relationship between driving experience and traffic accident. More than 70% of the traffic accidents in the city are attributed to those drivers having more than 5 years of driving experience. The other possible contributory factor for traffic accidents is the relation of the driver and the vehicle he/she drives (Persson, 2008). About 62% of damage to property, 58% of fatal, 51% of serious and 40% of slight injury accidents and about 57% of the total casualties are caused by employed drivers (Segni, 2007).

2.6. Factors for occurrence of Road Transport Traffic Accident

There are four major factors influencing road traffic accident. Those are:

i. **Vehicle related factors:** This may be due to inherent design limitations or defects to lack of maintenance, failure of components like brakes, tires and lighting. Visibility, speed and vehicle lighting are also important. It is not only the improvement in the standards and design of vehicles that matters, but also adequate maintenance of the vehicle during its working life. Older vehicles with mechanical

defects and poor maintenance cause higher fatal injuries and property damage. For instance, studies in Britain show that about 20-30 percent of personal injury crashes involve a vehicle having some deficiency (Sweedler, 1995). In most cases, defects associated with the break, tire, light and other mechanical defects are associated with crash. Size difference between colliding vehicles also affects the severity of injury, particularly in cases when heavy vehicles impact light vehicles.

ii. **Road related factors:** this includes pavement design and conditions, road network, horizontal curves, insufficient lane and shoulder width, vertical curves.

iii. **Road user related factors**: psychological factors of the users, alertness and intelligence, patience of driver, drivers experience and age

iv. **Environmental related factors:** rain, reduced visibility, bad weather etc. heavy fog and mist and heavy rain also plays important role. Development and various factors causing road accident are described in the following sections. RuiGarridoa (2014) report that an effective road safety management requires a good insight into the factors that are believed to be related to road traffic accidents. In the area of accident severity, continuous efforts have been conducted in order to investigate the relationship between the level of severity (dependent variable) and a set of explanatory variables (Independent Variables).

2.7. Impacts of road infrastructure

Road infrastructure is a fixed entity where the road transport operation takes place. Its physical elements are road networks which include tracks, nodes, terminals and bridges. Road infrastructure is playing a key role in the progress and socioeconomic growth of a nation, both through the direct effects of mobility for the society and goods and also via the indirect benefits derived from the process of constructing infrastructure (Papí *et al* 2007: Ochieng 2002:3; Islam *et al.*,2008).

2.7.1. The direct impacts of a road development

Apply in the form of (a) an enhancement of the level of spatial connectivity (and the consequent increase of passenger and freight traffic carrying capacity) which may be initially low (b) a reduction of the cost of provision as well as the cost of use of road infrastructure, and (c) the increase in turnover of the users (Islam *et al.*, 2008).

2.7.2. The indirect impact of a road development

On the other hand, would work through the dynamic developmental synergies generated through the forward and the backward linkages. The change in agricultural land use pattern can be an example. This can be induced by changes in the patterns of settlement, agricultural land use, trading and other services and non-farm unorganized sector activities (Persson, 2008). All these would be reflected in the changes in the pattern of socioeconomic activities, income generation, price evolution, employment conditions and land rent prevailing in the concerned local region. A new land use pattern may in turn create a greater attraction zone and accessibility to jobs, markets, health and educational facilities and attract investment for the development of feeder roads, power distribution networks, telecommunication facilities and other modes of connectivity leading to a greater access. All these should have a bearing on the level of well-being of the households (Sengupta et al., 2007; Islam et al., 2008 2). As stated by Ochieng (2002), generally it is not meaningful to study indirect effects without any knowledge of direct effects.

2.8. Black or Hot Spot

There is no universally accepted definition of a black spot. (Rokytová, 2000) defines black spot as location that are generally classified after an assessment of the level of risk and the likelihood of a crash occurring at a location. On the other hand, black spot as "a road location of limited with a high concentration of accidents" (Kamal et.al, 2008)

Geographic Information System (GIS) for Transport Models

Geographic Information System (GIS) are a computer-based system that enables users to collect, store, process, analyses and present spatial data (David, 2003). It provides an electronic representation of information, called spatial data, about earth's natural man-made features. GIS are capable environments for the capturing, management, analysis and visualization of spatial data. They allow for an integration of various data sources into a scalable, dynamic and adaptable geospatial framework. Through models, simulations and analyses, each with an explicit consideration of the spatial nature of transport, new information can be generated. Besides, GIS also facilitates information visualization which serves as a communication platform with feedback loops to the data integration and the settings of models, simulations and analyses (Miller *et al.,* 2015).

Up to now most transport models rely exclusively on static data. These are datasets that are generated at a certain point in time for a specific purpose. Examples are road network graphs, travel diaries, census, or land use data, etc. The amount of available, static data varies depending on the analysis area. Open (Government) Data and crowd-sourced spatial data, with Open Street Map as the most prominent example; facilitate many transport-related geospatial analyses. The same holds true for timetables of public transit, but with a greater variation of availability between cities and regions. Mainly for privacy reasons, address-specific data are treated restrictively almost everywhere (Persson, 2008). Thus, statistical data on the individual or household level are related to blocks, census districts, or regular grids as the spatial reference unit. In the European Union, the publication of authoritative transport data currently gains momentum due to the INSPIRE (Infrastructure for Spatial Information in the European Community) and PSI (Public Sector Information) directives, which push authorities to publish their data in a freely accessible manner. The latter aspect is expected to result in a more positive ratio between data availability and accessibility (Deepthi and Ganshkumar 2010).

2.9. The Use of GIS in Hotspot Analysis

GIS represent a new paradigm for organization of information and design of information system, the essential aspect of which is use of concept of location as the basis of structuring information systems. Traffic accident analysis means to investigate the cause of accident, to determine hazardous location (accident prone location) and to determine to enhance road features, to evaluate traffic safety and enhancement. GIS can easily represent accident road accident-based results using various tools like linear referencing, dynamic segmentation and spatial analyst (Deepthi and Ganshkumar 2010). Moreover, query can be easily performed, enhanced by graphical representation. Road characteristics, demographic and socio-economic data enhance high safety analysis can also integrated in to analysis (Kamalasundhan, 2011).

CHAPTER THREE

3. RESEARCH METHOD AND MATERIALS

3.1. Location of the study area

Burayu Town is located in the western fringe of Addis Ababa, along the Addis Ababa to Ambo road at about 15km from the center of Addis Ababa. Burayu town is one if the nine municipal town administration in Oromia Special Zone Surrounding Finfine. Astronomically the town is situated between $9^0 0' 0''$ to $9^0 50' 0''$N Latitudes and $38^0 35' 0''$ to $38^0 42' 30''$E longitudes. It is bounded Addis Ababa city in East and south East, forest owned by Addis Ababa in the North, Sululta town in North east, Menagesha Kolobo town in west, Sebeta Hawas district in South (BTA, 2021).

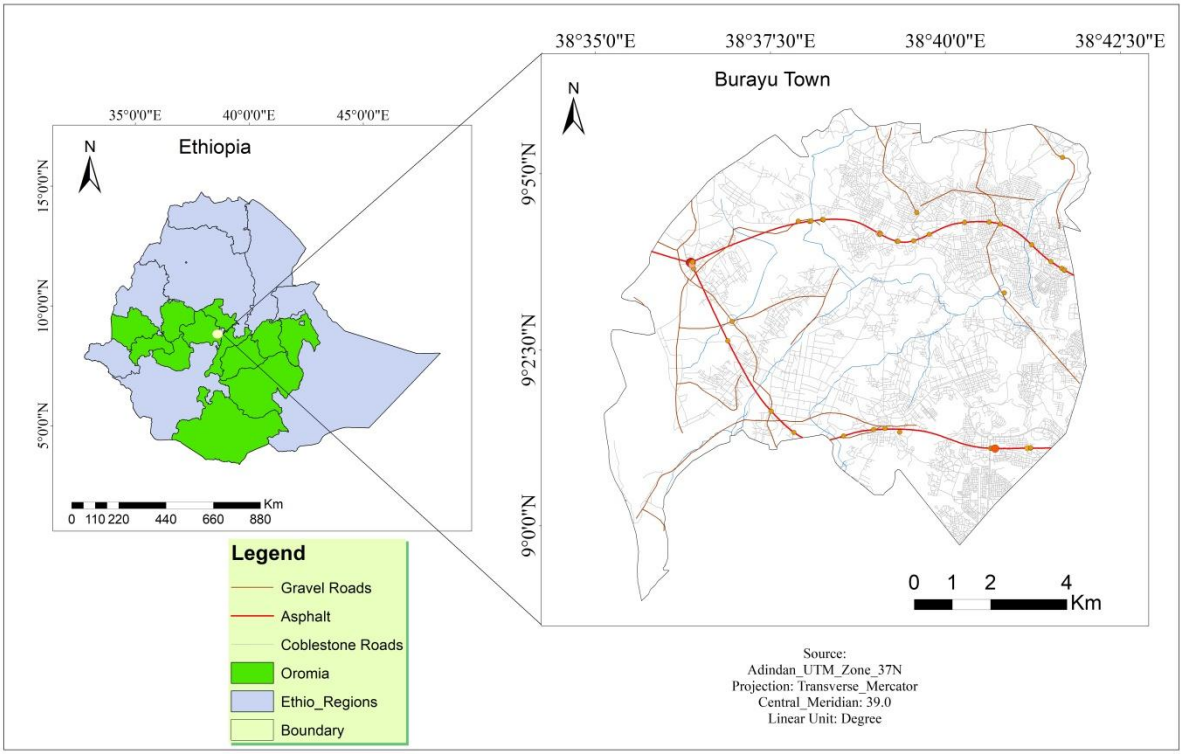


Figure 2: Location map of study area

3.1.1. Topography

The topography of the area varies from chain of mountains around *Intoto* ridge in the North-East to plain land to South, South-West, and West. Buarayu Town is situated at the southwest foot of Entoto Ridge, most of the existing built up areas of the Town lies on rugged terrain.

According to Land Administration of Burayu town (2019) most of the proposed expansions areas are characterized by gentle slopes and undulated plains (northwest) with limited steep slopes and deep gorges (South). With Altitude range of the Town from 2370 meter above sea level to 3310 meters above sea level(Figure 3).

