EXPLORATION OF FACTORS THAT INFLUENCE INCIDENCE OF ROAD ACCIDENTS IN KENYA: A SURVEY OF BLACK SPOTS ALONG THE MOMBASA-MALABA ROAD

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Exploration of Factors that Influence Incidence of Road Accidents in Kenya: A Survey of Black Spots along the Mombasa-Malaba Road

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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This thesis has been submitted for examination with our approval as University Supervisors

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DEDICATION

This study is dedicated to my parents, John and Beatrice, my wife Juliana, my children Georgina, Redemta and Arnold, all the victims of Road Traffic Accidents and all the families affected by road accidents.

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ABBREVIATIONS AND ACRONYMS

ASHTO	**-**	America Association of State Highway Transport
AUSVET	**-**	Australian Agriculture and Veterinary Health Sciences
COMESA	**-**	Common Market for Eastern and Southern Africa
DSD	**-**	Decision Sight Distance
FMCSA	-	Federal Motor Carrier Safety Administration
GDP	**-**	Gross Domestic Product
GIS	-	Geographical Information System
GNP	**-**	Gross Net Product
MoRP	**-**	Ministry of Roads and Public Works
NACOSTI	**-**	National Commission for Science, Technology and Innovation
PSD	**-**	Passing Sight Distance
PSV	-	Polished Stone Value
RTAs	**-**	Road Traffic Accidents
RTS	**-**	Road Traffic Systems
SPSS	**-**	Statistical Package for Social Sciences
SSD	-	Stopping Sight Distances
UN	**-**	United Nations
US	**-**	United States
WHO	**-**	World Health Organisation

DEFINITION OF TERMS

Access Management: Is the concept that access-related vehicular manoeuvres and volumes can have serious consequences on the performance of traffic operations and road safety (Houquani *et al*., 2012).

Roadway Cross-section: Includes the width of the travel lane, width and type of the shoulder, and skid resistance of the surface of the travel way

Curvatures: These are bends or curves of roadways which may be horizontal, vertical or transitional.

Decision Sight Distance: This is the sufficient distance on the roadway needed by a driver to sight roadway conditions, an unexpected, or otherwise difficult information source or environment to perceive; and/or recognise potential threats so as to enable him or her select an appropriate speed and lane; and/or make decisive manoeuvres that can enable him or her prevent a crash or accident on the roadway.

Horizontal curvature: Is important because when a vehicle moves in a circular path, it undergoes a centripetal acceleration that acts toward the centre of the curvature (Lee and Mannering, 2002).

Passing Sight Distance: Is a sufficient distance on the road for the driver to sight an on-coming vehicle on undivided road or a two-lane road to enable him/her to overtake the other vehicles on the same lane or travel-way without interfering with oncoming vehicles

Road Accident: It is a rare, random and unexpected event of one moving vehicle hitting another approaching vehicle in the opposite direction or an object or obstacle on the road way resulting in the injuries or fatalities of one or more persons.

Road markings: These are continuous or broken solid lines on road surface which control the access to main highway or indicate overtaking, climbing lanes, bicycle lanes and also used to divide lanes of motorways and also act as medians in dual-carriage or highways.

Shoulder: Is the portion of the roadway continuous with the travel lane that accommodates stopped vehicles, emergency use etc.

Sight distance: Is the length of roadway visible to a driver for him or her to stop, overtakes, and/or makes decisive manoeuvres on the travel-way at a given travelling speed without causing an accident or suffering a road crash.

Stopping Sight Distance: Is a sufficient length of distance on the road necessary for the driver to sight an object or a vehicle ahead to enable him or her control the operations or manoeuvre the vehicle to avoid hitting unexpected object or stalled vehicle on the road at a given travelling speed.

Transitional curves: These are rather straight sections connecting the curves with straight stretches of the roadway.

Verges: These are spaces of the roadway land between the shoulder and the barriers to prevent errant vehicles from crashing on obstacles and enable safe recovery.

Landmark: For the purpose of this study landmark is an object or feature of a landscape or town or building that is easily seen and recognised from a distance, especially one that enables someone to establish their location and also obstructs clear vision to road users.

ABSTRACT

High morbidity, disability, mortality, economic cost and burden arising out of road traffic accidents (RTAs) are a major public concern globally and more specifically to a growing economy like Kenya. The disproportionate 80% of all RTAs with unusually high fatality of 24.1% in developing countries points to a systematic failure in the management of road construction standards and safety performance and measures in Road Transport Systems (RTS). Annually Kenya experiences one of the highest fatality rates in the world at 34.4% that costs the economy 11% of GDP. Additionally, there are over 80 accident prone sections (black spots) on a 788 kilometres highway. This situation raises concern and calls for intervention to minimise the incidence of such accidents. The influence of road geometrical variables on road accidents at these black spots remains unclear at present. The existing road safety information is not based on scientific findings and is therefore subjective and unreliable. The aim of this study was to unravel the causes of road accidents and influence of road design and standards on incidence of road accidents and road safety with the for the purpose of finding a lasting solution to road carnage in Kenya. Descriptive statistics were employed to describe factors that cause occurrence of incidence of RTAs in Kenya Road networks with focus to black spots along Mombasa–Malaba road. The questionnaire as a data collection instrument was employed to give relevant information from respondents because of ease of administration, time saving, upholding of confidentiality between the respondents and the researcher as well as being the best source of primary data. The data collected was checked for errors or omissions, exaggerations and biases, responses and cleared before subjection to appropriate statistical tools of analysis. Data was coded into Statistical Package for Social Sciences (SPSS) and used to analyse descriptive statistics. Descriptive statistics involved use of absolute and relative (percentages) frequencies, measures of central tendency and dispersion (mean and standard deviation respectively). The study found that incidence of fatal road traffic accidents frequently occur in the black spots in Kenya. It was also established that the nature of the incidence of accidents that occur within the black spots, affected the various people such as local community, police and other road users. The study established that road surface conditions greatly influence incidence of road accidents in black spots. In addition, the study established that, to a moderate extent, road conditions, vision, speeding, bad brakes or tyres, and trees along the roads correlated with the factors that influence incidence of traffic road accidents. Primarily, the study concluded that drivers' driving behaviours, personal characteristics and the road surface conditions influence incidence of road traffic accidents in black spots along Mombasa-Malaba road. The study recommended that, stakeholders in the transport and communication sector should establish a well-coordinated and funded road safety research and development programme(s) in Kenya to provide the information needed for necessary decision-making process in road safety measures.This will assist in coming up with essential stop-gap measures and road improvement/rehabilitation to eliminate or reduce incidence of road traffic accidents along black spots in Kenya. The PSV drivers and conductors should be trained on safety rules especially those being introduced to improve on the awareness and use of the related tools and equipment hence improve their knowledge on road safety. The government should implement rules that will govern the conduct of the drivers especially on drunk driving and speeding which have been found to be the main contributors of most of the accidents in Kenya

CHAPTER ONE
INTRODUCTION

1.1 Background to the Problem

Globally Road Traffic Accidents (RTAs) are claiming about 1.2 million lives and nearly 50 million injuries annually (Manyara, 2016) and mortality, morbidity, disabilities and economic costs and burden arising out of them make RTAs a major public health concern that attracted the United Nations' (UN) attention. In Kenya, about three thousand (3,000) people die in road crashes annually (Ogendi *et al*; 2013) majority of whom are between 15-44 years of age; an economically productive group of our population, in spite of the government's road safety measures put in place (Asingo & Mitullah, 2014). In fact, there are about eighty (80) accident prone sections, referred to as black spots, on the key highway of our paved road network (Odera *et al.* 2013).

An estimated million people die annually on the world's roads, with 20–50 million sustaining non-fatal injuries and disabilities occur annually worldwide through road accidents (WHO, 2013). The problem of road accidents apparently has not yet grabbed the attention of governments to marshal the will to arrest situation of these high mortality and morbidity with the attendant economic costs and burden approximating to 1 to 2 percentage of annual Gross Net Product (GNP) in the developing countries (Ogendi *et al.* 2013). Surprisingly, Kenya lost about U.S. dollar 500 million which translated to 11 percent of its GNP in the year 2013, due to road accidents (Manyara, 2016; Muchene, 2013).

Road design has been viewed as one of the main causes of road accident (World Health Organization, 2013). According to data provided by the Federal Motor Carrier Safety Administration (FMCSA), there are generally over 5,000,000 police-reported accidents each year. While these accidents can occur for a wide variety of reasons, each year some of the accidents are the result of improperly maintained or poorly designed roads (Odera et al., 2013). Issues like narrow roads, steep curves, slope of the roads, blind corners, improper illumination, improper traffic junctions (without signals), and lack of speed signboards are found to be the major road design issues

that cause accidents. At some places there are even parking lots on the roadside becoming reasons for road accidents (Mitullah, 2004).

Mombasa-Malaba Highway has at least 80 black spots with Mombasa-Nairobi trunk having 28 black spots which translate to 35 percent (Ruyters, 1994) and other paved road networks also have their share of the problem both in rural and urban locations they traverse (Jacobs 1976; Ruyters *et al* 1994). This disproportionate occurrence of road traffic crashes and fatalities at particular black spots is a major cause of concern in academia, public and Government circles (Ogendi *et al,* 2013; Mitullah, 2004) that needs empirical research data collection and analysis to fix in Kenya and the rest of developing countries (Manyara, 2016; Jacobs, 1976). According to National Transport and Safety Authority (2017) Mombasa-Malaba Highway remains one the riskiest road with highest cases of accidents in Kenya. The report indicated that there were 365 cases of road accidents reported to the authority with Mombasa-Malaba road leading having 45 cases recorded.

1.2 Statement of the Problem

Road safety trends in Kenya seem to be worsening day by day despite the fact that the components of the revised traffic rules popularly known as “Michuki Rules” are very well defined (Manyara, 2016). In most Public Service Vehicles speed governors are fitted but one wonders whether they are really in a working condition due to the fact that in our roads everyone is over speeding if not held up by traffic jam thus being a major cause of accidents (Asingo & Mitullah, 2014).The influence of road design factors on road accidents at black spots remains unclear at present. The existing road safety information is not based on scientific findings and is therefore subjective and not reliable.

High morbidity, disability, mortality and economic costs and burden arising out of road accidents are a major public health concern globally and more specifically to a growing economy as Kenya. The disproportionate 80 percent of all road traffic accidents, with unusually high fatality rate of 24.1 percent in developing countries points to a systematic failure in the management of road construction standards and safety programmes or measures in road transport systems (Odera et al., 2013). The circumstances or “causes” of any one single accident on a roadway are multi-

factorial, involving human, vehicular, environment and road design variables. In relation to the human variables there is a high possibility of accident when one drives in the influence of alcohol because lack of concentration and sometimes sleeping on the steering thus causing accidents (Manyara, 2016).

It is unclear which road geometric variables, separately or in combination, cause accidents at the black spots and/or correlate separately or in combination or interaction with other independent variables to predispose accidents on Kenyan road network. The influence of road design and standards on accidents and road safety therefore needs to be investigated (Odera et al., 2013).Despite the many interventions the government has tried to put in place to avert the road accident menace involving all road service providers ranging from vehicles to motorcycles, news about accidents and by extension motorcycle related accidents dominates the local media houses. The most recent attempt to avert the situation is the introduction of alcohol blow, mobile courts and night travels ban but still motorcycle accidents are on the toll in our roads (Ministry of Transport, 2014). It is for this reason that the current study aimed at exploring the factors that influence the incidence of road accidents in Kenya: views of road users at black spots along the Mombasa-Malaba road.

1.3 Objectives of the Study

1.3.1 General Objective

The main objective of this study was to explore the factors that influence the incidence of road accidents in Kenya

1.3.2 Specific Objectives

The specific objectives are:

i. To describe the incidences of road accidents on Kenyan highways.
ii. To describe factors influence the incidences of road accidents in Kenya?
iii. To investigate the impact of road design on the incidence of road accidents on Kenyan highways.

1.4 Research Questions

From the specific objectives, the following research questions will be answered:

i. What are the incidence of road accidents on Kenyan highways?
ii. What factors influence the incidences of road accidents in Kenya?
iii. What is the impact of road design on the incidence of road accidents on Kenyan highways?

1.5 Research Hypotheses

$H_{o(1)}$ No significant difference between human, vehicular, environmental and road design variables on incidence of accident along black spots on highways in Kenya.

$H_{o(2)}$ No significant relationship between road geometry variables and other independent variables in "causing" road accidents on Kenyan highway.

$H_{o(3)}$ No significant interaction between road design variables and road accidents along accident-prone sections on the road networks.

1.6 Justification and Significance of the Study

Empirical research into road engineering design impact or functionality on the road traffic accidents is both critical and imperative to understanding predisposing variables for unusually high incidence of road crashes along accident-prone-sections and to finding lasting safety measures to road carnage and casualties at the black spots in Kenya and elsewhere in developing countries. The findings were predicated on empirical data on road geometric variables or measurements with the sole object of:

i. Drafting standards of road geometry and recommendations to be used in East African region and COMESA member states.
ii. Formulation of policy and legal framework on road safety strategies and measures for curbing numerous fatalities and morbidity to road crashes

iii. Instituting proper road designs for construction of new roads, widening and maintaining the existing roads in safety-worthy manner
iv. Constructing a novel model to fit accident rates, fatalities and casualties to independent variables predisposition to the black spots in the design execution and maintenance of highways
v. Engendering sufficient and relevant knowledge on risk indicators to incidence of road traffic accidents on the highway or potential black spots
vi. Putting forward sufficient recommendations for prevention of road accidents through planning and evaluating approved road safety measures
vii. Providing a baseline data for future researches of related concerns.