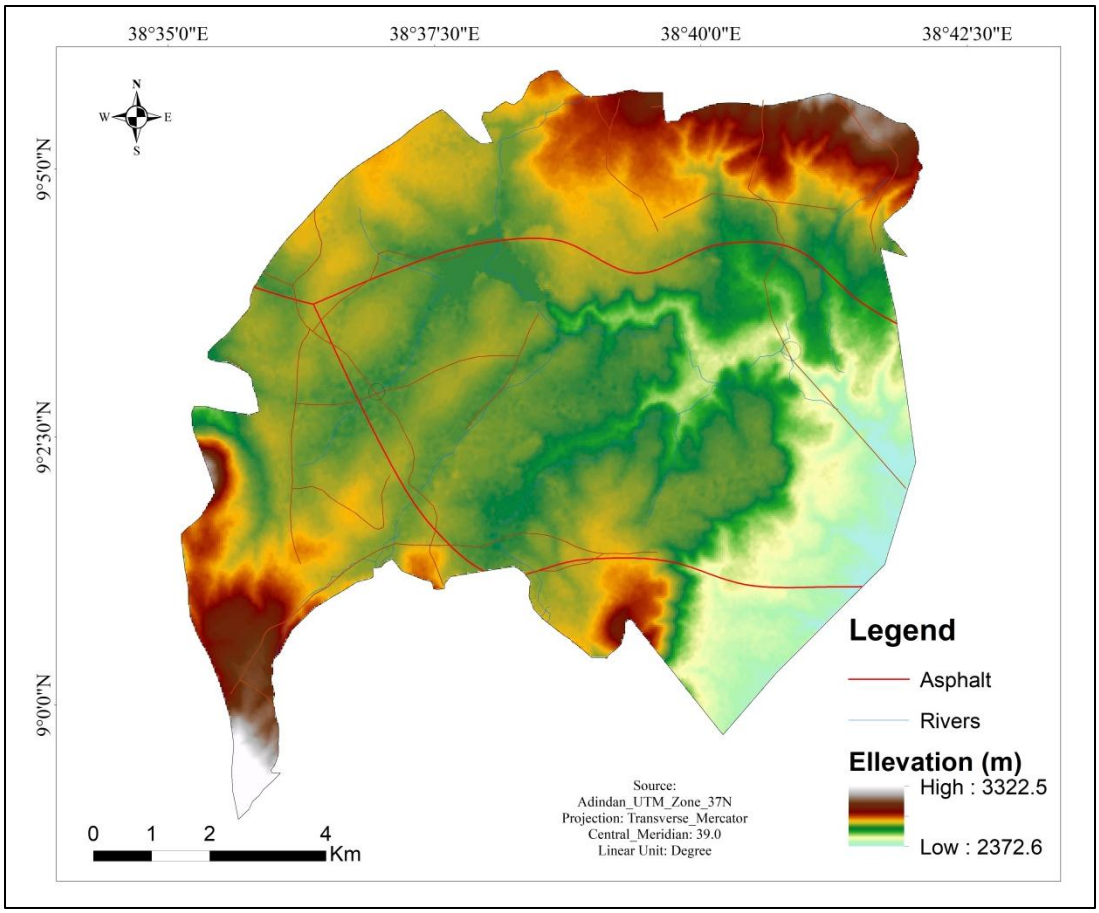


Figure 3: Topography of the study area

3.1.2. Demography and socio-Economic Aspect

Burayu is relatively the largest town with 100,200 populations in 2010 in Oromia Special Zone Surrounding Finfinne. Burayu town is very proximate to Addis Ababa. Because of its proximate to the capital city of the country, better infrastructure, relatively high cost and tedious procedure to get land for residence in Addis Ababa, so many people want to have residence their residence to Burayu town. Thus formal and informal land transaction in the town has been increasing. So the population of the town is increasing from time to time. The detail information of the population of the town is indicated in fig 4 below

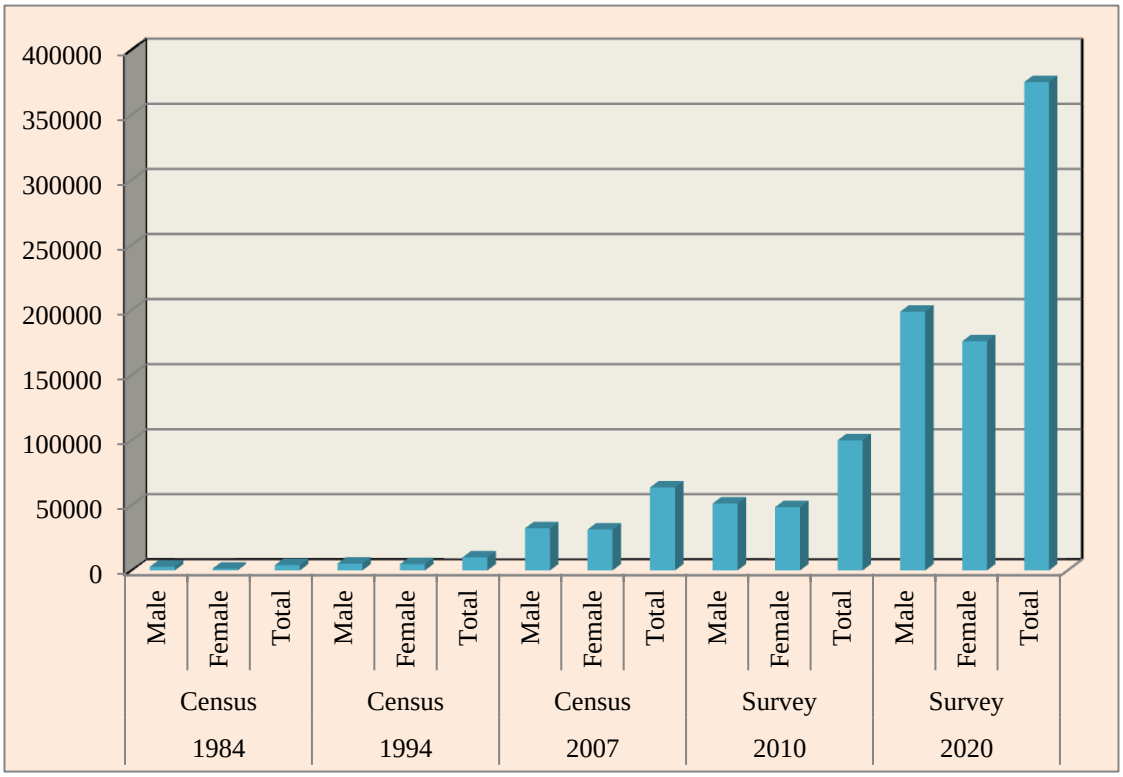


Figure 4: Population of Burayu town, (Source: Burayu town administration, 2020)

Economic activities: Because of its proximity to capital of the country better infrastructure development, relatively high cost and tedious procedure to get land for residence in Addis Ababa metropolis and other reason, many people to have residence in Burayu town. Even though the economy of the town is largely based on commercial economic activities, industrial and some of the societies are public administration, transport, construction and other services like trade, hotel and restaurants

3.1.3. Road and transport services

Road

Although roads are the vital components of transport system, the coverage and quality of roads in Burayu Town very low, currently only about two asphalt roads crossing the town of which one has 5m length of 15km on the average it serve 1700 cars and 150 motorcycles per day. The other roads have width of 7m and length of 20km which serve as the main roads. On the average this roads serve as 5080 cars and 90 motorcycles per day (WHO, 2008). There are also 451.59 km gravel surfaced collector and local roads part of the town, almost all local / feeder roads in existing built up area properly made by coble stone is covered 399.2m (Burayu Town Road Authority office, 2020).

A. Inter-Urban Transport

In study area motorized transport services is limited only along major roads. So according to Burayu town transport Authority (2012) the number of Taxi from 2009_ 20011/12 is 228 and Freight passenger's motorcycles and others 8 the total transport 6367. Non-motorized Transport is more than 80 in this year consecutively. Carts (Gray) 90, Bajaj's 125 they give regular services in the areas where modern transport sectors do not operate.

B. City Bus

There is a regular city bus services between Burayu and Addis Ababa city from 12:00 AM to 8:00 PM. Averagely about 2500 to 3000 people get city Bus transport service from Burayu to Addis Ababa (Burayu town traffic police department, 2020)

Burayu town is located in high land area with an altitudinal ranges from 2600 meter above sea level m.a.s.l North at *Entoto* Ridge to 2450 m.a.s.l at *Tinshu Akaki River* in South (Burayu town Administration, 2019). As data on climatic condition of Burayu Town is not available, attempt has been made to adapt the climatic condition of Addis Ababa where the nearest metrological station is there.

C. Climatic condition

The mean annual temperature, the mean annual maximum and the mean annual minimum temperatures of the Town is reckoned to be about 14^0C, 22^0C and 6^0C, respectively, which is the characteristic of a warm temperate climate.

The mean annual rainfall is about 1188 mm. The highest rainfall concentration (70%-80%) occurs from June to September. Thus, low infiltration of rain water, storm water occurrence, inundation of low gradient areas, sheet and gully erosion are common problems in the town.

3.1.4. Soil

The study area contains two major geologic soil types. The first one is Tertiary Plateau basalts are volcanic products consisting huge accumulation of basaltic rocks and the second one is Quaternary Rift Volcanic and sediments comprises variety of rocks unit associated to the formation of Rift system during Quaternary period (Ethiopian geologic map 2011). These are the reddish brown salty clay soil of friable nature which is highly leached and the dark gray sticky clay soil with expansive nature. Soil development and the nature of the soil in the area are mainly controlled by geology, topography and hence drainage. In the areas like northwest of St marry church and the area at the eastern tip of Tatek-sigameda the soil is clayey and has got expansive nature.

3.1.5. Research design

To conduct this study, explanatory research design with the application of quantitative approaches was employed.

Mixed approach to research, is used to collect and analyze not only numerical data, which is customary for quantitative research, but also narrative data, which is the norm for qualitative research in order to address the research question(s) defined for a particular research study. The goal for researchers using the mixed approach to research is to draw from the strengths and minimize the weaknesses of the quantitative and qualitative research approaches (Johnson and Onwuegbuzie, 2004).

3.1.6. Data type and sources

Both primary and secondary sources were explored to collect the required data. The type and availability of data are identified before beginning filed work.

The primary data were collected from derivers, traffic police with the help of interviews and questionnaires. Also, from survey using GPS, photo camera and field observation. The GPS survey was carried out over the two main asphalt road roads of Burayu town.

The secondary data was collected from Town administration; Burayu Town Police report, Burayu Town Transport Office report, as well as form published and unpublished materials. Moreover, reliable internet sources, different books, journals and government reports were utilized. In addition to these demographic characteristics and related data were gathered from Central Statistical Agency (CSA) and from Administrative Office of Burayu town.

3.1.7. Sampling procedure and Sample size

The study was identified 13 Accident hot spot area on two main Street in Burayu town that area characterized by a dense vehicle and pedestrian movement. To evaluate the nature, causes and consequences of traffic accidents in the town, the researcher selected 30 respondents purposively. The reason behind choosing 30 respondents was mainly due to time and financial constraints. These 30 respondents were individuals who were well experienced in road and traffic related issues. Of these total respondents, about 21 of them were traffic police experts who were believed to provide detail and adequate information about car accidents in Burayu town. The questionnaire was distributed in this area. In order to select this sample street and concern populations the researcher first assessed the recorded road traffic accident by traffic police from the year 2016 to 2020.

3.2. Variable Definition

Based on the objective of the study and type of data, I collected from traffic police , the study identified the following independent and dependent variables will be used for research under consideration.

3.2.1. Independent Variables

- Accident causes related variables (unethical driving, technical problem, sleeping problem)
- Vehicle type related variables (Automobile, Pickup up to 10 quintals), minibus (up to 12seats), Medium Bus (13_45, Large bus (above 46 seat), Medium Truck (11-40 quintal)
- Topography related factors (Slope, Aspect)

- training schools' performance
- climate issues
- people's culture of respecting traffic rules

3.2.2. Dependent Variables

In line with the objective of the research, the dependent variable is Accident.

3.2.3. Materials used

The materials used in this study for data collection and analysis includes, Sony trace digital camera for car crash (accident area), GPS Garmin 72 receiver used for collect ground control point, The software's used for data pre-processing and preparation, data analysis, editing and output generation were ArcGIS 10.4.1 applied for digitizing and overlay analysis and data base creation.

3.3. Methods of Data processing, Analysis and Presentation

3.3.1. Data processing

The black spot data were collected with the help of hand held GPS of Garmin 72 in WGS1984 datum. The accident spot location was converted into shape files using ArcGIS software. The accident details were added as attribute data. The OSM were geo-referenced using the given location. All OSM be mosaic into a single map. Digitized method is used to extract the vector data from the base raster data. The extracted layers are Burayu boundary, Major District Roads, Cobble stones, gravel roads, road network and streams. These layers were saved as shape files. These extracted and generated layers are added into the geo database.

Road accident data set used for the present study was obtained from the Traffic Police Headquarters of the Burayu Town. The accident locations were attributed with detailed information such as place, vehicle type, reason, fatality etc. the road networks were digitized from the OSM. After digitization, the road map was updated by GPS field survey.

3.3.2. Data analysis

Parameters for road transport traffic accident analysis include; road networks, master plan of the town, road type, slope.

A. Spatial statistical mapping

Spatial statistical mappings the key to understanding the spatial and temporal occurrence of accidents and spatial statistics comprises a set of techniques for describing and modeling spatial data (Mitchell, 2005).

Spatial statistical analysis related to road accidents can be performed on a spatial database incorporating all the desired information and by generating data layers from the available sources updated by field verification. All spatial processing were carried out using ArcGIS 10.4 and its extensions. A Global Moran's I spatial autocorrelation test was carried out for each type of accident incidence in the area. In addition, a hot-spot analysis and Kernel density estimation were also carried out based on the Getis-Ord Gi* statistics and point Kernel density function. Both of these analyses were carried out using ArcGIS' Spatial Statistics tools.

B. Spatial Autocorrelation: Moran's I method

The Spatial autocorrelation (Moran's I method), works not only on feature locations or attribute values alone but on both feature locations and feature values simultaneously. Given a set of features and an associated attribute, it evaluates whether the pattern expressed is clustered, dispersed, or random. Moran's I is one of the oldest indicators of global spatial autocorrelation and is still used for determining spatial autocorrelation (Zhixiao *et al.,* 2008).

C. Hot Spot Analysis

A hot spot is a location or a small area within an identifiable boundary showing concentration of incidents (Zhixiao *et al.,* 2008). The three major processes involved in the estimation of desired hotspots of accident incidents are collection of events, mapping of clusters using Getis-Ord GI* function and density estimation using Kernel density tool.

Collect-event function available with the spatial statistic tool was used for performing the function, which in turn will yield a new weighted point feature class with a field I Count that indicates the sum of all the accidents happened in a unique geographic location. This weighted point feature was used as the input for running the hotspot function (Getis-Ord GI*) to identify whether features with high values or features with low values tend to cluster in the study area. This tool works by looking at each feature within the context of neighboring features. If a feature's value is high, and the value for all of its neighboring features is also high, it is a part of a hot spot. The local sum for a feature and its neighbors is compared proportionally to the

sum of all features; when the local sum is much different than the expected local sum, and that difference is too large to be the result of random chance, a statistically significant Z score is the result (DeGroote *et al.,* 2008). The statistical equation for calculating Gi and Gi* can be written as,

$$Gi*(d) = \frac{\sum jWij(d)Xj - Wi\dot{x}*}{s*\{[(nS*1i) - Wi*2]/(n-1\}½}$$

Where;

'Wij (d)' is a spatial weight vector with values for all cells 'j' within distance d of target cell i,

W*i is the sum of weights, S*1i is the sum of squared weights and s* is the standard deviation of the data in the cells. The Gi* statistics is actually a Z score. For statistically significant positive Z scores, the larger the Z score, the more intense the clustering of high values. For statistically significant negative Z scores, the smaller the Z score, the more intense the clustering of low values is. Finally, the Kernel density hotspots with the populated field as GiZScore were performed with the point density calculator function available with the spatial analyst tool. It calculates the magnitude per unit area from each hot spot features using the populated GiZScore field. The output of the Kernel density function is a raster file displaying the areas of high and low clusters of accident occurrence (Zhixiao *et al.,* 2008).

The hotspots and Kernel density surfaces were derived for total accidents. The hotspots for each classified types of accidents were calculated using the Getis-OrdGi* function followed by the event calculation. The Getis-Ord Gi* statistics identifies spatial clusters of high values (hot spots) and of low values (cold spots). The output of hotspot analysis tool is GiZScore for each feature. These values represent the statistical significance of the spatial clustering of values, given the conceptualization of spatial relationships and the scale of analysis. A high GiZScore for a feature indicates a spatial clustering of high values; whereas a low negative GiZScore indicates a spatial clustering of low values (Mitchell, 2005).

The higher the GiZScore, the more intense is the clustering. A Z score near zero indicates no apparent spatial clustering. The GiZScore for unclassified total accident locations varies between -2.093 to 7.781 and the GiPValues from 0 to 0.998. From this, it is inferred that

statistically significant positive GiZScore (high values) indicates accident hotspots, while statistically significant negative GiZScore (low values) indicate cold spots.

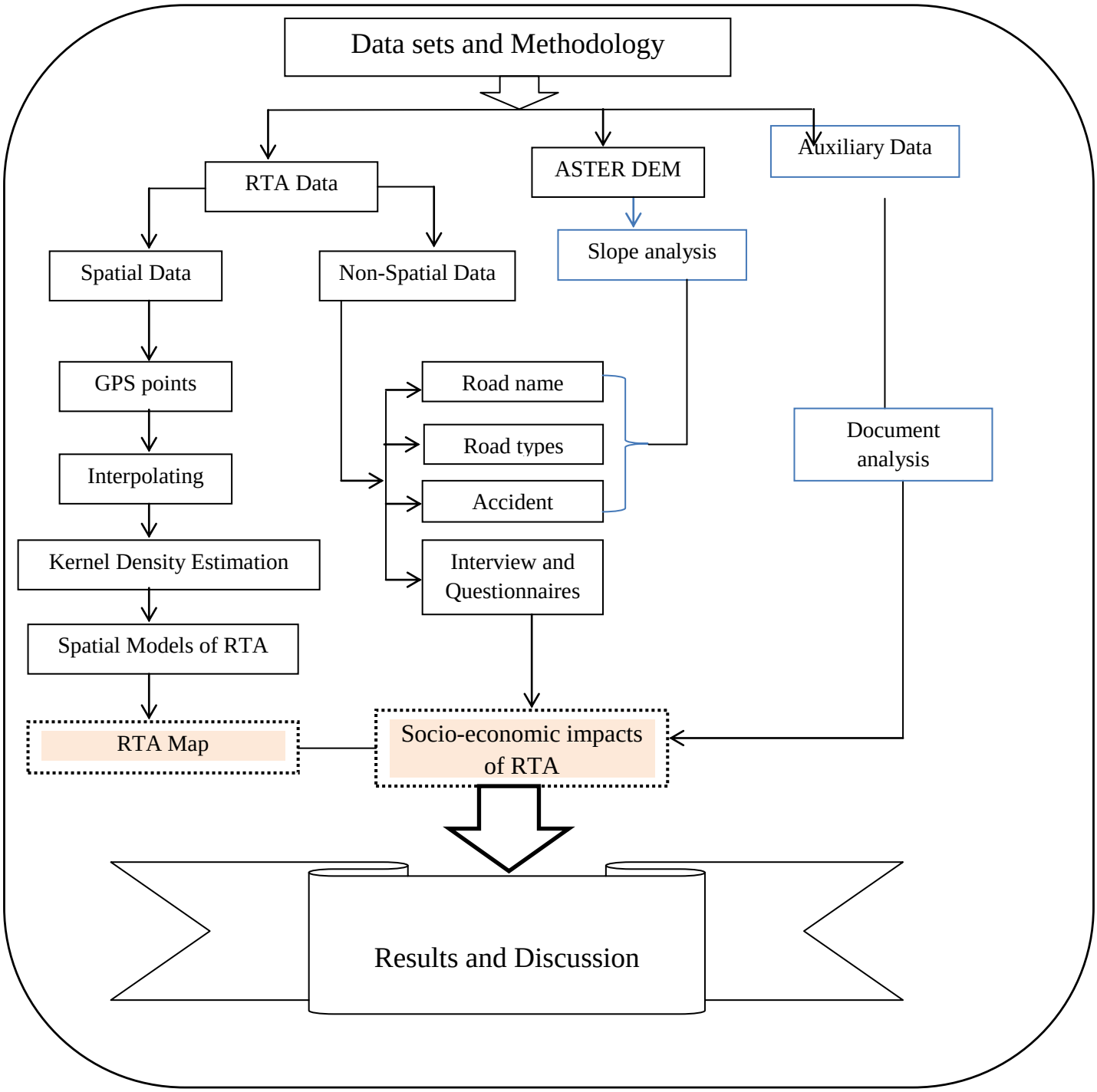


Figure 5: General work flow diagram

CHAPTER FOUR

4. RESULT AND DISCUSSION

This chapter presents the empirical finding of this study and it incorporates statistical and spatial analysis (presented in tables, figures, and maps). For this study, 77 fatal and 188 injuries, were collected and included in the database from the year 2016 to 2020 in Burayu town. Out of 156 fatal case traffic accidents, only 139 fatal cases were geo-coded on the road network and located exactly within the study area. The spatial analysis was based on 139 fatal accidents.

4.1.1. Socio- Demographic Characteristics of respondents

4.1.2. Age of respondents

In terms of age category, respondents who engaged in this study aged between 31-41 years old. This shows that majority 12 (40%) of them were grouped under young age group (Table 2). According to Temesgen *et al.,* (2019) most young age (18-50) drivers are characterized by high speed, low driving experience and driving with over confidence. Parallel to age category, educational level also makes a great variation on the occurrences of RTAs.