1.7 Scope of the Study

The scope of the study shall be limited to surveying the black spots along Mombasa – Malaba road in relation to incidence of road accidents and variables that influence them. It shall also concern itself with measuring and describing road geometrical variables at various sample units. The study used questionnaire to collect primary data form the respondents targeted. The information collected concentrated only to the objectives of the study as stipulated in previous section (specific objectives). The data collected was quantitative in nature and was analysed using descriptive statistics where it was presented in form of tables and figures while interpretation was done in prose.

1.8 Limitations of the Study

The anticipated limitations of the study were:

i. The incidence of road accidents, their casualties and fatalities were under-reported by police. Possibly police records were at variance with insurance firms' records besides those of other institutions charged with managing or administrating road traffic codes, regulations or standards.

ii. The sections of the road had to be measured which required interrupting the flow of traffic or regulation of traffic by police or road engineers to help the researcher and his research assistants collect the empirical data.

iii. There was paucity in data collection in road design on which the researcher could rely as a control or for comparison purposes.

iv. Some innovations and use of available information technology was integrated into the study such as Geographical Information System (GIS) and census data in sampling of both respondents and highways.

1.9 Outline of the Study

The study is organised into chapters: Chapter one, an introduction, explores the background, problem aim and objectives, hypothesis, assumptions and limitations of the study. Chapter two, a literature review, examines relevant literature of similar works, dependent and independent variables, literature gap and conceptual framework. Chapter three, methodology, clarifies the study, target populations, subjects sampling techniques and sample size calculation, data collection and analysis, variables and statistical tools and models and ethical consideration of the study. Chapter four included the data analysis, presentation and interpretation of findings on the data based on factors that influence the incidence of road accidents in Kenya. Chapter five presented the summary of study findings, conclusion and recommendations of the study.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter reviews relevant literature on studies on road accidents. The review targets the relationship between occurrence of road accidents and road designs.Proper road design is crucial to prevent human errors in traffic and less human errors will result in less accident. Three safety principles have to be applied in a systematic and consistent manner to prevent human errors: prevent unintended use of roads and streets; prevent large discrepancies in speed, direction and mass at moderate and high speed; prevent uncertainty amongst road users, i.e. enhance the predictability of the road's course and people's behaviour on the road. It is to be expected that proper road design, according to these safety principles, could reduce considerably the number of accidents and accident rates

2.2 Road Accidents

Many researchers have tried to find out the causes of traffic road accidents in countries the world over. The research reports compiled on road traffic accidents forms the base of literature on road safety studies. Some of these researches on road accidents are carried out by government agencies, international organisations such as the UN, individual scholars and researchers. This section reviews available information on road traffic accidents as the causes of road safety problems.

Verberckt (1987) suggests that environmental issues do not influence modal choice in passenger transport. He identifies speed, frequency of service, costs, comfort and accessibility to a place as the major determinants of modal choice in passenger transport. He further suggests that railway transport is the most environmentally friendly mode of transport, yet, as long as economic system allows people to freely choose a mode of transport, only a marginal proportion of them will voluntarily use trains in the interest of the environment.

As argued by Verberckt (1987), the modal choice in passenger transport identifies speed as one of the factors in play. Speed has causal effects in road accidents and in fact it is of major concern in road safety programmes of many countries. Manyara

(2013), states that Kenya in recent times experiences one of the highest fatality rates and economic burdens/costs with little emphases placed on the problem of road accidents save half-hearted safety measures that police have challenges enforcing. In fact, road accidents will be third-leading cause of injury deaths world over by 2020, 50-60 percent being young males in the 15 - 44 age groups (UN 2015). There has been paucity in scientific research on the correlation of road geometric elements to road accidents since John Cohen's study carried out in Kenya in 1973 (Ogendi *et al*. 2013).

The cost of road traffic accidents to global economy is enormous, close to US$ 500 billion annually (WHO, 2013) of which US$ 100 billion is lost in developing and transition countries of Eastern Europe (WHO, 2013). Kenya's economic cost is well in excess of US$ 50 million exclusive of actual loss of life which translates to 11 percent of its gross domestic product (GDP) when compared to 1-2 percent of all developing countries (Manyara, 2016). The country loses US$ 4 billion annually in fatalities while the costs of medical treatment and care are shouldered by friends, relatives and family and this put together result in huge burdens to the community and dramatic damaging effects on the families' standards of living and education of the orphans and the affected (Manyara, 2016).

This economic cost and burden can be expressed as (Burden/Cost) B/C ratio (Odero, 2012) and in terms of percentage of GDP annually. The percentage of economic cost of the GDP has exponentially increased from 5 percent of GDP in 1980 to 11 percent of GDP in 2012 (Manyara, 2016) and there is no let-up in the trend in foreseeable future.

2.3 Road Accidents and Safety

Worldwide, road accidents are emerging as a leading cause of deaths, injuries and disabilities (Razzak & Luby, 2008 & Tercero *et al*. 2009) of monumental proportion that has jolted the United Nations to craft UN global plan of action of making roads safer 2011-2020 (UN, 2015). Although the scourge of road accidents seems a curse of developing countries, which the developed worlds of North America and European Union have contained, empirical researches and data on road accidents need to be analysed to awaken the governments of the developing countries to the

nature of this imminent epidemic (Manyara, 2016). The circumstances obtaining in the occurrence of any one single accident on the motor way are multi-factorial event probably involving combinations of other variables besides road engineering design parameters and drivers' competences and behaviours (Odero, 2012).

The road traffic accidents as a parameter has its own measurable dependent variables such as a total number of accidents per thousand vehicle kilometres per year, number of deaths per 100,000 population per year, death per 10,000 vehicle kilometres and as U.S. dollar per annum, or percentage of Gross Domestic Product, Burden-Cost Ratio (Manyara, 2016). Studies elsewhere have related variables of road accidents to independent variables such as human factors (fatigue, drink driving, incompetence, non-adherence to rules and rebellion), road design geometry, environment and vehicles (Ruyters *et al.* 1994).

Notwithstanding that road accidents cannot completely be eliminated or prevented, suitable traffic engineering and management have reduced accident rates in U.S. and Canada by 35 percent and 65 percent respectively (Manyara, 2016). The existing circumstances of road geometric and road condition variables inmost highways or other classes of roads in relation to stipulated international standards obtaining in Europe, Canada or U.S. remains not well understood from empirical researches particularly in developing countries (Ruyters *et al*. 1994).The road traffic accidents are assumed to be "curses" of which blame targets the drivers for incompetence in handling or controlling of vehicle, drink-driving and not heeding traffic rules, regulations and safety measures (Ogendi *et al.* 2013).

2.4 Incidence of Road Accidents

There is a disproportionate prevalence and incidence of accidents between developed and developing countries, along the highways of road networks, times of day, days of the week and in sectors or classes of road users (Ogendi, *et al.* 2013). For instance, 80 percent of all road accidents globally occur in developing countries (Ogendi, *et al* 2013). Incidence or prevalence of road accidents are influenced by vehicular variables or parameters such as volume of traffic, traffic flows and other parameters such as road geometry, road conditions, environment and other physical factors like terrain and weather patterns (Lee & Mannering, 2002). Notably, traffic volume,

traffic flow and population growth have put untold pressures on drivers and other road users beyond the geometric design variables of the road networks in developing countries Kenya inclusive. Elsewhere studies have revealed that incident rate of accidents measured either as total number of accident per kilometre-length of road per 24 hours day or total accidents per kilometre road - per year are lower in developed than developing countries.

In United States and Canada, the incidence of road accidents on the road networks have been reduced by 35 percent and 65 percent respectively through implementation of robust road safety measures (safety belts, campaign against drink driving, speed limits, traffic rules enforcement and highway cameras), including the construction of new highways and expansion of existing roads in accordance with stipulated standards of empirically safer road geometry and conditions (Torregrosa, *et al.,* 2012).

In African region, the average annual fatality rate now stands at 20.1 deaths per 100,000 populations for developing countries and at 24.1 deaths per 100,000 populations compared to 8.7 deaths per 100,000 populations in developed countries (Manyara, 2016). Comparatively, Kenya has one of the highest fatality rates of 34.4 deaths per 100,000 populations in the world (WHO, 2013). Developing countries are known to experience largest mortality and fatality of about 85 percent deaths compared to a paltry 4 percent ascribed to developed world's global rate fatality, annually (Ogendi *et al.* 2013).

The morbidity (injuries and disabilities) due to Road Traffic Accidents (RTAs) is disproportionately higher, 90 percent of the 50 million fatalities, which occur annually worldwide; occur in the developed countries (WHO, 2012). Although morbidity is about ten times the fatality in the preventable road accidents that occur globally (Muchene, 2013), developed nations of North America and Europe have contained incidence of road accidents and by extension morbidity and mortality, through vehicular designs and road geometric designs specifically suited to needs of road users in complete contrast to developing countries such as where vehicles and roads designs are solely tailored to vehicle drivers' instincts or whims (Ogendi *et al.* 2013).

World Health Organisation (WHO) projects that RTAs shall be the third significant cause of injury deaths worldwide by 2020 (WHO, 2013) and has impressed upon UN to embark on Global plan of action for safer road towards that end. The vulnerability of populations or sections of it using public or private transports on road ways varies from one country to another between classes of roads, locality to locality and along sections of the highway (Jacobs, 1976). Evidently, vulnerability tends to be clustered along accident prone sections (black spots) of highways, amongst specific or particular classes of road users on highways or urban centres and to specific times or hours of the day or days of the week (Manyara, 2016) and is attenuated by wet weather conditions, land use and terrain which affect the road geometry and conditions on road networks in Kenya and world over (Ruyters *et al.* 1994).

2.5 Factors that Influence Road Accidents

The factors that influence road accidents are generally referred as causes or determinant variables which are here-in examined. The epitaph that road accidents are "caused" is untrue and unfounded by systematic scientific researches (Manyara, 2016) since they are simply rare and random occurrences or incidence involving a mishap or crashes between one moving vehicle and another object on the road or another vehicle moving in the approaching direction within contributing or predisposing circumstances or parameters where the driver has failed to respond or manoeuvre the vehicle in a controllable manner (Ogendi *et al.* 2013).A study in Tanzania established a host of about 31 supposedly predisposing factors that can be collapsed into four independent parameters, vehicular, human, road geometry, road safety measures, road surfaces and road environment (Bhuyan, 2013). Interestingly, empirical studies on "causes" of road crashes, comprising other parameters in exclusion of road geometric and road conditions, have ended up with non-effective road safety rules, regulations and measures (Dehurry *et al.* 2013). The road design that is, road geometry and conditions, greatly have significant influence or impact on incidence of road accidents, frequencies and severity whose magnitudes are evidently aggravated by intervening variables such as terrain (topography), wet weather, traffic volume, drink driving and speeding on highway (Patnalk, 2013).

The human variables attributable to occurrence of road crash comprises driver's inattention or distraction, fatigue, drink-driving, visibility, speeding and general indiscipline, impairment of judgement and competence of the drivers and other road users (Ogendi *et al.* 2013) besides their knowledge, competence and perception of road networks in their locality (Odero *et al.*2012). However, elsewhere research has shown that over 70 percent of all fatality and serious injuries is attributed to drivers' errors (Ogendi *et al.*2013) which is consistent with 85 percent of crashes as reported by police department, are caused by poor driver's discipline or judgement in Kenya (Manyara, 2016). The driver impairment is a significant variable of road traffic accidents both in developed and in developing countries (Muchene, 2013).

Driver's impairment may be attributed to situations such as being under the influence of alcohol, drug, sleepiness or fatigue and condition of extreme weather, especially wet weather and short hours of day light. In Far East countries, Singapore, Korea and Malaysia, increased illumination and use of head lights by mopeds and cyclists during the day have reduced accidents by 40 percent. Vehicular variables contributing to high incidences, mortality and morbidity in road accident include mechanical failure (failing to brake), flattened tyre treads, bad brakes or tyres, anti-crash devices such as seat belts, air bags, and speed governors (Asingo *et al.* 2014, Manyara 2013 &Ogendi *et al.* 2013), vehicle speed, capacity, and sensors monitoring the driver's performance and behaviour on the road; alcohol-vehicle locks, collapsible steering, secured car doors and wind screens which do not open upon crash (Thomas & Jacobs 1995). These vehicular variables have been successfully used to reduce road crashes in developed countries such as North America and Europe (Artamoshina, 2014).

Furthermore, vehicular designs can be operated on auto mode where variables of road geometry and conditions are interfaced with in-built devices for auto drive with maximum anti-crash sensor–mechanisms (Muchene, 2013) and further interconnected to roadways surveillance cameras to enable enforcement of traffic rules and safety regulations through computerised systems (O'Neill, 2011). Environmental variables include trees, power posts, terrain, weather conditions, wild animals, land use, encroachment on the road reserve, buildings or built-up or residential areas along the road (Jacobs 1976) that may alter visibility sight distance,

driver judgement and traffic flow that may include a road crash or accident on road or highway (Derry, 2011).

The human, vehicle and environmental parameters may interact into a complex matrix of predisposing circumstances or situations within unexpected spatial and temporal dimensions not cogent to the driver's behaviour, pedestrians or cyclists involved in the road (Muchene, 2013). Road geometry and road condition in road design are dictated by soil texture, structures, rock types, terrain and prevailing weather conditions such that a highway or road is never entirely a straight strip of pavement or travel way but a construction land mark with geometric and condition variables.