Table 2: Age of respondents

Age category	Frequency	Percent
18-30	10	33.3
31-40	12	40.0
41-50	6	20.0
above 50	2	6.7
Total	30	100.0

Source: (Own processing, 2021)

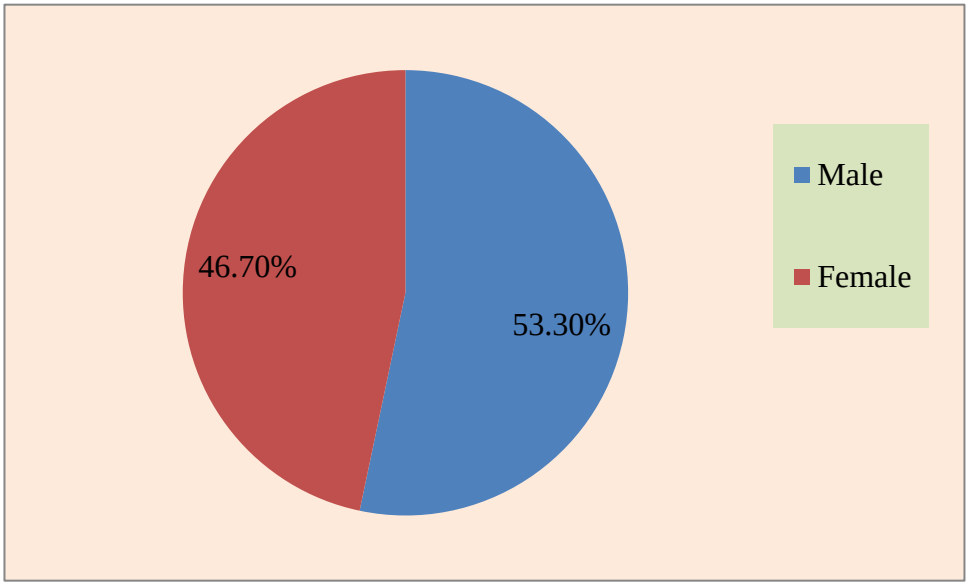
4.1.3. Marital status of the respondents

Of the total respondents, more than half percent of them 18 (60%) were married. **Table3:** Marital status of the respondents

Marital status	Frequency	Percent
Single	12	40.0
Married	18	60.0
Total	30	100.0

Source: (Own processing, 2021)

4.1.4. Gender of the respondents



More than half percent (53.30%) of the respondents were male population.

Figure 6: Gender of the respondents

Source: (Own processing, 2021)

4.1.5. Educational status of the respondents

Nearly half percent (46.7%) of the respondents were diploma holders. This indicates that the selected respondents could provide detail information on the nature, cause and consequences of road traffic accidents in the study area.

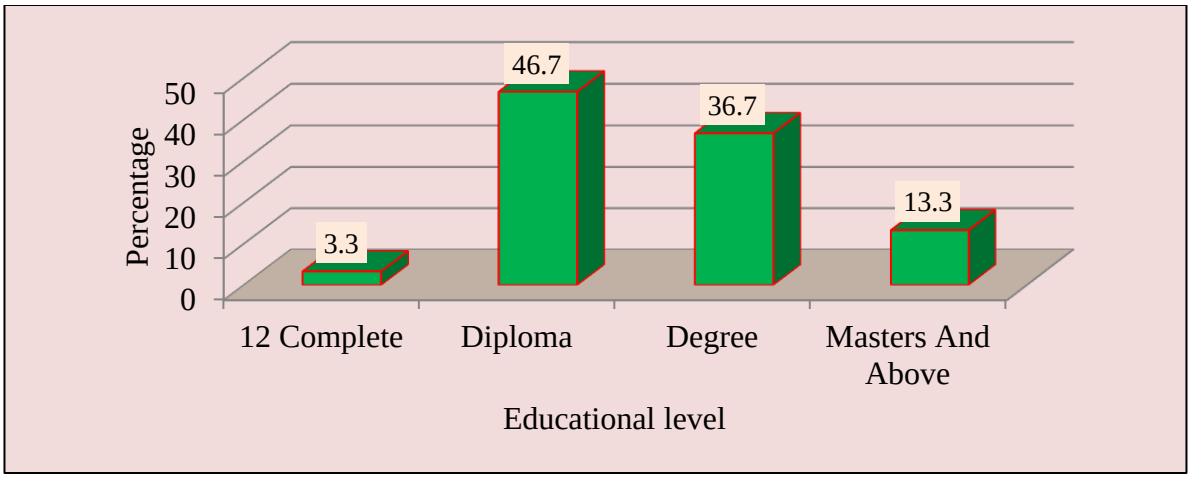


Figure 7: Educational Background of the respondents Source: (Own processing, 2021)

Educational qualification of drivers were the predictors of fatal accidents in this study because drivers who completed primary levels of education (4–8 grade) caused a large number of fatalities, but fewer fatalities, were caused by grade 8 and above and though it was not statistically significance, which is similar to study done in Addis Ababa (Fantahun, 2012).

4.2. Road Networks of Burayu town

Regarding the road density, the traffic count data for the main Federal Roads show flows of the order of 10,000 vehicles per day on the main road from through Burayu town. Trucks and truck-trailers accounted for 57%, buses (including minibuses) for 23%, cars and other small vehicles accounted 20%. The width of the road is less compare to the carrying capacity of vehicles, currently only about two asphalt roads crossing the town of which one has 5m length of 15km on the average it serve 1700 cars and 150 motorcycles per day. The other roads have width of 7m and length of 20km which serve as the main roads. On the average this roads serve as 5080 cars and 90 motorcycles per day

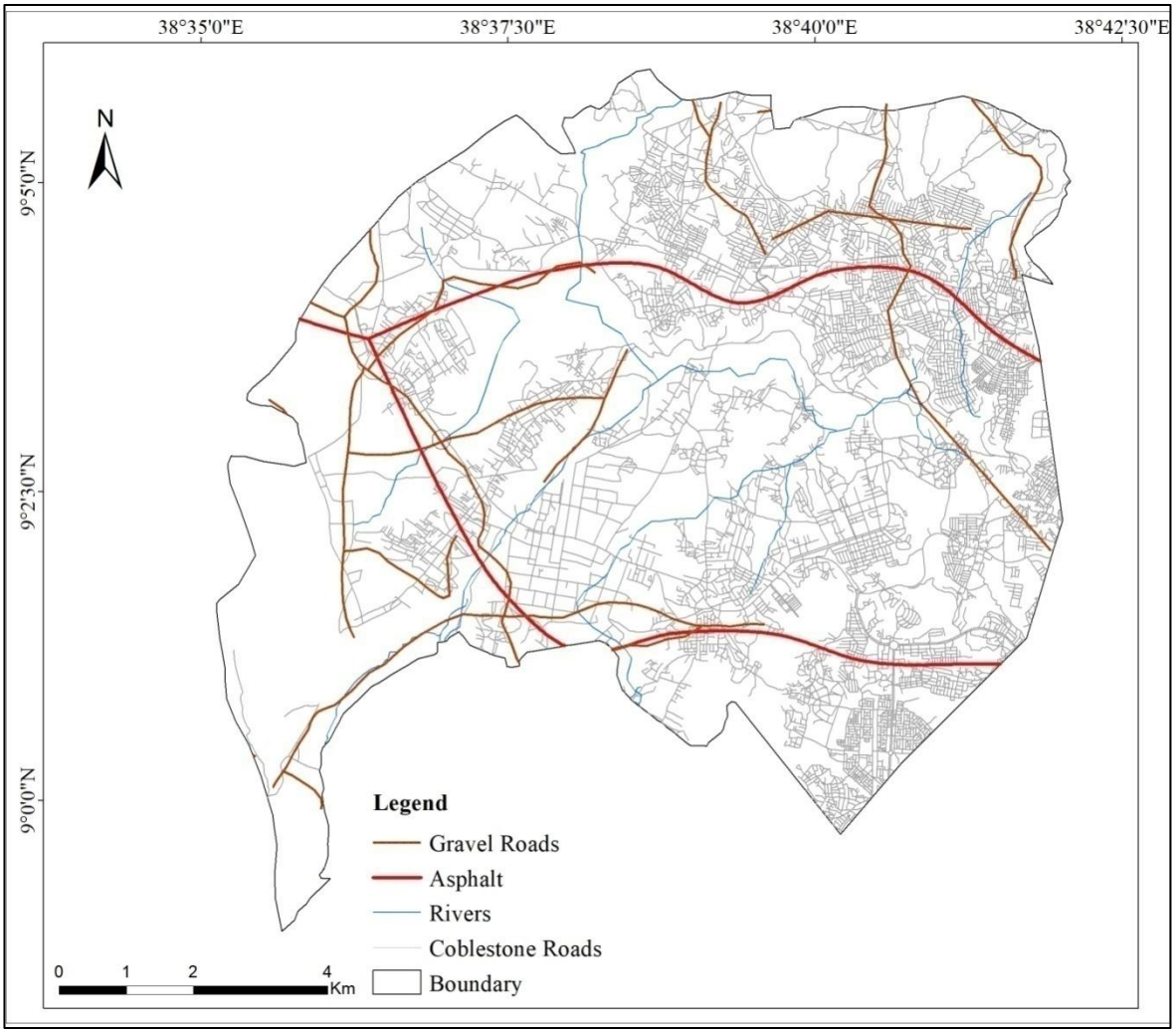


Figure 8: Road Transport Network Structure in Burayu Town

4.3. Major Causes of Road Traffic Accident in Burayu Town

The results gained from both in-depth interview and questionnaire was computed in SPSS v23 software. Accordingly, the main reason for road accidents in Burayu Town is mainly attributed to both spatial and non-spatial characteristics.

While looking at the number of injuries per crash, majority of them were emanated from technical problem of vehicles. Results obtained from sample respondents trough questionnaire with car drivers of the town shows that among the total three causes of accidents, technical problem constitutes highest mean 0.606 followed by unethical driving with a mean of 0.586. On the other hand, the rate of death per crash due to unethical driving is the highest of all the causes of accident with a mean of 0.121. These show that human behavior is critical for minimizing the level of accidents happening on the expressway.

According to personal observation and discussion made with traffic police of the town, road accident leads to several unwanted consequences, including death, permanent injuries, loss of earnings, etc. Speeds, not giving the right of way, pedestrians' lack of discipline, carelessness at shifting the road lane are the major possible causes for road traffic accidents in Burayu town particularly at *Kella* area (plate 1).

This finding is in agreement with a number of studies like Berhanu, 2000, which pointed out that roadside encroachments begin when the vehicle unintentionally leaves the travel lanes, veering toward the roadside. Most encroachments are quite harmless: the driver is able to regain control of the vehicle on the shoulder and safely return to the travel lanes. When coupled with nearby roadside hazards, however, encroachments can result in roadside accidents.

Table 4: Accident statistics of Burayu Town from year 2016 - 2020

S/N	Causes	Accidents	No. of injured
1	Drivers faults	87	75
2	Mechanical defect	57	15
3	Fault of pedestrian	65	11
4	Others	81	23
5	Unknown causes	39	22

Source: (Burayu town traffic police department, 2020)

Plate 3: Picture showing congestion

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 technical problem and unethical driving of drivers as well as 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. There is a significant lack of road signs on the roads. The road signs are necessary to alert the motorists and pedestrians about the turns, speed limits, crossings, etc which will help them with the proper driving and road usage.