The contributory or predisposing circumstances in any single road accident can either act/interact individually and/or in combination as independent variable(s) (Manyara, 2016) in correlation with dependent variable in our case the road accident and its variables (Ruyters *et al*. 1994). Elsewhere correlation or multiple regressions between road accident variable(s) and above four independent parameters or their variables have been established in a couple of studies (Lee & Mannering, 2002). Empirical studies carried out in Kenya, Jamaica, Sri Lanka, Malaysia and other countries of developing world in 1972-73 produced data that have been systematically analysed to help draw the road construction and inventory manuals and standards for developing countries of European Union, and Northern America (Ruyters *et al.* 1994)

2.6 Road Designs and Maintenance Standards

Studies elsewhere in developed world have reported that only 30 percent of road traffic accidents are correlated to road geometric variables and 34 percent RTAs to combination of geometric variables with other parameters (ASHTO, 1968) and majority of accidents correlated to driver and vehicle factors (Anne *et al.* 2010). There is paucity of data or publications establishing correlation or interaction between road geometric and road condition variables with road accidents or its variables in Kenya and elsewhere in developing and developed countries (Muchene, 2013).

Odera *et al.* (2012) reported that only 17 percent of road accidents are contributed by human and road environment while 83 percent is contributed by road design, and maintenance standards, vehicular factors (i.e. traffic laws, traffic volume, vehicle design, mechanical performance and speed governors), safety measures among other factors. These findings, taken together, point to road design being a probable inherent variable responsible for high incidence of road crashes and carnage along black spots on the highways (Refer Appendix . All roads and highways are designed, executed and maintained to take into account vehicles, drivers (human) the roadway and environmental parameters that may compromise road safety and induce road crashes. Road geometry has a couple of variables that affect both the traffic speed, flow and road safety of motorway or highway (Derry, 2011). The variables include carriage width in metres, curvatures whether horizontal, transition and vertical measured in degrees, shoulder width and type, road margin or road side features and border lines.

The cross-sectional road geometric elements such as travel way (carriageway), shoulder, medians, verges, borders and pavements have typical or characteristic width dimensions. From empirical research, non-adherence to standards, recommendations, guidelines or codes is known to have serious impacts on the safety of road network or highway on a country's road transport system (Jacobs 1974, Ruyters *et al.* 1994 &Muchene, 2013). However, it is unclear whether road design and standards in developing countries where high incidence of road accidents occur, comply with or have modified these standards. The standards of European Union countries, Canada and United States are acceptable all over the world (Jacobs 1976, & Ruyters *et al.* 1994).

Pavements, travel lanes and shoulder width dimensions are known to range from 6.0 to 12.0 metres, 2.75 to 3.75 metres and 0.6 to 3.75 metres respectively against stipulated standard of 11.5 to 12.0 metres for highway pavements in Europe (Jacobs 1976 & Ruyters *et al.* 1994). Width dimensions of elements have been associated or correlated to high incidence of accidents, their frequency and severity if reduced or modified for whatever reason, during the construction of roads (Lee & Mannering, 2002). Narrow pavements, shoulders, lanes and verges or median have been associated with high incidence of accidents or unsafe roadways (Asingo & Mitullah 2014 & Muchene 2013).

Kenya has approximately 11, 197 kilometres of paved or bituminous roads, which translate to only 7 percent of 160,886 kilometres of road network (Kenya Roads Board, 2013). Globally, standard pavement width ranges from 11.5 to 12.0 metres for multilane highway and 6 – 12 metres for undivided rural roads but shoulder width may range from 0.6 to 3.75 metres. Emergency lanes on highways serve as a shoulder for vehicles to pull off or to stall. Roads with narrow shoulders or without shoulders experience high incidence of RTAs whereas those with narrow pavements or travel ways are associated with high incidence of road crashes and collisions (Thomas & Jacobs 1995, Asingo2004, Muchene 2013).

Horizontal curvatures are mainly on the level terrain of land whose radius influences the incidence of road crashes or accidents. However, horizontal curves of short radii are associated with highest incidences, frequency and severity of RTAs on highways and road networks and those with elevation (Refer to Appendix VII) of less than 2 percent experience more than 3 per cent increase in road crash risks (Thomas & Jacobs 1995 & Mudena, 2011). However, curvatures are associated with low wet skid resistance and reduced sight distances which could be the explanatory variables for high incidence of RTAs on roadways (Refer to Appendix IX) (Roberts *et al.* 2003, Asingo 2004 & Mudena 2011) in spite of them keeping drivers alert. Vertical curves are commonly rampant on sections of road networks or highways that traverse critical topography with hilly terrain. Existence of vertical curves serenely comprises the stopping, decision and passing sight distance of the road increasing the likelihood of road crashes on carriageway besides frequent incidence of heavy trucks or vehicles stalling or slowing down speed (Ruyters *et al.* 1994). Vehicles experience difficulties when climbing vertical curves or steep slopes hence an additional climbing lane for heavy vehicles (Jacobs 1974, Ruyters *et al.* 1994, & Muchene 2013). Transitional curves are associated with high incidence of crash, if the drivers of vehicle engage high speed, due to centrifugal force created by the curved section (Ruyters *et al.* 1995). The effects of road curvatures on skid resistance and sight distance are aggravated by wet weather conditions, speeding and traffic flow (Jacobs 1976, Ruyters *et al.* 1994, Asiyo 2004 & Muchene 2013).

Verges are spaces of the roadway land between the shoulder and the barriers created to prevent errant vehicles from crashing on obstacles and enable safe recovery

(Jacobs 1976). Verges overgrown with shrubs, tall grass and bushes decrease visibility of drivers who look into the distance at junctions, thus increasing chances of road accidents and making the road unsafe (Ruyters *et al.* 1994 & Torregrosa *et al.* 2012). The widths of verges have influence of occurrence on road crashes. Narrow verges experience higher incidence of road crashes.

Proper access management through access junctions, bicycle and cyclist facilities, signage, road markings and pedestrian crossings facilitate traffic flow without delays or impede traffic, reduce visibility and sight distances and conflicts on the road. The access facilities reduce incidence of road crashes, fatalities and delays in travelling. A study in an Indian highway found that, the highest number of road crashes occurred at access junction entries to the highway and steep slopes of the flyovers (Rao *et al.* 2004). However, well-managed access facilities such as bicycle or cyclist lanes and pedestrian crossing reduce vehicle-vehicle or vehicle-pedestrian conflicts on the highway (Muchene 2013, Ogendi *et al.* 2013 & Manyara 2013). However, the doubling of access points from 10 to 20 per kilometre, and of driveways from 20 to 40 per kilometre increase road crash rates by about 30 percent and 30 to 60 percent in existing urban corridors, respectively (Bendale, 2005).

In the towns and cities, traffic on roads are regulated or controlled with traffic lights and signs and/or signals (Ogendi *et al.* 2013). Road signs and sign boards are used as virtual information instructing or guiding the drivers on the decisions and manoeuvres on the section of road ahead. However, the gravel surface and road bumps are included on the highway to draw attention to drivers who have not been keen on road signs and sign boards (Osueke & Okorie, 2012). As a road design variable, signage may be expressed as the number of signboards per kilometre on road (Muchene, 2013). In Kenya, there is no actual number of road signage recommended per kilometre. The signage depends on the nature of road and usage of the road. The lowest recommended speed limit is 10 km/h, and this should only be used in exceptional.

The condition of road surface has important influences or effects on speed, manoeuvres and traffic flow on sections of the road or highway. The road conditions as a variable may be measured and expressed in units of surface friction coefficient, skid resistance and polished stone value (PSV) to quantify the roughness and friction

on the road surface as well as its texture (Ruyters *et al.* 1994). The road micro texture, macro texture, friction and skid resistance are variables of road surface conditions which have significant impact on road safety or its failure that results in road crashes. The skid resistance and surface friction coefficient of road surface increase following the opening of the road for traffic then remain constant and gradually decrease with passage of time with increased incidence or risks of crash on the road (Muchene, 2013). Highest accident rates on the black spots coincide with reduced skid resistance on the section of the road or where there is likely to be change in the speed or direction on the highway (Rao *et al.* 1994). Skid resistance is severely compromised by wet weather, steep slope greater than 8 percent and curvatures on the hilly terrain (Ruyters *et al.* 1994, Jacobs 1976).

Sight distance is the length of roadway visible to a driver (Refer to Appendices IX & X). Road geometric variable of alignment of the highway besides the terrain, weather, and land use has significant influence on the sight distances: Passing Sight Distance, (PSD), Decision Sight Distance (DSD) and Stopping Sight Distance (SSD). The aforesaid sight distances are geometric variables, if maintained prevent drivers from hitting vehicles or obstacles on the roadway, which could be explanatory variables or contributory variables to high incidence of road crashes or accidents on the roads (Thomas & Jacobs 1995 & Muchene, 2013). The vertical, horizontal and transitional curvatures severely reduce the sight distance, as light or illumination from vehicles or object into driver eyesight travels in a straight line (rectilinear property of light), making it impossible for the driver to sight a stalled or an in-coming vehicle on the roadway. These sight distances are expressed in metres of the road length; of which stopping sight distance and passing sight distance are 85 kilometres and 180 kilometres ahead, respectively. Decision sight distance varies from driver to driver, from road alignment to another and importantly dictates the driver's skill and competence in making appropriate judgements and manoeuvres on the highway to avoid incidence of frequent crashes (Chandraratna *et al.* 2006, Muchene 2013 & Manyara 2013). However, the sight distances are severely reduced by alignment of the road, terrain, curvatures, illumination and wet weather conditions. Severity of RTAs is associated with night travels due to reduced visibility and sight distances at night.

2.7 Safety Measures on Road Accidents

Several safety measures and counter measures have been planned and instituted to curb incidence of road carnage, road crashes and to reduce the mortality, morbidity and economic cost and burden (Peter & Roberts, 2009). These safety measures have worked effectively to reduce incidence of road accidents by 35 percent in US and 65 percent in Canada (WHO, 2012). However, they are only specific to obtaining circumstances or situations in one country but cannot be applied to other countries wholesomely (Bhuyan, 2003) as they have failed to bear the intended effects in developing countries (Anne *et al,* 2010). UN Global Plan for the Decade of Action for Road Safety 2011-20 imputes the need to raise the inherent safety and protective quality of road networks for the benefits of all road users at risk of road crashes (WHO, 2015, UN 2015, & Muchene, 2013) through encouraging governments to set targets of eliminating high-risk roads by 2020, developing safe new infrastructure which meets the mobility and access; and identifying hazardous road sections or locations that are accident prone (black spots) or have exclusive numbers of severity of crashes occurring and taking corrective measures (Derry, 2011).

In developed countries, priority have been given to road safety aspects in road planning and maintenance reflects, to some degree, the priority of the donors rather than that of the recipient countries (Ruyters *et al.* 1994) on highways or motorways while the governments in developing world's still waffle with non-empirically obtained solutions to specific road traffic problems (Muchene, 2013). RTAs or injuries and fatalities have been addressed from vehicular and road geometric designs that cater for the human limitations and challenges on the traffic flow on the road networks. Vehicles with drivers' biometric data and sensors monitoring their behaviours on the road are designed with safety controlling or regulating mechanisms to eliminate human errors, drink-driving and fatal crashes (Bendan 2005, Ogendi *et al.* 2013 & Chandraratna *et al.* 2006). The impact of safety measures heartedly put in place need to be assessed and revamped by research based findings specifically suited to the road geometric designs and road condition designs on the black spots in the Kenyan roadways (Asingo & Mitullah, 2014)

The object of road safety engineering is essentially to reduce the frequency and severity of road crashes (Hassan & Aty, 2012) by application of road traffic engineering principles, sound analysis of empirical data, coupled with understanding of road-user behaviours and cost-effective ways of reducing economic burden/cost of road crashes casualties and fatalities on road networks (Elvok, 2015). All these are achievable at stages of planning, designing execution and maintenance of new roads and developments of safety improvements for existing roads (Hassan & Aty, 2012). Developed worlds of North America and European Union have successfully reduced road accidents through implementation of principles of road safety and standards of road construction and inventory manuals founded on scientific research and analysis on road accidents and road parameters (Jacobs, 1976). Safety measures or programmes were empirically predicated on three components and/or parameters, driver's behaviour, vehicular and road way-geometry and/or its environment, in combination, all acting as "cause" of road accidents (Chandraratna, 2006). Vehicular and human variables have been predominantly taken into consideration in the design of safety measures with the limitations and possibilities of human capacity in mind (De Boni *et al.* 2010).

2.8 Theoretical Framework for Road Traffic Accidents

In theories of accident causation there are several major theories each of which has some explanatory and in predictive values understanding the causal factors of road traffic accidents (RTAs). The initial theories of accident causations were developed by Heinrich (1932) a safety engineer and pioneer in the field of Industrial accident safety are the domino theory and the human factors theory.

2.8.1 The Domino Theory

The domino theory of accident causation was one of the earliest developed by Heinrich (1932). The theory posits that injuries result from a series of factors, one an accident of which is an accident. According to Heinrich's domino theory, an accident is one factor in a sequence that may lead to an injury. In the scientific approach of this theory there are five factors in the sequence of events leading to an accident; the

mistakes in social environment, the faults/carelessness of a person, unsafe acts/performance, mechanical or physical hazard, the accident and the injury. The critical issue of Heinrich's domino theory is that, the factors preceding the accident and mostly the unsafe act or the physical hazard should receive the most attention and those responsible be concerned with the proximate causes of all accidents.

The emphasis here is that accidents and not injuries or property damage be the points of concern in accident situations. The scientific views of the domino theory as postulated by Heinrich have some relevance in this study of road traffic accidents on the accident black spots. The domino theory factors on the sequence of events leading to accidents applicable in this study includes; the mistakes in social environment in form of road side activities affecting motor flows, the faults/carelessness of persons in form of poor pedestrian road usage, unsafe acts/performances in forms of driver over speeding, accidents occurrences due to pedestrian-motor conflicts and injuries occurring from those accidents. This study applies these views in analysing the causal effects of RTAs.

2.8.2 The Human Factors Theory

Heinrich posed this model in terms of a single domino leading to an accident. The human factors theory premise is that human errors cause accidents. The structure of human factors theory is a cause/effect format one. This theory of accident causation attributes accidents to a chain of events ultimately caused by human error. It consists of three broad factors that lead to human errors categorised as overload, inappropriate worker responses, and inappropriate activities. In overload the work is deemed to be beyond the capability of the worker on physical/psychological factors. There is the influence by environmental factors, internal factors and situational factors. In the case of inappropriate worker responses, there are hazards, safety measures/workers faults and compatibility of workstations that are deemed to cause accidents. On the case of inappropriate activities there is lack of training and misjudgement of risks as the causal effects of accidents. In summary, the aspects human factors theory by Heinrich attributes accidents to human errors. These human errors are influenced by capability of the workers (driver/law enforcers), the environmental conditions (roads infrastructure/road pedestrian facilities), hazards

(lack of safety measures/facilities), lack of training/misjudgement of risks (driver over speeding and road safety unawareness). These views in the human factors theory are relevant and are applied in this study.

2.8.3 The Accident/Incident Theory

The accident/incident theory of accident causation is an extension of the human factors theory. It introduces such new elements as ergonomic traps which are the compatible workstations, tools or expectations. It also includes the decision to err which is the conscious/unconscious (personal failure) and the systems failures (management failure). These aspects of accident/incident theory on personal failures and systems failures as the causal effects of traffic accidents are very relevant in this study. The decision of vehicle drivers to err and over speed with no regard to set rules and regulations on speeding, these are personal failures which this theory addresses in accident causation. When traffic law enforcers fail to strictly enforce the traffic rules and regulations, these are system/management failures alluded to in this theory. This theory was helpful in this study.

2.9 Research Gap

In undertaking a study of so complex a phenomenon as occurrence of road traffic accidents, it is seldom that the "cause" of RTAs is very simple but more often than not a combination of circumstances playing function, in which human, vehicle and road, are important as independent variables (Jacob, 1976)

In any country, the key to safer road traffic lies in the design of proper road geometry conditions in accordance with traffic volumes, flows and structures, standards and principles of safety (Roberts 2004, Jacobs, 1976 & Ruyters, 1994). Through construction of ultra-modern highways of proper road design, developed countries of Canada, USA and Europe have observed considerable reduction in the number of accident rates and economic burden compared with developing countries especially Kenya (Jacob, 1976; & Ruyters, 1974).

The disproportionate 80 percent of all road traffic accidents, with unusually high fatality rate of 24.1 percent in developing countries (Jacobs, 1976 & Ruyters *et al.*

1994), points to a systematic failure in the management of road construction standards and safety programmes or measures in road transport systems. Annually, Kenya experiences one of the highest accidents rates in world, which bring economic costs of 11 percent of GDP exclusive of fatalities (Manyara, 2016). Additionally, there are over 80 accident prone sections (black spots) on a 788-kilometre highway which is exactly 50 percent of all black spots mapped in the whole republic of Kenya (Chitere & Kibua, 2012). This scenario raises eyebrows and call for a change to minimise the damage and losses.

The influence of road geometrical variables on road accidents at black spots remains unclear at present. The existing road safety information is not based on scientific findings (Ruyters *et al*. 1994) and is therefore subjective and not reliable. Kenya's high fatality rates are 34.4 percent due to road accidents and 4 deaths per 100,000 population could be due to lack of proper road design standards or inability to always apply them in the planning, execution and maintenance of road construction works. It is unclear which road geometric variables, separately or in combination, cause accidents at the black spots and/or correlate separately or in combination or interaction with other independent variables to predispose accidents on Kenyan road network.

However, if the multi-functionality of the relationship of road accident is taken into account (Haddon, 1971, Jacob, 1976 & Odero *et al.* 2012), correlation, multiple regression analysis and/or logistic regression analysis could be employed to establish and quantify the relationship between one dependant variable of road accidents and one or more independent variables of road design elements and/or other parameters as cogent statistical tools or techniques (Muchene, 2012, Jacobs, 1976 & Ruyters, *et al*. 1994). The relationships could then be expressed in simple mathematical representations or equations as:

(a) (i) For simple correlation $y = f(x)$

(ii) $y = f(x_1 + x_2 + x_3 + x_4)$ for multiple regression

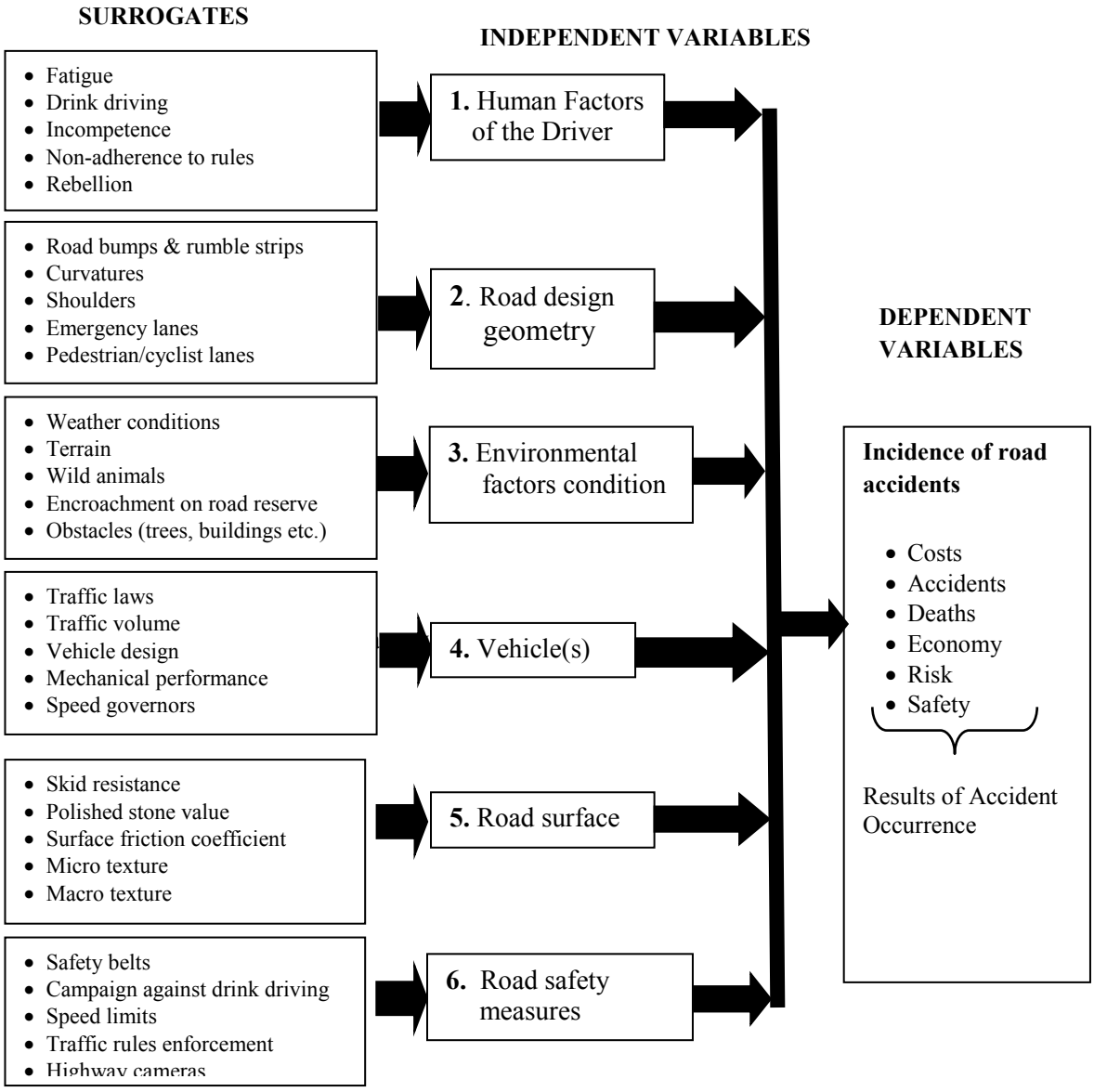
(b) $y = f\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix}$ for logistic regression, where y is a probability or dichotomous variable

Where, x_1, x_2, x_3, and x_4 are independent variables and the "y" being the dependent variable. In the entire equations, "y" is a function (f) of independent variables of the road accidents along either the black spots or the entire road network in Kenya.

Studies elsewhere have reported lack of "hard" evidence about the relationship between road designs and road accidents or road safety (Khayesi, 2010) partly because these findings were compounded or obscured by a variety of variables such as driver, vehicle, traffic flow, regulations and risk increasing circumstances and/or the relationship between road safety or its failure and road features were not understood quantitatively (Jacobs, 1976, & Ruyters, *et al.* 1994) for lack of appropriate statistical analysis techniques. However, no studies have reported existence of causality between the above independent variables and incidence of RTAs so far in Kenya. The word "cause" is but misnomer referring to predisposing or contributory parameters or variables. Essentially, such contributory parameters of construction must be operationalized into specific variables, measurable in quantitative units whose relations with road accidents may be established by statistical tests, or tools of analysis.

2.10 Conceptual Framework

The study's conceptual framework is predicated on six independent variables indicated in the literature above that cause RTAs. The human, road, environmental and vehicular constructs are predisposing parameters to be operationalized into explanatory variables and related to the accident variables in the research.



2.1 Conceptual framework

Source: Researcher own concept (2015)

CHAPTER THREE
RESEARCH RSEARCH AND METHODOLOGY

3.1 Introduction

This chapter outlines the research design and methodology applied in the study. The chapter discusses research design, sample design, data collection, processing and analysis. It further addresses the reliability and validity of the research instruments; and ethical considerations pertaining to the study

3.2 Research Design

A descriptive survey design was adopted in this study. This method of research was preferred because the researcher is able to collect data to answer questions concerning the status of the subject of study. Descriptive survey research determines and reports the way things are and also helps a researcher to describe a phenomenon in terms of attitude, values and characteristics (Mugenda & Mugenda, 1999). According to Orodho (2003), descriptive survey is a method of collecting information by interviewing or administering a questionnaire to a sample of individuals.

3.3 Study Location and Area

The study was carried out around accidental prone sections (black spots) along the Great North Road on the Kenya-portion that spears northward towards Cairo through vast terrain of bush, hilly slopes, valleys and swampland in a warm Tropical-Equatorial climate of East Africa.

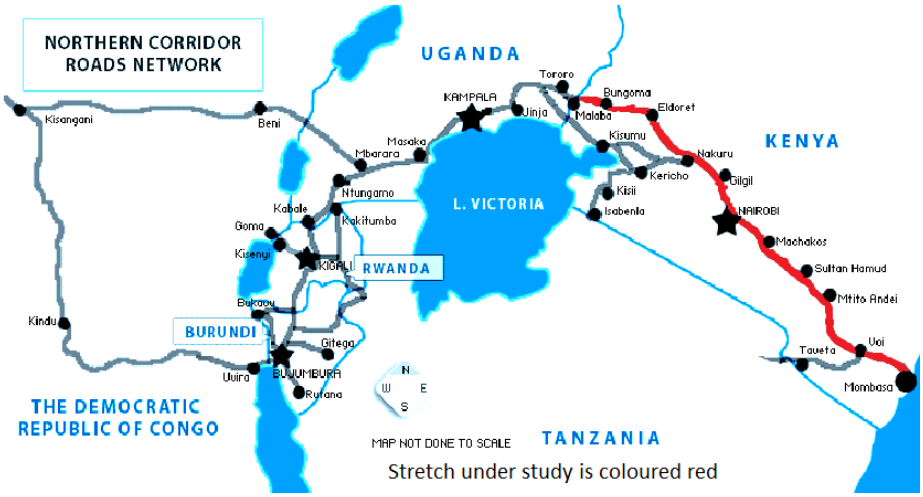


Figure 3.2 Study Location and Area

Source: Kenya Roads Board (2016)

3.4 Population

The population contains both the unit of analysis and the unit of observation. The unit of analysis was the black spots along Mombasa/Malaba road and the unit of, observation was the police officers, pedestrian, neighbour and driver. The study population consisted of 80 black spots (according to data by road safety department) in areas along Mombasa-Malaba road (Refer to Appendix IV) and the police officers, pedestrian, neighbour and driver. Road users whose responses to the structured questionnaire in relation to road design variables and accident variables were sought and compared with actual measures and observations of the research team.

3.5 Sampling Techniques

Random sampling of sections of Mombasa/Malaba road, which are accident-prone (black spots), and which are mostly used for public transport was carried out. The sampling of the study population and road sections was done to measure the state of affairs of existing variables in the field without an experimenter bias or manipulation of data or responses.

3.5.1 Sampling Frame

A sampling frame was drawn from the list of 80 black spots on Mombasa/Malaba Highway, from the police reports or listing and compared with drivers' knowledge of the black spots from the drivers plying aforesaid roads. Simple random sampling technique was used to select black spots from the sampling frames prepared using Geographical Information System (GIS) and a mobile vehicle.