4.3.1. Drivers related causes

Concerning the drivers that give priorities for pedestrians' about 2 (6.7%) respondents respond as "excellent situation. Whereas, 13 (43.3%) responded as "poor" condition. From these data

the respondent who said "good" condition was less than that of said poor condition According to the information obtained from Burayu town traffic police department, inadequate training of drivers, not adapting the speed to traffic conditions, lack of attention while driving and excessive speed are the major possible causes of road traffic accident. Results obtained from sample respondents trough questionnaire with car drivers of the town shows that giving priority for pedestrians in the town is poor (Table 4).

Table 5: Respondents response on giving priority for pedestrians

Priority for pedestrians	Frequency	%
Excellent	2	6.7
Very good	6	20.0
Good	9	30.0
Poor	13	43.3
Total	30	100.0

Driver factors are depend on the individuals unique characteristics like age, sex, education and training level, as well as the living environment has an impact on the occurrence of RTAs. The driver's age and educational levels are fundamental factor for occurrence of RTAs. The traffic Police data of Burayu town showed that, younger age (18-30) drivers were more frequently involved in RTAs than adult and old aged (>51) years. Several studies like Fantahun, (2012) also justify that the young drivers with an age from (18-30) are the most vulnerable, which results a total record of 122 accidents (50.6%) within only four years. This is mainly due to the fact that the adolescent's age groups are risk taking behavior and have low driving experience. Age from (31-50) were the second most susceptible groups, they hold about 20% of road accidents.

Around 89% of the fatalities and 83% of injuries of traffic accidents were caused by driver errors, such as over speeding, failing to give priority to other vehicles and pedestrians and only 6% were caused by pedestrian error. Sixty six percent of fatal and 56% of nonfatal accidents were caused by driving above the speed limit alone This is consistent with the finding of study in Kenya which showed 85% of the accidents were caused by human factors (driver and pedestrian errors) and also to the finding from Ethiopia on the road traffic collision between Akaki, and Adama town reported that high speeds and failure to give priority to other vehicles

and pedestrians caused five times more fatal collisions than their counterparts. In contrast to this, driving experience was not a determinant factor for fatal accidents. However, drivers with only 3–5 years' experience were frequently involved in the accidents. A study in Qatar noted that drivers who drove for more than five years were less frequently involved in the crashes (Chalya *et al.*, 2010).

4.3.2. Speed breakers

Roads in Burayu Town aren't really known for their proper construction; and this is a major problem in the town. Speed breakers are one of the main reasons for the road accidents and deaths in Burayu Town. Car drivers try to avoid these speed cracks on the road and end up in road accidents. Motorcyclists end up in problems because of improper bumps more than car drivers. The speed breakers are usually unscientific and constructed at unwanted places. There are many obstacles that could be encountered on the road. Sudden unexpected turns, bends, curves, etc will surprise the drivers while driving and this may cause accidents.

4.3.3. Road excavating

Road excavating is usually done in Burayu Town for the repair of the telephone wires or water pipes. These roads after being dug up are not properly closed; and causing cracks in the road. These disturbances cause road blocks, traffic jams and accidents as a result.

Plate2: Crashing downs of cars due to poor quality of roads (Burayu town traffic police department, 2020)

From the point of personal observation, the quality of roads has not been improved enough and safety standard of vehicles has not reached a desired level. It could possible to find out all the utilities which are nearby some particular point. In addition, the people have not received required instructions and training to improve their attention in terms of safe driving. More number of accidents is occurred around local place named by *Dirre gujje and Ashewa meda or Tetic flor factory* compared to the other zones. Heavy vehicles were major cause of accidents. Most of accidents occurred during day time. This finding is in agreement with Fekede et al., 2014; Ogendi and Ayisi 2012 that High numbers of nonfatal traffic accidents were registered on straight and little curved road. So, fatal accidents were more likely to occur in curved road than straight road.

Plate 3: Crashing downs of cars due to poor quality of roads in front municipal area.

4.3.4. Slope

The surface of Burayu Town exhibits varied slope characteristics. As shown in figure 9 according to the slope classification criteria set by FAO (2006), of the town's total surface area (102km2), 51.6km^2 (7%) is gently sloping with degree value of (0-12) whereas, 32.1km^2 (31.5%) is fall under steep slope with degree value of (13-30) and the remaining 18.3km^2 (17.9%) of the surface of the town is very steep with degree value of greater than thirty (>30^0).

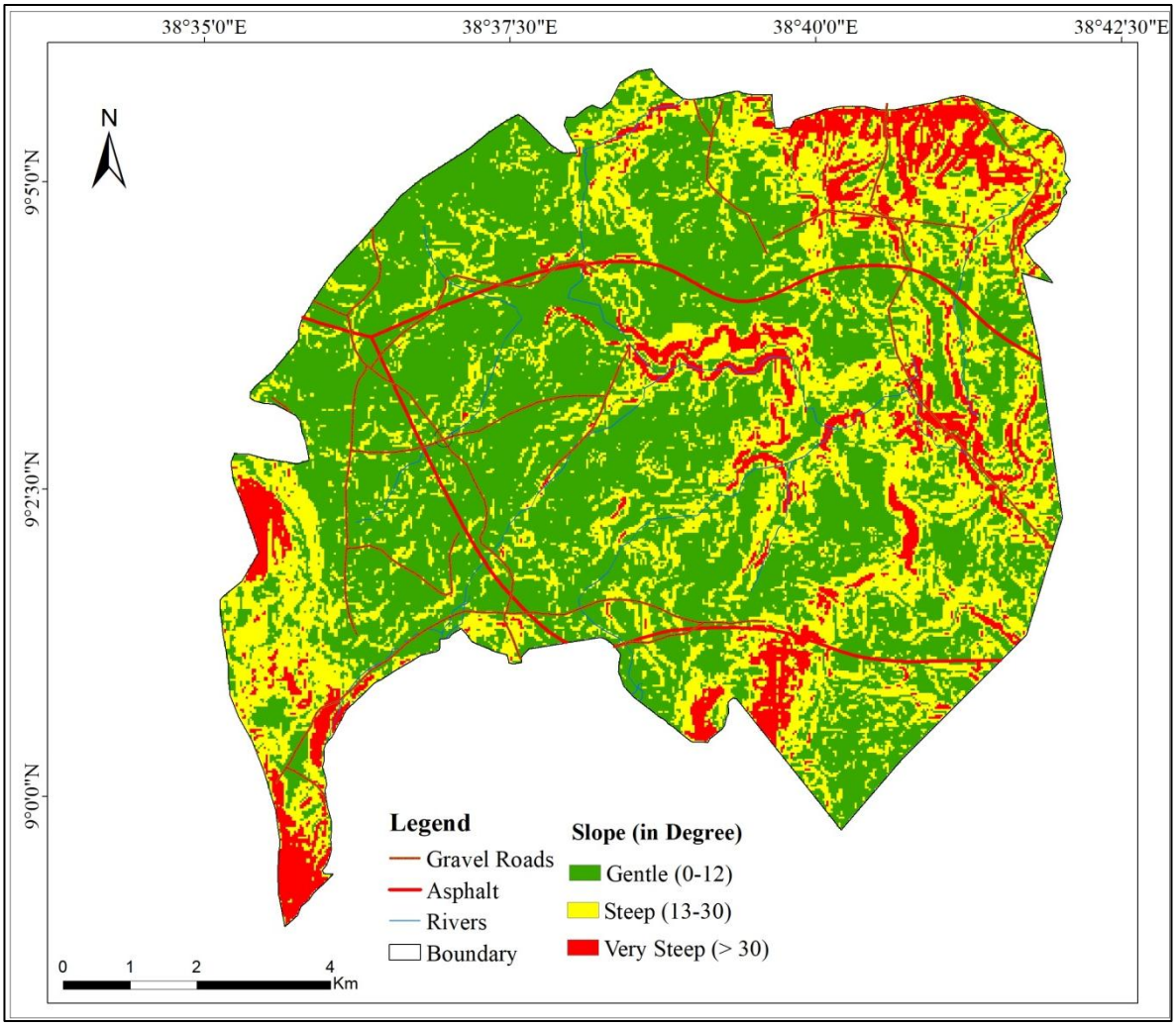


Figure 9: Slope map of Burayu town

Dangerous curves and the roads on the hilly areas have caused many fatal accidents. Many have toppled over due to acute turns in the hilly areas of the study area. Landslides and marsh will cause skidding and the heavy vehicles will topple over.

Plate 4: Curved and steeped slope causing RTA

4.4. Road traffic accidents hotspots areas

Road traffic accidents hotspots are determined by the support of GIS technology. In 2016, the RTAs hotspot site map showed that, the highest frequency was recorded in *Kata Burayu* sub-town which was happening because of high vehicle congestion since most of governmental and nongovernmental institution, schools, and hotels are found in this sub-town (Fig. 10). *Gefersa Guje* and *Kata Burayu* kebele show relatively lower RTAs than Dirre *Gujje*. The highest frequency (5) of RTAs was recorded around *Kella*, Dirre Gujje, Ashewa meda and or Anfo Flor factory mainly due to the existences of pedestrian, vehicle congestion and small size of road width. The geographic location and coordinate information about the traffic accidents may provide more detailed information compared to traditional statistical analysis methods (Yang *et al*., 2013).