3.5.2 Sample Size

Sampling design is that part of statistical practice concerned with the selection of a subset of individual observations within a population of individuals intended to yield some knowledge about the population of concern, especially for the purposes of making predictions based on statistical inference (Cooper & Schindler, 2003).

From 80 black spots along Mombasa-Malaba road, the researcher used simple random sampling technique to select 8 black spots along the road under this study. According to Mugenda and Mugenda (2003) a sample of 10-40 percentages is adequate for a study. Out of 80 black spots, the study sampled 8black spots, which represents 10%. From the 8 black spots, the study employed simple random sampling techniques to select2police officer, 6 pedestrians, 3 neighbours and 5 drivers [(PSV), private service vehicle, long distance drivers, motorists and cyclists] in each black spot totalling 128 respondents. This method of sampling was used in this study since it yields a sample that is representative of the group being studied. Sampling units were selected through random sampling technique that the opportunity of every sampling unit will be included in the sample (Karla, Alan, Girling, Marsh, Richard & Lilford, 2011). The sampling segment was selected since pedestrians and drivers are the users of the road while the police are the enforcers of the laws in the road, hence have critical information that they can share for the purpose of this study to identify factors that influence incidence of road accidents in Kenya.

3.6 Data Collection

The study collected primary data using the questionnaire. The study research assistants helped to collect accident primary data from the respondents along the

Mombasa-Malaba road and using a checklist, observed the road design variables on the sample sections. Primary data was collected to show the actual situation in the ground on the incidences of road accidents.

The questionnaire as a data collection instrument was employed to give relevant information from respondents because of ease of administration, time saving, upholding of confidentiality between the respondents and the researcher as well as being the best source of primary data (Orodho, 2009).

Both closed and open-ended questions were prepared for data collection. Closed questions were expected to offer uniformity to respondents in answering the questions while open-ended questions accorded objectivity and freedom to respond to question without personal indulgence or biasness (Copper & Schindler 2011).

3.6.1 Reliability

Reliability refers to a measure of the degree to which research instruments yield consistent results or measurements of variables (Mugenda & Mugenda, 2003). A pilot or pre-test study was conducted where randomly selected respondents were exposed to the tools, questionnaires and interviews beside empirical measurements of geometric variables on sampled sections of the road. The data obtained was subjected to rigorous analysis to ensure research objectives were successfully tested, firm and accurate, correct and meaningful data. The questionnaire and interview checklist were pretested through a pilot study (Sushil & Verma 2010). The research instruments are accepted as reliable when Cronbach's alpha coefficient (α) for determining reliability is 0.8 or higher.

3.6.2 Validity

Validity is the degree to which results obtained from the analysis of data actually represent the phenomenon under study in the general population from a representative sample (Robinson, 2002 & Kyale 2009). The researcher ensured that validity was achieved by inclusion of objective questions and content in the questionnaire and other instruments and the supervisors' or principal investigators' involvement and guidance. The research assistants and key informants evaluated the pilot study responses to questionnaire, discussed and reviewed the instruments of

study to ensure the questions and content addressed the research objectives and hypotheses through clear responses from the intended respondents to remove ambiguity (Copper & Schindler 2011).

3.6.3 Variables in Study

Variables in this study were dependent and independent variables whose indicators or surrogates were used to measure them where may be could not be directly measured.

a) Dependent Variables

The incidence of road accidents as a phenomenon has its own dependent variables namely;

i.	Accidents rate	Y_1
ii.	Fatality rate	Y_2
iii.	Morbidity rate	Y_3
iv.	Economic costs	Y_4
v.	Risks	Y_5
vi.	Road safety	Y_6

b) Independent Variables

The independent (explanatory) variables for the incidence of road accidents and safety shall be the following:

i.	Human factor	X_1
ii.	Vehicular factor	X_2
iii.	Environmental factor	X_3
iv.	Road surface conditions	X_4
v.	Road design geometry	X_5
vi.	Road safety measures	X_6

c) Conceptual and Operational Definitions

This study summarised the variables into a table of conceptual and operational definitions. A conceptual definition accords a variable a constitutive meaning from

one concept to another while an operational definition defines or assigned clear and quantifiable meaning of what the variable is and how to measure it. A Likert scale, of 1 to 5, was used to quantify the variables in the questionnaire or interview checklist where a continuous scale of the measurements is not objectively attainable.

3.7 Data Analysis

On receipt of the completed questionnaires, the data collected was checked for errors or omissions, exaggerations and biases, responses and cleared before subjection to appropriate statistical tools of analysis. Data was coded into Statistical Package for Social Sciences (SPSS) was used in data analysis using descriptive statistics. Descriptive statistics involved use of absolute and relative (percentages) frequencies, measures of central tendency and dispersion (mean and standard deviation respectively).

Initially the data was verified, coded and entered in SPSS, before being subjected to analysis. Inconsistencies, anomalies, missing data and outliers was cleaned using SPSS syntax test potential irrelevant summaries were produced. Results for each item were based on the number of cases which had valid data for the item in question.

Quantitative data was presented in tables, charts and graphs to illustrate the relationship between variables. Descriptive statistics was used to complement inferential or parametric tests in demonstrating patterns, frequency and severity of accidents on Kenyan highways.

3.8 Study Ethics

The researcher and the research assistants conformed to ethical considerations, codes and regulations in view of sensitivity of legal implications and therefore treated all information and relevant data obtained from the study with uttermost confidentiality. The respondents were briefed on the study aims and/or objectives and allowed to make informed consent to participate and their responses be used in the study. There was no data manipulation, speculation or bias by the researcher and his assistants of any sort. The research assistants assured the respondents that the research was purely

for academic purpose and the final report maybe availed to them upon request. This was so because the researcher did not favour any respondents in any way since the study was voluntary. The research assistants and/or respondents signed a declaration of consent and confidentiality on information and secondary data they may come across in the course of the research. The respondent victims of the road accidents was debriefed and counselled before accepting to participate in the research and no respondent was coerced or forced to sign a declaration or consent form or to participate in the research. The study was conducted within two months from (September to November 2017).

CHAPTER FOUR
DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents data analysis, presentation and interpretation of findings on the data based on factors that influence the incidence of road accidents in Kenya. The study sampled 128 respondents residing within Mombasa-Malaba road. The data was interpreted as per the research questions.

4.1.1 Response Rate

One hundred and twenty eight (128) questionnaires were distributed to the respondents, out of which 120 were completed and returned. This gave a response rate of 94percent. According to Mugenda and Mugenda (2003) a response rate of 50 percent is adequate for a study; 60 percent is good and 70 percent and above is excellent. Thus, a response rate of 94percent was fit and reliable for the study as shown in Table 4.1 and figure 4.1.

Table 4.1Response Rate

Details on Respondents	Frequency	Percent (%)
Respondents	120	94
Non-respondents	8	6
Total	**128**	**100**

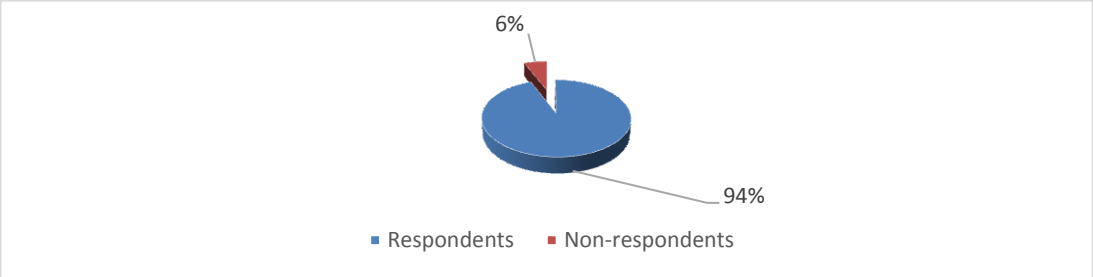


Figure 4.1Rate of Response

Source: Field Data (2018)

4.2 Demographic Information

4.2.1 General Information

The researcher considers the background information to be very meaningful because of the role it plays in enabling the understanding of the logic of the responses issued by respondents.

4.2.2 Category of the Respondents

The respondents were requested to indicate the category they are in. The findings are shown in figure 4.2

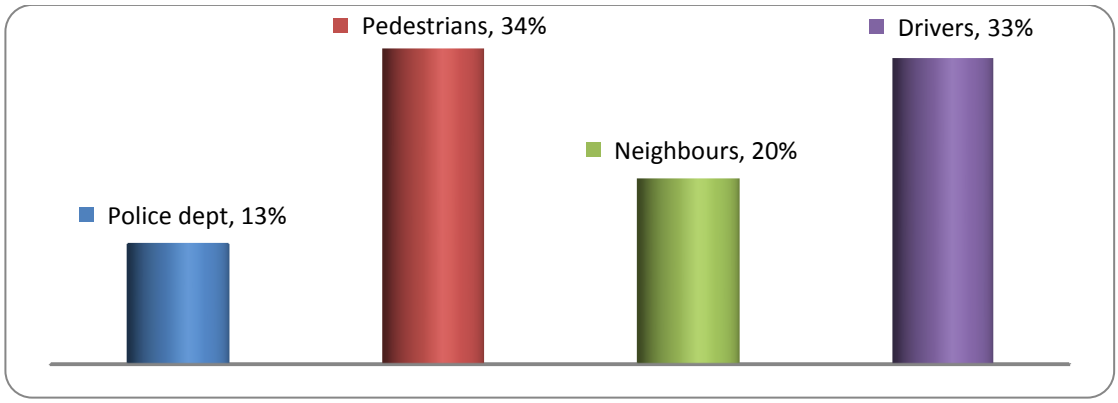


Figure 4.2 Category of the Respondent

Source: Field Data (2018)

From the findings 34 percent of the respondents indicated they were pedestrians, 33 percent indicated they were drivers, 20 percent indicated they were neighbours while 13 percent indicated they were from police department. This depicts that majority of the respondents were pedestrians as shown in figure 4.2.

4.2.3 Type of Vehicle Operated by Respondents

Respondents who were drivers were requested to indicate the type of vehicle they operated. The findings are shown in figure 4.3.

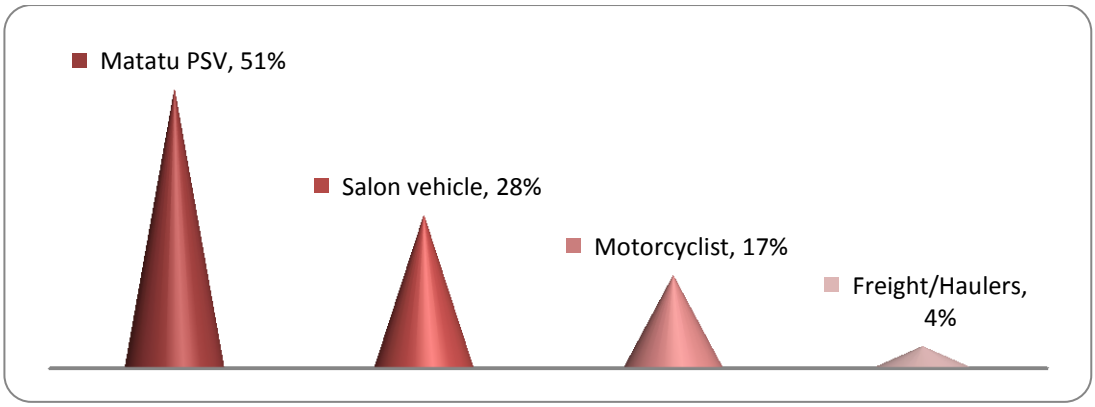


Figure 4.3 Type of Vehicle Operated by Respondents

Source: Field Data (2018)

From the findings 51 percent of the respondents indicated they were operating PSV (*matatu*), 28 percent indicated that they operated saloon vehicle, 17 percent indicated that they were motorcyclist while 4 percent operated freight/haulers. This shows that a large number of the respondents operated PSV (*matatu*).

4.2.4 Duration of Working/Using/Living along the Road

The respondents were requested to indicate the length of time they have been working, using or staying along this road. The findings of this study are shown in figure 4.4.

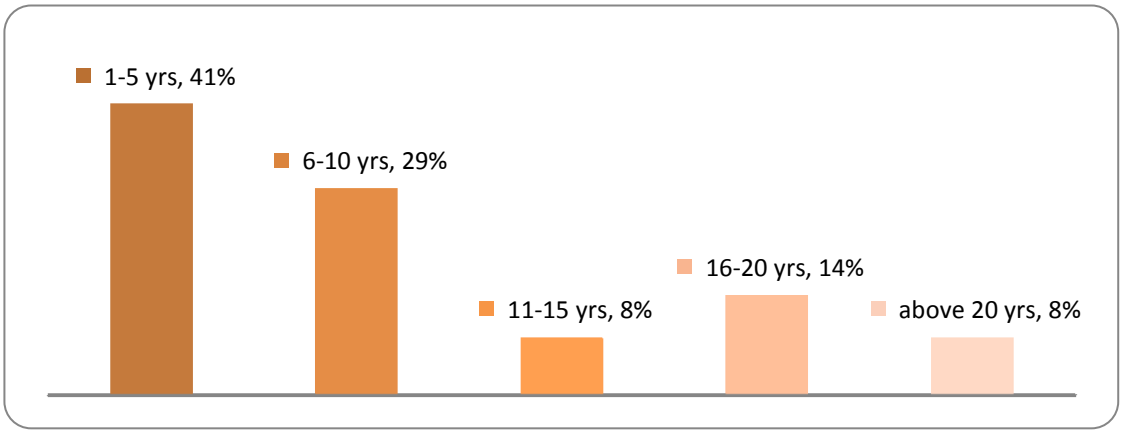


Figure 4.4 Duration of Working/Using/Staying around the Black Spots

Source: Field Data (2018)

4.3 Incidence of Road Accidents in Sampled Black Spots

From the findings, 41 percent of the respondents indicated that they worked, used or lived around black spot area for a period ranging from 1-5 years; 29 percent indicated 6-10 years, and 14 percent indicated 16-20 years, while 8 percent indicated 11-15 years and above 20 years respectively. This implies that majority of the respondents worked, used or lived near the vicinity of the black spot for a period ranging between 1-5 years, this being an indication that they were conversant with occurrences within the areas of study.

4.3.1 Frequency of Road Accident Incidences

The respondents were requested to indicate how frequent the incidences of road accidents occur in this region. The findings of this study are shown in figure 4.5.

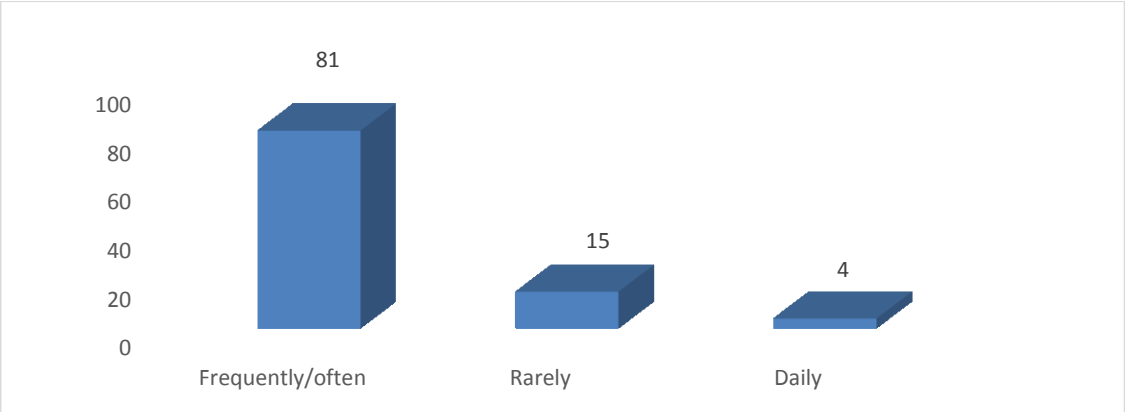


Figure 4.5 Frequency of road accident incidences

Source: Field Data (2018)

From the findings 81percent of the respondents indicated the incidence of road accidents occur in this region frequent or often, 15% indicated rarely, while 4 percent indicated daily. This depicts that incidence of road accidents occur in this region often. This agrees with a study by Manyara, (2013) that vulnerability of accidents tends to be clustered along accident-prone sections (black spots) of highways, amongst specific or particular classes of road users on highways or urban centres and to specific times or hours of the day or days of the week

4.3.2 Nature of the Incidence of Accidents

The respondents were requested to indicate the extent/nature of the incidence of accidents. The finding of this study is shown in figure 4.6.

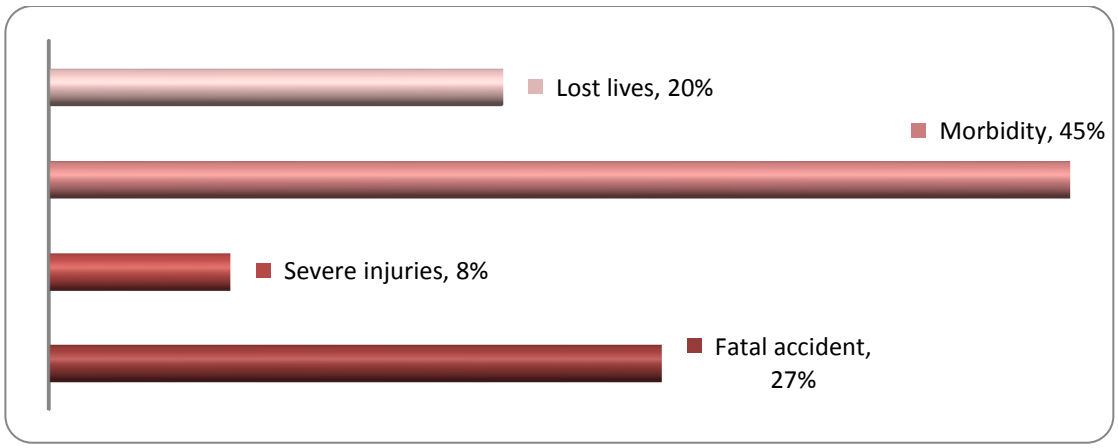


Figure 4.6 Nature of the Incidence of Accidents

Source: Field Data (2018)

From the findings, the majority of the respondents (45%) indicated that incidence of accidents were mainly characterised by morbidity occurrences, 27 percentage indicated that incidence of accident caused fatal accidents, while 20 percentage indicated that victims of the incidence of road accidents lost lives, however 8 percentage indicated severe injuries occurred due to incidence of road accidents. This depicts that the nature of the incidence of accidents that occur in black spots to the victims was morbidity incidences. This is in agreement with a study by WHO (2012) which reported that morbidity (injuries and disabilities) due to Road Traffic Accidents (RTAs) is disproportionately higher, and constitutes 90 percentage of the 50 million fatalities, which occur annually worldwide.

4.3.3 Causes of the Road Accidents

The respondents were requested to indicate the causes of the incidenceof road accidents on the sampled black spot. The finding of this study is shown in table 4.2 and figure 4.7.

Table 4.2 Causes of the Road Accidents

Causes	Frequency		Percentage	
	Yes	No	Yes	No
Police interferences	18	102	15	85
Local residents	37	83	31	69
Motorists	37	83	31	69
Pedestrian	52	68	43	57
Cyclists	24	96	20	80
Drivers	83	37	69	31

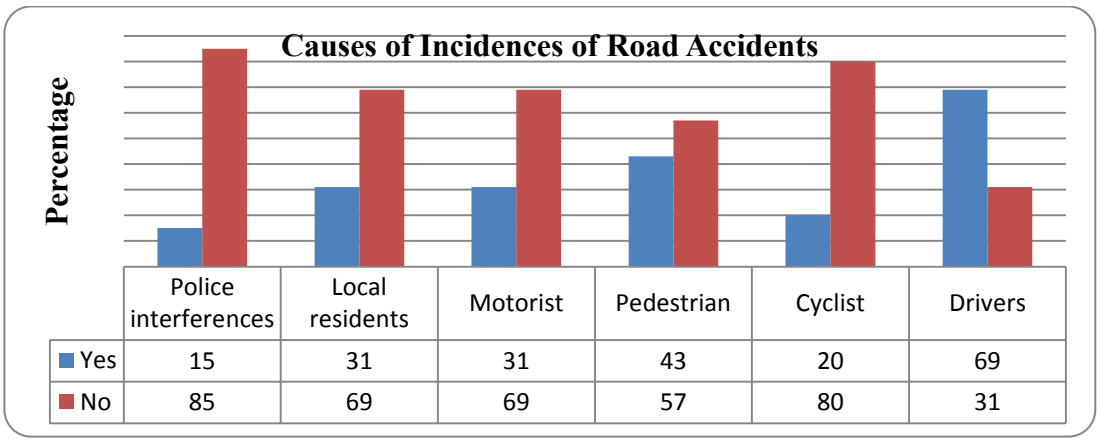


Figure 4.7 Nature of the Incidence of Accidents

Source: Field Data (2018)

From the findings majority (69%) of the respondents indicated that drivers were the main cause of road accidents, followed by pedestrian (43%), motorists and local residents at (31%) respectively, cyclist (20%), while police interferences were 15%. This depicts that the drivers are the main cause of road accidents at the black spots. The findings agree with a study by Ogendi et al. (2012) which established that 70% of all fatalities and serious injuries are attributed to drivers' errors among others. This is consistent with police department report (85%) of incidence of road accidents mainly caused by poor drivers' discipline or judgement in Kenya (Manyara, 2016).

4.3.4 Major Reasons Associated with Traffic Accident Incidence

The respondents were requested to indicate the major reasons associated with road traffic accident incidence. The findings of this study are shown in table 4.3 and figure 4.8.

Table 4.3 Major Reasons Associated with Traffic Accident Incidence

Reasons Associated with Traffic Accident	Frequency		Percentage	
	Yes	No	Yes	No
Driving behaviours (speeding)	100	20	83	17
Fatigue driving	26	94	22	78
Environmental factors	20	100	17	83
Vehicle conditions	34	86	28	72
Drunk driving	78	42	65	35
Ignorance to road accidents	27	93	23	77
Roadway	20	100	17	83
Overloading	47	73	39	61

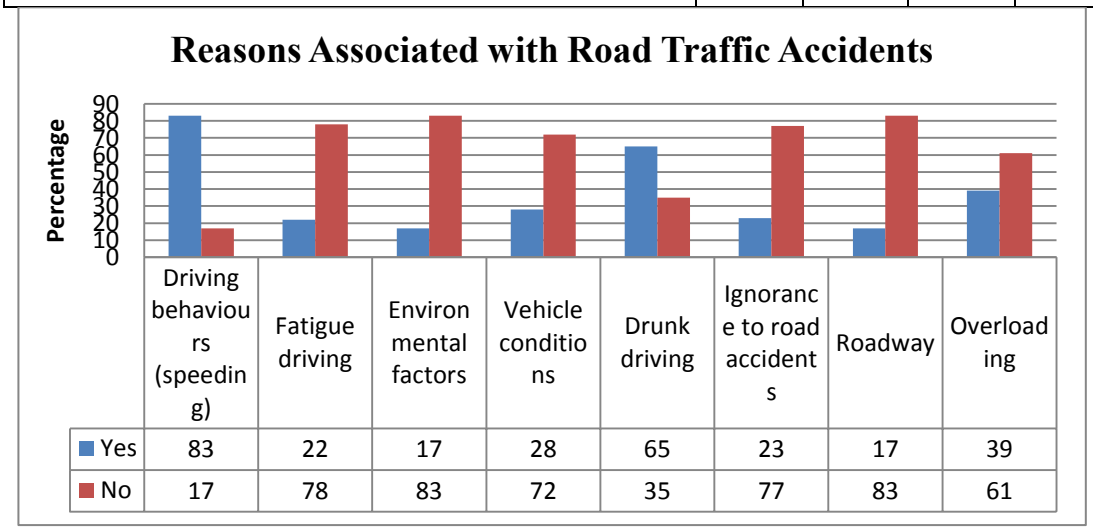


Figure 4.8 Reasons Associated with Road Traffic Accidents

Source: Field Data (2018)

From the findings majority (83%) of the respondents indicated that driving behaviours such as speeding were the major reasons associated with traffic accident incidence, followed by drunk driving (65%), overloading (39%), vehicle conditions (28%), ignorance to road accidents (23%), fatigue driving (22%), environmental

factors, and roadway at (17%) respectively. This depicts that driving behaviours such as speeding were the major reasons associated with traffic accident incidence. This agrees with a study by Ogendi et al. (2012) who argued that variables attributable to occurrence of road crash comprises driver's over speeding, inattention or distraction, fatigue, drink-driving and general indiscipline, impairment of judgement and competence of the drivers and other road users.

4.3.5 Influence of Drivers' Personal Characteristics on Road Accidents

The respondents were requested to confirm whether drivers' personal characteristics influence incidence of road accidents within the vicinity of the sampled black spots. The finding of this study is shown in figure 4.9.

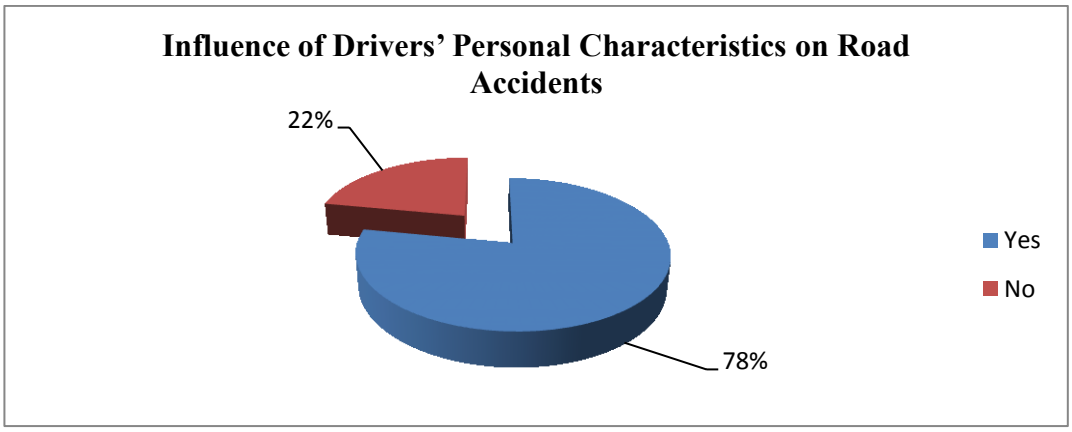


Figure 4.9 Influences of Drivers Personal Characteristics on Accidents Incidence

Source: Field Data (2018)

From the finding majority (78%) of the respondents indicated that drivers' personal characteristics influence incidence of road accidents to happen while 22% were of contrary opinion. This shows that drivers' personal characteristics influence incidence of road accidents. This agrees with a study by Muchene (2012) which stated that drivers' impairment among other personal characteristics are a significant cause of incidence of road traffic accidents both in developed and in developing countries.