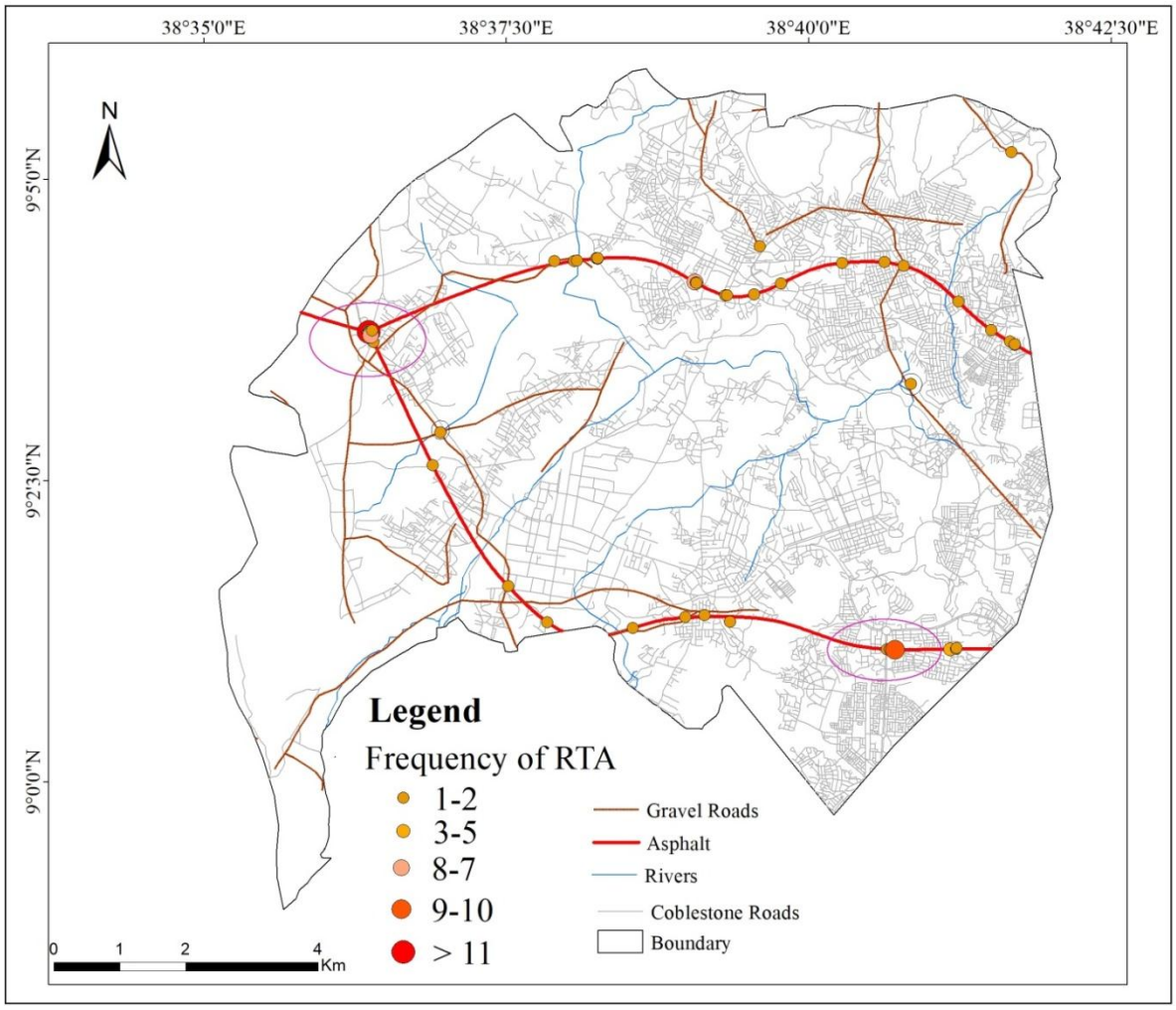


Figure 10: Frequency of RTA

Figure 11 below showed that the road traffic accidents that happened at different place of occurrence which were spatially distributed. Accordingly the business areas accounted the highest and places where exchange of goods and services take place. More of the road side trade also contributed a lot. Next to these, school areas where high-density of the population and not giving attention rather playing on the road side contributed its own for traffic accident. The least road traffic accident reported from residential areas.

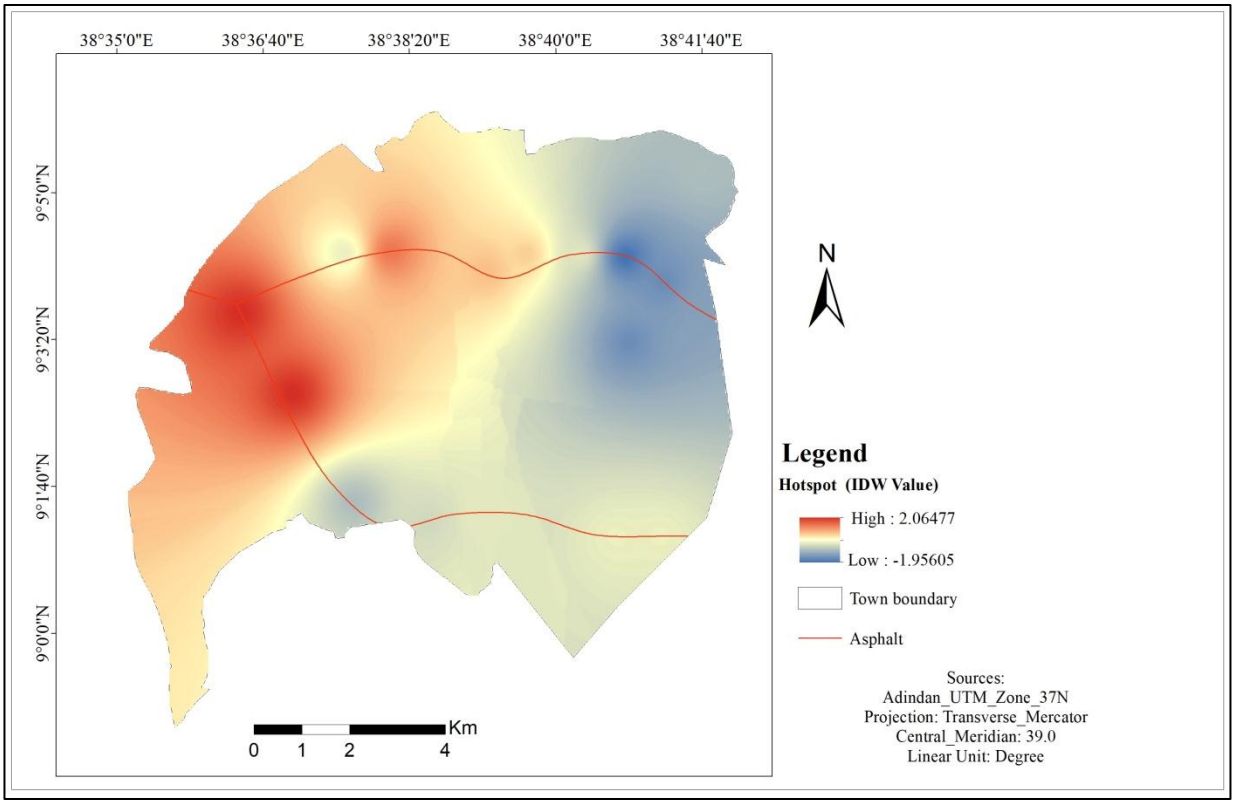


Figure 11: Accident Hotspot

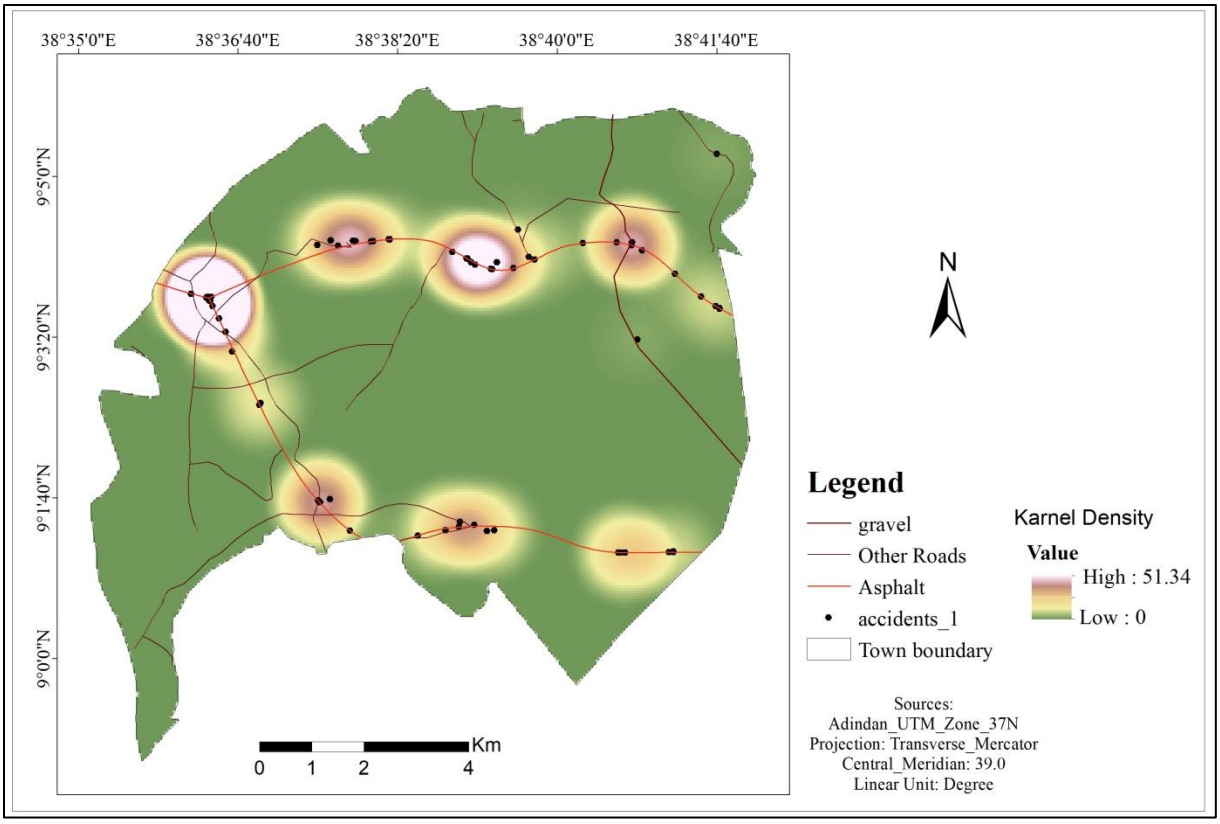


Figure 12: Spatial Distribution of accident hotspots

The Kernel density estimated from the derived hotspots suggests spatial variability in the distribution pattern of accident hotspots and cold-spots in the study area.

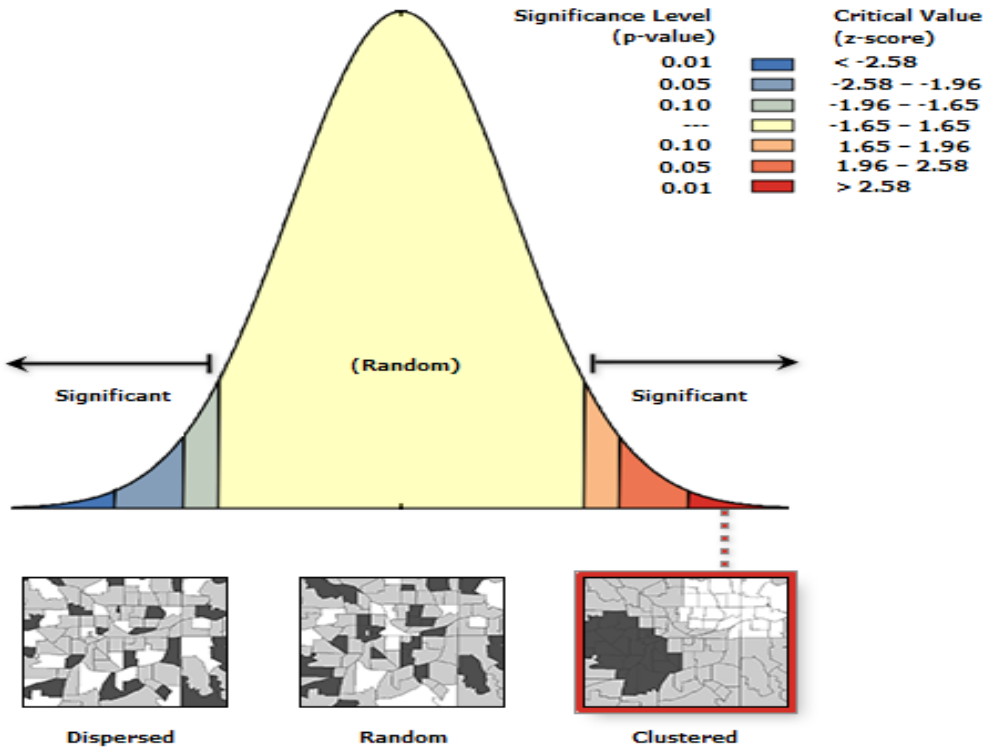
The hotspots and Kernel density surfaces were derived for total accident and incidents near to educational institution and religious places. The hotspots for each classified types of accidents were calculated using the Getis-Ord Gi* function followed by the event calculation. The Getis-Ord Gi* statistics identifies spatial clusters of high values (hot spots) and of low values (cold spots). The output of hotspot analysis tool is GiZScore and GiPValue for each feature. These values represent the statistical significance of the spatial clustering of values, given the conceptualization of spatial relationships and the scale of analysis (Table 6).