4.3.6 Influence of drivers' attributes on Road Accidents

The respondents were requested to indicate whether driver's personal attributes influence incidence of road accidents. The finding of this study is shown in table 4.4 and figure 4.10.

Table 4.4 Influence of Personal Characteristics on Incidence of Road Accidents

Drivers personal characteristics	Frequency		Percentage	
	Yes	No	Yes	No
Driver experience	68	36	65	35
Age	22	82	21	79
Sex	5	99	5	95
Education	3	102	3	97
Level of income	4	101	4	96
Driver inattention	47	57	45	55
Driver's impairment/judgements	27	77	26	74
Driver's manoeuvres	18	86	17	83
Negligence	52	52	50	50

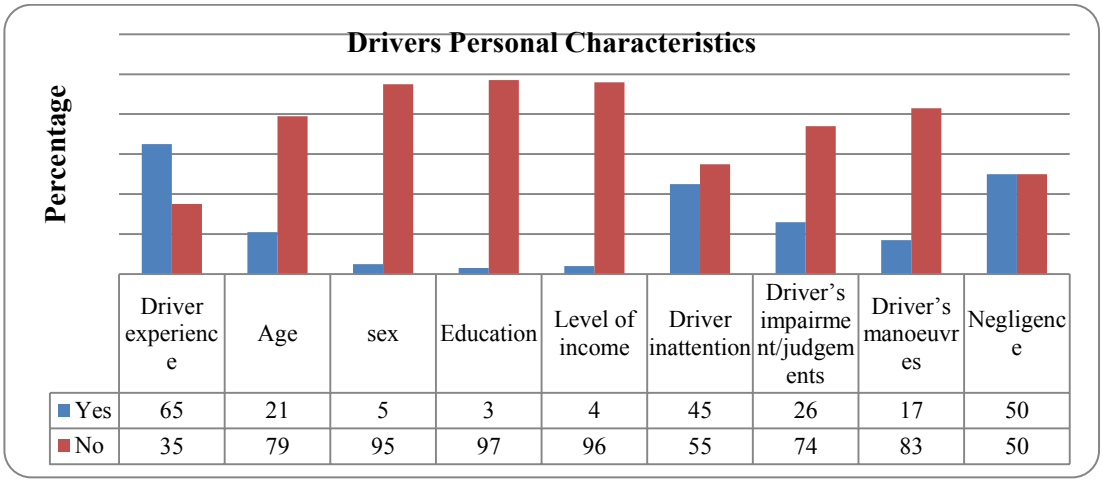


Figure 4.10 Influences of Personal Characteristics on Incidence of Road Accidents

Source: Field Data (2018)

From the findings majority of the respondents (65%), indicated that driver experience influence incidence of road accidents, followed by negligence (50%), driver inattention (45%), driver's impairment/judgments (26%), driver's age (21%),

driver's ability to maneuver (17%), and gender, level of income, and education at (5%, 4%, and 3% respectively). This depicts that drivers' experience influence incidence of road accidents the most. This outcome may be interrelated to situations such as being under the influence of alcohol, drug, sleepiness or fatigue and condition of extreme weather, especially wet weather and short hours of day light (Manyara, 2013).

4.3.7 Influence of Environmental Condition on Road Accidents

The respondents were requested to indicate whether environmental condition influences incidence of road accidents in the sampled black spots. The finding of this study is shown in figure 4.11.

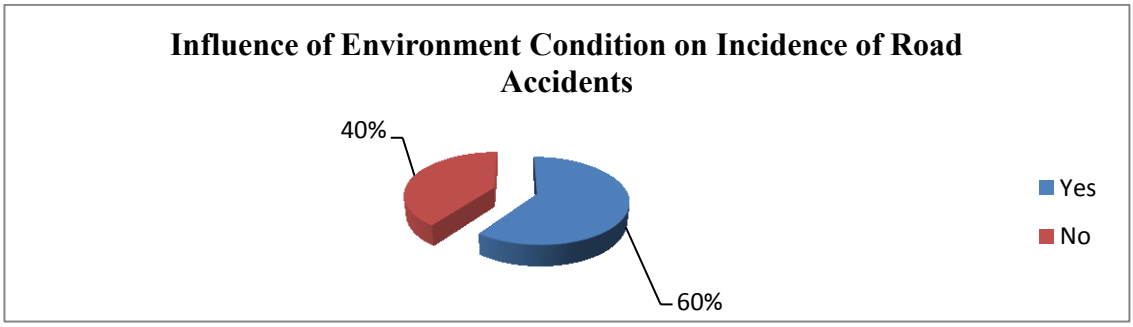


Figure 4.11 Influence of Environment Condition on Incidence of Road Accidents

Source: Field Data (2018)

From the finding majority (60%) of the respondents indicated that environmental conditions do not influence incidence of road accidents in the sampled black spot region, whereas 40% were of contrary opinion. This depicts that environmental conditions do not influence incidence of road accidents around the black spot regions. This outcome is in agreement with studies by Jacobs (1976) and Rao & Jacobs (1995) and which established that environmental variables that cause accident include trees, power posts, terrain, weather conditions, wild animals, land use, encroachment on the road reserve, and buildings along the road. These environmental conditions may alter visibility sight distance, driver judgement and

traffic flow that may include a road crash or accident on road or highway (Derry, 2011).

4.3.8 Time of Occurrence of Incidence of Traffic Road Accidents

The respondents were requested to indicate time incidence of road accident mostly occur. The finding of this study is shown in table 4.5 and figure 4.12.

Table 4.5 Time of Occurrence of Road Traffic Accidents

Time	Frequency		Percentage	
	Yes	No	Yes	No
During the day	49	42	53	47
During the weekend	42	46	48	52
During the night	73	23	76	24
During misty season	50	38	56	44
In the evening	36	50	42	58

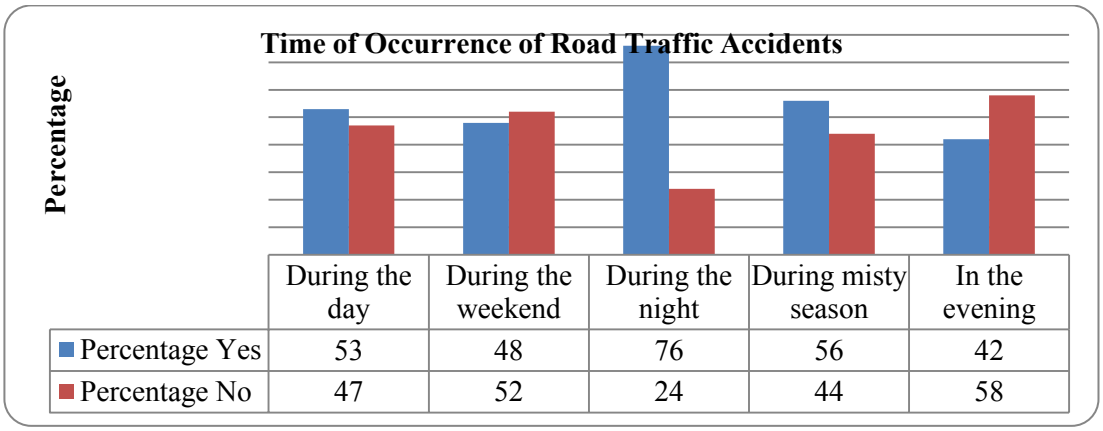


Figure 4.12 Time of Occurrence of Road Traffic Accidents

Source: Field Data (2018)

From the findings majority (76%) of the respondents indicated that the incidence of road accidents occur during the night, followed by during misty season (56%), during the day (53%), during the weekend (48%), and in the evening (42%). This depicts that most of incidence of road accidents occur during the night. This contradicts with a study by Lee & Mannering, (2002), who argues that incidence rate of accidents measured either as total number of accident per kilometre-length of road

per 24 hours day or total accidents per kilometre road per year are lower in developed than developing countries.

4.3.9 Cases of Accidents Due to Drunk Driving

The respondents were requested to indicate if there were cases of road traffic accidents, which occur due to drunk driving. The finding of this study is summarised in figure 4.13.

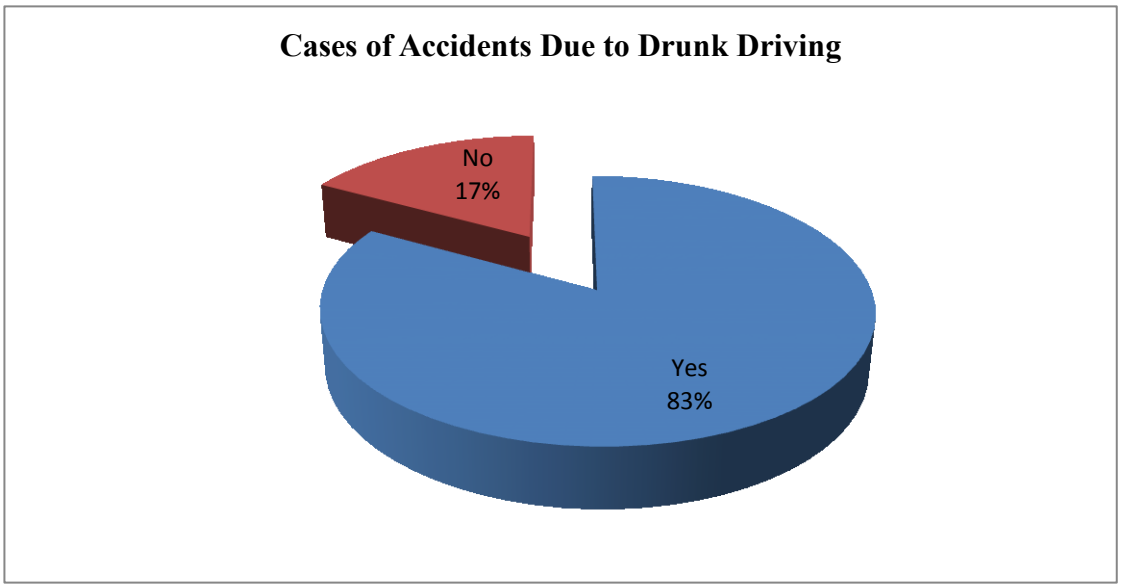


Figure 4.13 Cases of Accidents Due to Drunk Driving

Source: Field Data (2018)

From the finding, majority (83%) of the respondents indicated that there were cases of drivers causing accidents due to drunk driving, while 17 percent felt that most of the accidents do not occur due to drunk driving. This portrays that drunk driving is the main cause of incidence of road traffic accidents around the sampled black spots. This agrees with a study by Odero *et al.* (2012), who states that accident fatalities and serious injuries are attributable to drivers' errors due to drunk driving. Driver's impairment is largely be exaggerated by conditions such as; being under the influence of alcohol, drug, sleepiness or fatigue and condition of extreme weather, especially wet weather and short hours of day light.

4.3.10 Rate of the Cases of Road Accidents Caused By Drunk Drivers

The respondents were requested to rate intensity of the cases of road accidents caused by drunk driving. The finding of this study is shown in figure 4.14.

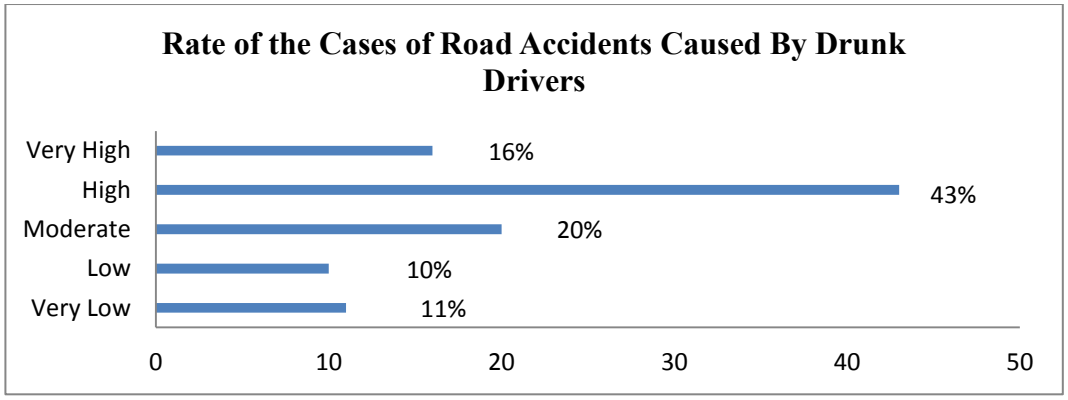


Figure 4.14 Rate of the Cases of Road Accidents Caused by Drunk Drivers

Source: Field Data (2018)

From the findings, 43 percent of the respondents indicated that incidence of road traffic accidents due to drunk driving is high, 20 percent indicated they were moderate whereas 16 percent felt that causes of road traffic accidents due to drunk driving to a very high extent while 11 percent indicated it to be very low extent. The study further established that 10 percent of the respondents indicated drunk driving accidents are of low extent. This shows that to a high extent incidence of road accidents are due to drunk driving. This is in agreement with a study by Muchene (2012) who states that 70 percent of all fatality and serious injuries through accident is attributable to drunk driving that affects drivers' concentration.

4.4 Factors Influencing Incidence of Road Accidents in Kenya

This section presents findings on the Factors influencing incidence of road accidents in Kenya. The findings are presented in subsequent headings.

4.4.1 Influence of Various Factors on Road Accidents

Respondents were requested to indicate the extent to what extent the following factors influence incidence of road accidents in the sampled black spot. The finding of this study is shown in table 4.6.