Table 6: GiZScore and GiPValue of Hotspot areas

GiZScore	GiPValue
2.065021348	0.03892098
-0.823394588	0.410283647
-0.449202347	0.653285696
2.065021348	0.03892098
-0.156837064	0.875373261
1.366016974	0.171933636
-0.230899011	0.817393259
-0.156837064	0.875373261
-0.156837064	0.875373261
0.661812789	0.508091213
0.493050528	0.621976888
-0.267286027	0.789248945
-1.959361402	0.050070478
-1.5341243	0.124999076
-1.5341243	0.124999076
-1.250826171	0.210997929
-0.823394588	0.410283647

A high GiZScore and small GiPValue (probability) for a feature indicates a spatial clustering of high values where as a low negative GiZScore and small GiPValue indicates a spatial clustering of low values (cook et al., 2001). Based on this standard, it is inferred that statistically significant positive GiZScore (high values) indicates accident hotspots, while statistically significant negative GiZScore (low values) indicates cold-spots (Levine, 2010).

The higher the GiZScore, the more intense is the clustering. A Z score near zero indicates no apparent spatial clustering (Figure 15). The GiZScore for the total accident locations varies between -1.95936 to 2.065021 and the GiPValues from 0.038921 to 0.875373. Based on GiZScore and GiPValue western and southwestern part of the study area particularly the local place named by *Kell* and *Dirre gujje* clearly indicate accident hotspots.



4.5. Socio-economic Impacts of Road Traffic Accidents in Burayu Town

The economic role and responsibility of the age groups in the community could contribute to the fatality of age groups in road crashes in Burayu town in between 2016 and 2020. The RTA incidences of the town have shown an increasing trend in the last five year. At an average, about 65.8 RTAs have occurred every year in the town from 2016 to 2020. The gradual growth in vehicle and human population in the town contributed much to the increasing trend of RTA frequency in Burayu town.

Traffic accidents are one of the most serious problems that destroy people life and properties. This study clearly indicates that the occurrence of RTAs in the study area is increasing from time to time. According to the information obtained from Burayu town traffic police department, among the accidents, 79 resulted in death, 188 caused injuries and 62 accident damaged property

Table 7: Number and type of RTAs in Burayu town from 2016-2020

Year	Fatality			Injure			Property	Sum	%
	Male	Female	Total	Male	Female	Total	-	-	-
2016	7	2	9	17	8	25	6	40	12.2
2017	4	6	10	21	15	36	11	57	17.3
2018	12	9	21	18	11	29	15	65	19.8
2019	9	7	16	29	23	52	12	80	24.3
2020	13	10	23	26	20	46	18	87	26.4
Total	45	34	79	111	77	188	62	329	100

Source: (Burayu town traffic police department, 2020)

Fatalities and injuries resulting from RTAs are major public health problems in Ethiopia. There has been an alarming increase in accidental deaths in Burayu town. Road accidental fatalities have increased from 9 people in 20116 to 23 in 2020. Property costs due to traffic accidents have been a serious issue in Ethiopia.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

Transport system in developing world is a challenging task. This study made an effort to analyze the nature, cause and effects of road traffic accidents.

In this study GIS and Remote Sensing were used as important techniques to adequately evaluate the major possible causes, consequences and the current status of road traffic accidents in Burayu Town. The study reflects that the frequency and occurrence of RTAs in Burayu town shows variations because of the impact of various variables like age and driving experience of drivers, vehicle category, road divide, road pavement, road moisture condition and slope. Road Traffic Accidents are randomly distributed in the town in terms of time and space. The RTA Black Spots exhibit the highest frequency of RTA occurrences in Burayu town.

The GiZScore for the total accident locations varies between -1.95936 to 2.065021 and the GiPValues from 0.038921 to 0.875373. Based on GiZScore and GiPValue western and southwestern part of the study area particularly the local place named by *Kell, Dirre gujje* and Ashewameda or Anfo clearly indicate accident hotspots.

The major possible cause for RTA in Burayu town is mainly attributed to both spatial and non-spatial characteristics, 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.

5.2. Recommendations

Based on the findings of this study, the following are recommended:

- The vehicle to pedestrian crash is the one of the most common type of RTA incidences in Burayu town. Hence, continuous and participatory public campaigns concerning the use of roads should be given to pedestrians. In line with this, additional pedestrian side walkways must be constructed in the side of roads of the city.
- Young drivers with an age from (18-30) are the most vulnerable, which results a total record of 122 accidents (50.6%) within only four years. This is mainly due to the fact that the adolescent's age groups are risk taking behavior and have low driving experience. Therefore, Burayu town traffic police department should give adequate trainings for that vulnerable age group.

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APPENDICES

Appendix I: Questionnaire

Jima University

Questionnaire on Analysis of road transport network and traffic accident in Burayu Town Oromia region

Dear respondent:

I would like to say thank you for your willingness and readiness to participate in this study. My name is JiregnaRoro, I am a Master's degree program students in Geo information system and

Remote sensing in Jima university. Currently I am conducting research on title of road transport network and traffic accident analysis in Burayu Town

The aim of the questionnaire is to gather data that are important to analyze and asses the road transport network and traffic accidents in Burayu Town. The data will be used for the study leading to master's thesis requirement GIS and RS. The information you provide in this questionnaire will be kept confidential and utilized only for the purpose of study. Your genuine response is highly important for the achievement of the objective of this research.

Thank in advance of your cooperation

Name of researcher: JiregnaRoro

e-mailjiegnaroro985@gmail.com, phone No.0923787612

General direction

1, No need of writing name

✓ 2. Put in appropriate box/place of your answer

3. Value:

Part One: Background information/Demographic of data of respondent

✓ **Questionnaire filled by Traffic police department and Burayu Transport Authority Please fill the blank space and tick the rectangle ( )**

1. Gender: Male ☐ Female ☐

2. Age: 18-30 ☐ 30-4 ☐ 40-50 ☐ above 50 ☐

3. Marital status: Single ☐ Married ☐

4. Level of education: 12complete ☐ Diploma ☐ Degree ☐ Master &above ☐

5. Occupation; Government employee ☐ Self employed ☐ Unemployed ☐

6. How long have you been in Burayu Town? 1---2 year ☐ 3----5 ☐ 6----7years ☐

8---10 ☐ above 10 year ☐

7. How do you describe the road network in this Town

Excellent.....V☐ good..... G☐..... Po☐..... ☐

8. Have you faced or observed traffic accident in your journey? Yes..... ☐ No.....☐

9. If your answer is YES how many times?

One time.....☐ Two times.....☐ Three times..... ☐ More than three..... ☐

10. Which type of traffic accidents were highly prevailing in Burayu? You can fill more than once.

Motor vehicle with pedestrian..... ☐ Automobiles with heavy track..... ☐

Motor vehicles with static.....☐ motor vehicle with static object..... ☐

Motors with horse drawn carts.....☐ Horse drawn carts with minibus..... ☐

Bajaj with horse draw carts.....☐. Bajaj with Bajaj……..... ☐

Bajaj with pedestrians..... ☐ Bicycle with bicycle.....

Other (specify)……

12. In your understanding, in which point of time the road traffic accident seem more?

At working day……☐ At week end..... ☐ On pubic holy day..... ☐

13. How do you describe the traffic flow of the town?

Excellent.....Very good..... ☐

Unsatisfactory..... ☐ Good..... ☐

14. Which type of vehicle most of the time make an accident?

Bajaj passenger vehicle---------- ☐ Private car..... ☐

Commercial car..... ☐ Government car..... ☐

15. How frequent do you have sidewalks along road?

Always---------- ☐ Sometimes---------- ☐ Rarely-------- ☐ Never do this-------- ☐

16. Is there traffic sign, symbols, and road marks while you are moving street?

Yes..... ☐ No..... ☐

17. Where the pedestrians do usually cross the main roads?

At traffic light..... At junction..... ☐

At mid-block pedestrians crossing way from junction..... ☐

At any point..... ☐

18. Crossing the main road in Town is: Easy..... ☐ Difficult..... ☐

19. How do you rate drivers give priorities to pedestrians as required by law?

Excellent.....Very good..... ☐

Good..... ☐ Poor..... ..... ☐

Very poor..... ☐

20. How do you rate the road transport authority commitment to their duties?

Very good..... ☐ Good..... ☐

Poor..... ☐ Very poor..... ☐

22. How do you perceived the level of road traffic accidents problem in your town?

A big problem..... ☐ A moderate problem..... ☐ Not a problem..... ☐

23. In your understanding, how do you describe road network of the town?

Excellent.. .....Very ☐ good..... ☐

Good..... ☐ Poor..... ☐

24. In your understanding, which point of hour's traffic accident is more?

6 am to 6 am..... ☐ 6 am to12 am..... ☐

12 pm to 6 pm..... ☐ 6 pm to 12 pm..... ☐

24. Have you ever been stopped a driver for any kind of violation?

Yes..... ☐ No....., ☐

25. What is your involvement to minimize accident severity in your duties?

Excellent.....very ☐ good..... ☐

Good..... ☐ Poor..... ☐

26. How do you rate the traffic police commitment to their duties?

Excellent..... ☐ Very good .....,..... ☐

Good..... ☐ Poor..... ..... ☐

27. Who is your source of knowledge & experience about road safety?

Myself..... ..... ☐ Government..... ☐

NGO..... ☐ Media..... ☐

28. Can derivers give way priorities to pedestrians as required by law

Always .....Som☐..... Neve☐..... ☐

29. If your answer of above question is never can you give counter measure?

Yes..... ☐ No..... ☐

30. How do you perceive the level of road traffic accidents in Burayu ?

A big problem..... ☐ A moderate problem..... ☐ Not a problem..... ☐

31. Does the drivers wear seat belt?

Yes, always..... ☐ Most of the time..... ☐

Some times..... ☐ Never..... ☐

32. As your experience what is the major cause of traffic accident in this town?

Road condition..... ☐ Road users..... ☐

Low priority giving for pedestrians..... ☐ Drug usage of drivers..... ☐

Phone usage of drivers..... ☐ faults of vehicles..... ☐

33. Which vehicles most frequently in accident?

Automobiles..... ☐ Minibus and Bus..... ☐

Pickup and medium truck..... ☐ Truck and above..... ☐

34. When vehicular direction flow, traffic accident is high?

Holeta to Addis Ababa..... ☐ ddis Ababa to Holeta....., ... ☐

35. From cause of accident which is frequently high?

Unethical driving..... ☐ Road network..... ☐

Sleeping problem..... ☐ Technical problem..... ☐

36. From common car crash collisions, which collision is high in this town?

Rear-end..... ☐ Side-impact..... ☐ Sideswipe..... ☐

Head-on..... ☐ Single car..... ☐ Multi-vehicle..... ☐

37. Do you know the term black spot?

Yes..... ☐ No.....☐

38. If your answer of above question is **YES**, please write shortly what you know?

.....
.....
.....
.....39. How do you comment the cause of road safety from the existing different vehicle? Please write either in positive or negative.

.....
.....
.....
.....
..... 40. Write any additional comments you think are important to solve Road safety problem in the town?

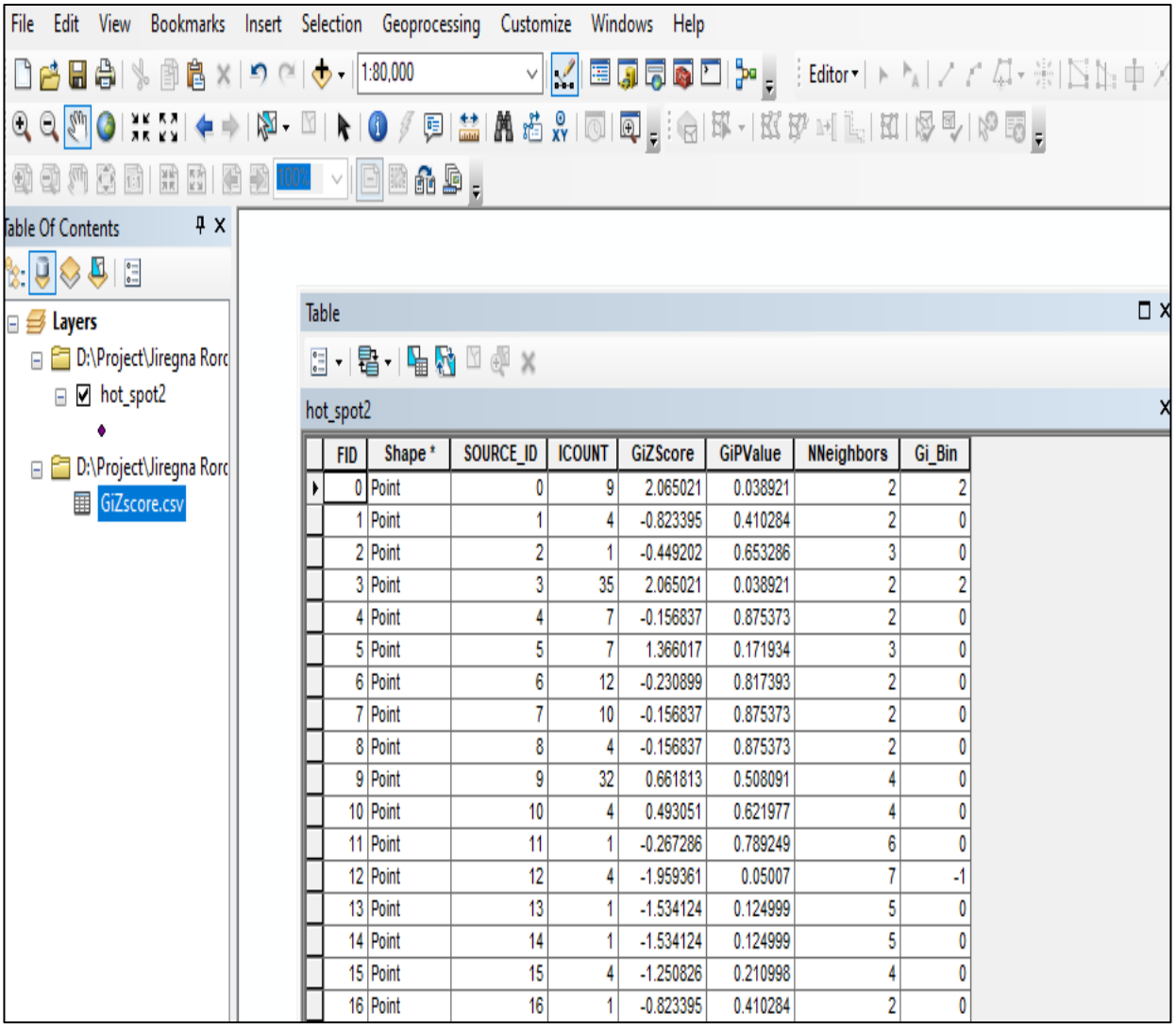
.....
.....
.....
.....
...

Thanks for your Cooperatives!!

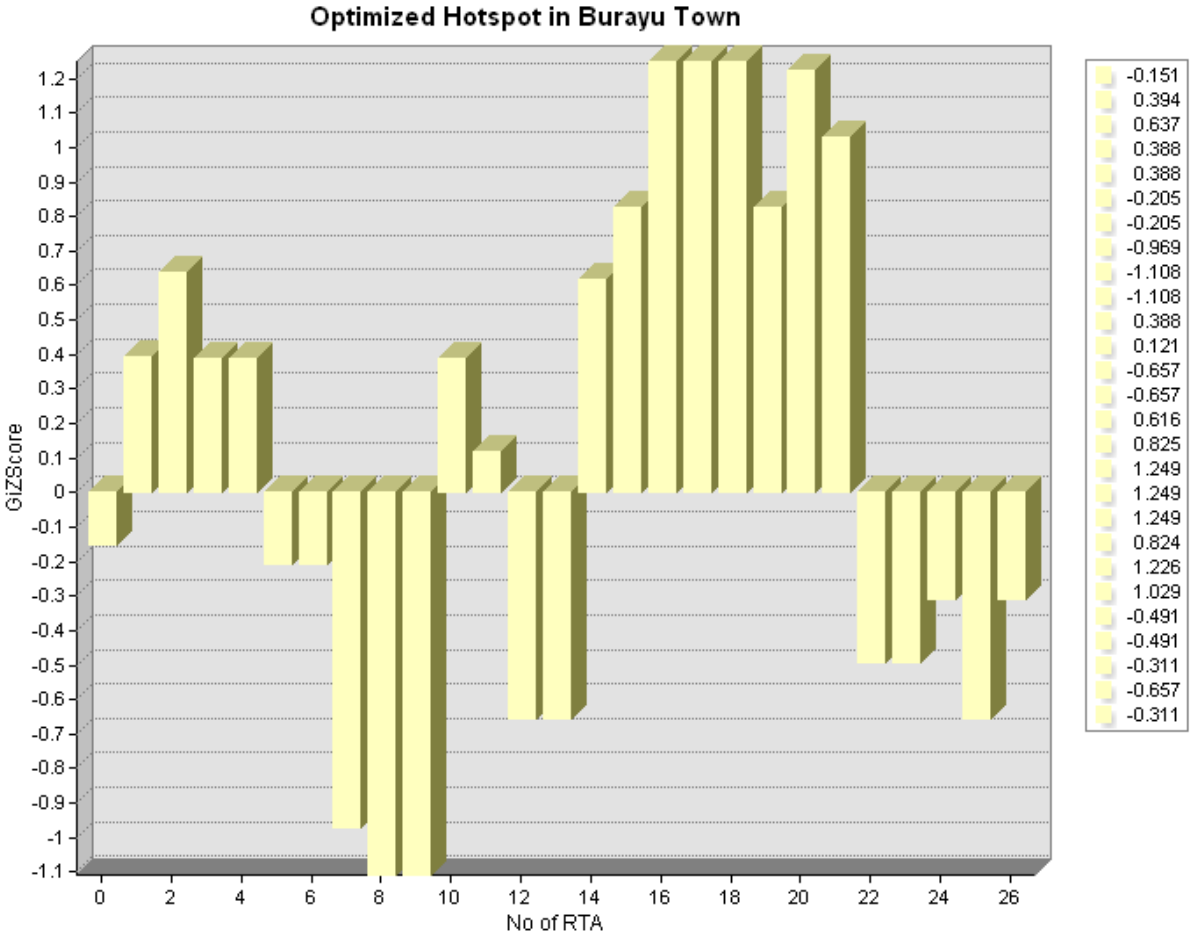
Appendix II: GPS points

X Coordinate	Y Coordinate
457677	999636
458818	997788
459410	997235
460710	997142
461497	997312
456709	1001685
457791	1000140
459521	1002765
459820	1002761
460156	1002803
461793	997341
462178	997242
464550	996819
465604	996823
461658	1002434
462137	1002234
462545	1002250
462627	1002987
462950	1002418
463873	1002730
464517	1002744
464808	1002686
464917	1000885
465635	1002142
466134	1001706
466439	1004433
466491	1001478
456758	1001701
456732	1001696
456663	1001690
456663	1001690
456663	1001690
456713	1001683
456713	1001683
456737	1001625
456737	1001625
456737	1001625
456784	1001525
456711	1001688

459818	1002760
459862	1002768
460177	1002800
460177	1002802
462107	1002238
461669	1002427
461643	1002440
461643	1002440
461643	1002440
466491	1001486
466418	1001528
464594	996817
464678	996814
464678	996814
464678	996814
464678	996814
464678	996814
464678	996814
464678	996814
464678	996814
465608	996836
465517	996821
465517	996821



FID	Shape *	SOURCE_ID	ICOUNT	GiZScore	GiPValue	NNeighbors	Gi_Bin
0	Point	0	9	2.065021	0.038921	2	2
1	Point	1	4	-0.823395	0.410284	2	0
2	Point	2	1	-0.449202	0.653286	3	0
3	Point	3	35	2.065021	0.038921	2	2
4	Point	4	7	-0.156837	0.875373	2	0
5	Point	5	7	1.366017	0.171934	3	0
6	Point	6	12	-0.230899	0.817393	2	0
7	Point	7	10	-0.156837	0.875373	2	0
8	Point	8	4	-0.156837	0.875373	2	0
9	Point	9	32	0.661813	0.508091	4	0
10	Point	10	4	0.493051	0.621977	4	0
11	Point	11	1	-0.267286	0.789249	6	0
12	Point	12	4	-1.959361	0.05007	7	-1
13	Point	13	1	-1.534124	0.124999	5	0
14	Point	14	1	-1.534124	0.124999	5	0
15	Point	15	4	-1.250826	0.210998	4	0
16	Point	16	1	-0.823395	0.410284	2	0


Optimized Hotspot in Burayu Town
GiZScore
No of RTA
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
0
2
4
6
8
10
12
14
16
18
20
22
24
26
-0.151
0.394
0.637
0.388
0.388
-0.205
-0.205
-0.969
-1.108
-1.108
0.388
0.121
-0.657
-0.657
0.616
0.825
1.249
1.249
1.249
0.824
1.226
1.029
-0.491
-0.491
-0.311
-0.657
-0.311