Table 4.6 Influence of Various Factors on Incidence of Road Accidents

Statements	Mean	Std. Dev.
Human factors	2.84	1.264
Environmental factors	2.70	1.274
Vehicular factors	2.96	1.233
Road surface condition	3.04	1.325
Road safety measures	2.70	1.400

Source: Field Data (2018)

From the findings the respondents indicated that the road surface conditions influence incidence of road accidents to a moderate extent in this area (mean=3.04), followed by vehicular factors (mean=2.96), human factors (mean=2.84), environmental factors and road safety measures (mean=2.70) respectively. This depicts that road surface conditions influence incidence of road accidents in the sampled black spots. The findings by Ruyters *et al.* (1994) agree with the findings of this study. In his study, he found out that the condition of road surface has important influence or effect on speed, manoeuvres and traffic flow on sections of the road or highway. The road conditions as a variable is measured and expressed in units of surface friction coefficient, skid resistance and polished stone value (PSV) to quantify the roughness and friction on the road surface as well as its texture.

4.4.2 Extent that Road Design Factors Influences Road Accidents

Respondents were requested to indicate to what extent road design factors influence incidence of road traffic accidents.

4.4.2.1 Road Design Geometry

Respondents were requested to indicate to what extent road design factors influence incidence of road traffic accidents. The finding of this study is shown in table 4.7.

Table 4.7 Road Design Geometry

Statements	Mean	Std. dev.
Volume of traffic	2.58	1.564
Traffic flows	2.89	1.453
Road conditions	3.23	1.321
Terrain	2.93	1.319
Weather patterns	2.76	1.245

Source: Field Data (2018)

From the findings, the respondents indicated to a moderate extent that road conditions were related to the factors that cause accident influences incidence of road accidents (mean=3.23), followed by terrain (mean=2.93), traffic flows (mean=2.89), weather patterns (mean=2.76), and volume of traffic (mean=2.58). This depicts that, road conditions to a moderate is related to the factors that cause accident influences incidence of road accidents.

4.4.2.2 Human factors

Respondents were requested to indicate how human factors influence incidence of road traffic accidents. The finding of this study is summarised in table 4.8.

Table 4.8 Human factors

Statements	Mean	Std. dev.
Driver's in attention	2.81	1.468
Distraction	2.72	1.251
Drink-driving	3.05	1.328
Visibility	2.70	1.332
Speeding	3.25	1.311
Indiscipline	3.21	1.347
Impairment of judgement	2.88	1.363
Incompetence of drivers and other road users	3.11	1.302
Use of head lights during the day	2.70	1.254

Source: Field Data (2018)

From the findings the respondents indicated to a moderate extent that speeding was related to the factors that cause accident influences incidence of road accidents (mean=3.25), followed by indiscipline (mean=3.21), incompetence of drivers and other road users (mean=3.11), drink-driving (mean=3.05), impairment of judgement (mean=2.88), driver's inattention (mean=2.81), distraction (mean=2.72), visibility, and use of head lights during the day (mean=2.70). This depicts that to a moderate extent vision speeding was related to the factors that cause accident influences incidence of road accidents. This agrees with a study by Manyara, (2013) that vision speeding can act in correlation with the human, vehicle and environmental parameters into a complex matrix of predisposing circumstances or situations within unexpected spatial and temporal dimensions not cogent to the driver's behaviour, pedestrians or cyclists involved in the road thus causing accident

4.4.2.3 Vehicular variables

The respondents were asked to indicate how vehicular factors influence incidence of road traffic accidents. The finding of this study is presented in table 4.9.

Table 4.9 Vehicular variables

Statements	Mean	St Dev.
Mechanical failure such as failure of brakes	2.85	1.527
Flattened tyre treads	2.75	1.272
Bad brakes or tyres	3.15	1.268
Anti-crash devices	2.76	1.264
Faulty seat belts	2.73	1.202
Faulty speed governors	2.94	1.311

Source: Field Data (2018)

From the findings the respondents indicated to a moderate extent that bad brakes or tyres was related to factors that influence incidence of road accidents (mean=3.15), followed by faulty speed governors (mean=2.94), mechanical failure such as failure of brakes (mean=2.85), anti-crash devices (mean=2.76), flattened tyre treads (mean=2.75), driver's inattention (mean=2.81), distraction (mean=2.72), and faulty seat belts (mean=2.73). This depicts that to a moderate extent bad brakes or tyres was related to the factors that cause accident influences incidence of road accidents. Vehicular variables contributing to high incidences, mortality and morbidity in road accident include flattened tyre treads, bad brakes or tyres, anti-crash devices such as seat belts, air bags, and speed governors (Asingo *et al*. 2014).

4.4.2.4 Environmental Factors

The respondents were asked to indicate how environmental vehicular factors influence incidence of road traffic accidents. The findings of this study are presented in table 4.10.

Table 4.10 Environmental Factors

Statements	Mean	Std. dev.
Trees along the roads	2.74	1.375
Power posts	2.52	1.181
Terrain	2.60	1.246
Wild animals	2.48	1.195
Encroachment on road reserve	2.52	1.138
Buildings along the road	2.55	1.222

Source: Field Data (2018)

From the findings the respondents indicated to a moderate extent that trees along the roads were related to incidence of road traffic accidents (mean=2.74), followed by terrain (mean=2.60), buildings along the road (mean=2.55), power posts and encroachment on road reserve (mean=2.52). In addition, the respondents indicated to a small extent that wild animals were related to the factors that cause accident influences incidence of road accidents (mean=2.48). This depicts that, to a moderate extent, trees in sampled black spots along Mombasa-Malaba road were related to incidence of road traffic accidents factors that influence cause accident incidence of road accidents. This agrees with a study by Derry, (2011), which indicates that variables such as trees along roads may alter visibility, sight distance, drivers' judgement and smooth traffic flow that may influence a road crash or accident on road or highway.

4.5 Road Designs

This section presents findings on the influence of road designs on incidence of road traffic accidents and road safety. The findings are outlined in subsequent headings and sub-headings.

4.5.1 Effect of Road Design on Speed, Flow and Road Safety on Motorway

The respondents were requested to indicate whether road design affects traffic speed, flow and road safety on black spots along Mombasa-Malaba road. The finding of this study is shown in figure 4.11.

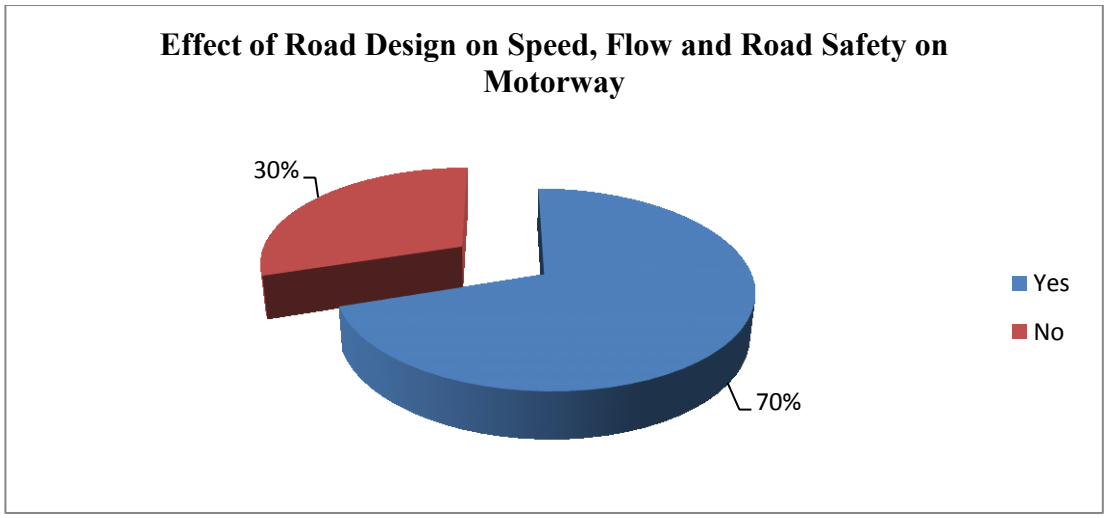


Figure 4.15 Effect of Road Design Traffic Speed, Flow and Road Safety of Motorway

Source: Field Data (2018)

From the findings, majority of the respondents (70%) indicated that road design affects traffic speed, flow and road safety of motorways while 30 percent were of contrary opinion. This depicts that road design affects traffic speed, flow and road safety of motorway. This agrees with a study by Derry, (2011) who argues that road geometry has a couple of variables that affect both the traffic speed, flow and road safety of motorway or highway which may lead to occurrence of accidents.

4.5.2 Extent to Which Road Characteristics Influence on Road Accidents

The respondents were requested to indicate the extent to which road characteristics influence incidence of road accidents. The finding of this study is shown in table 4.11.

Table 4.11Extent that Road Characteristics Influence Road Accident Incidences

Statements	Mean	Std. Dev.
Carriage width in metres	2.07	1.136
Curvatures whether horizontal	2.48	1.309
Transition and vertical measured in degrees	2.52	1.209
Road markings	2.74	1.231
Road signage	2.61	1.154
Pedestrian lanes	2.81	1.162
T- access junction	2.82	1.283
Road lighting	2.78	1.265
Sight distances	2.56	1.215
Pavement width	2.57	1.301
Road margin	2.40	1.162
Road side features	2.51	1.202
Border lines	2.52	1.195
Road signs and sign boards	2.51	1.111
Cyclist lanes	2.73	1.107
Footbridges	2.71	1.212
Steep slopes	2.73	1.150
Flyovers	2.63	1.243
Surge curves	2.69	1.282
Speed bumps	2.81	1.107
Road bumps	2.53	1.092
Pedestrian crossing	2.69	1.151
Rumble strips	2.72	1.175
Highway pavements	2.63	1.237
Shoulder width dimensions and type	2.73	1.250
Verges overgrown with shrubs	2.44	1.165
Roughness of road surface	2.53	1.061

Source: Field Data (2018)

From the findings, the respondents indicated to a moderate extent that T- access junctions influence incidence of road accidents (mean=2.82), followed by pedestrian lanes (mean=2.81), and cyclist lanes (mean=2.73). In addition, respondents indicated to a small extent that carriage width in metres (mean=2.07) influence incidence of road accidents followed by road margins (mean=2.40), and verges overgrown with shrubs (mean=2.44). This depicts that T- access junction's influence incidence of road accidents to a moderate extent. This agrees with a study by Ruyters et al. (1995) that transitional curves are associated with high incidence of crashes, especially if a driver engages high speed, a centrifugal force is created by the curved sections. Vehicles experience difficulties when climbing vertical curves or steep slopes hence an additional climbing lane for heavy vehicles.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter outlines summary of study findings, conclusion and recommendations on the factors that influence the incidence of road accidents in Kenya: a survey of black spots along Mombasa-Malaba road. An estimated million people die annually on the World's roads, with 20–50 million sustaining non-fatal injuries and disabilities occur annually worldwide through road accidents. The problem of road accidents apparently has not yet grabbed the attention of governments to marshal the will to arrest situation of these high mortality and morbidity with the attendant economic costs and burden approximating to 1 to 2 percentage of annual Gross Net Product (GNP) in the developing countries

5.2 Summary of Findings

The study was guided by the following objectives:-

i. To describe the incidence of road accidents on Kenyan highways.
ii. To describe factors that influences the incidence of road accidents in Kenya.
iii. To establish impact of road design on incidence of road accidents in Kenya.

5.2.1 Objective 1: To describe the incidence of road accidents on Kenyan highways

The study found that incidence of road accidents occur in this region often. 43 percent of the respondents indicated the incidence of road accidents occur in this region often, 38 percent indicated frequently, 15% indicated rarely, while 4 percent indicated daily (table 4.5). The study also established that that the nature of the incidence of accidents that occur in black spots to the victims was morbidity incidences. majority of the respondents (45%) indicated that incidence of accidents were mainly characterised by morbidity occurrences, 27 percentage indicated that incidence of accident caused fatal accidents, while 20 percentage indicated that

victims of the incidence of road accidents lost lives, however 8 percentage indicated severe injuries occurred due to incidence of road accidents (figure 4.6).The study established that the drivers are the main cause of road accidents at the black spots at 69% (Figure 4.3). Driving behaviours such as speeding were the major reasons associated with traffic accident incidence. The study also established that environmental conditions do not influence incidence of road accidents around the black spot regions.(60%) of the respondents indicated that environmental conditions do not influence incidence of road accidents in the sampled black spot region, whereas 40% were of contrary opinion (figure 4.11).

5.2.2 Objective 2: To describe factors that influences the incidence of road accidents in Kenya

The study established that road surface conditions greatly influence incidence of road accidents in black spots (mean=3.04). In addition, the study established that, to a moderate extent, road conditions (mean=3.23), speeding (mean=3.25), bad brakes or tyres (3.15), and trees along the roads (2.74) are some of factors that influence road traffic incidences. The findings illustrate that road condition in general influences the road incidence on Kenyan highways. This may be attributed by the general smoothness, roughness or visibility of the road that hinder use of the road hence causing the road accidences to the users. The study established that to a moderate extent that bad brakes or tyres was related to the factors that cause accident influences incidence of road accidents as depicted by the mean of mean=3.15.

5.2.3 Objective 3: To establish impact of road design on incidence of road accidents in Kenya

To the objective of road designs the study established that road design as indicated by (70%) of the respondents affects traffic speed, flow and road safety of motorway. In addition, the study found that T- access junctions influence incidence of road traffic accidents to moderate extent (mean=2.82). From these findings, taken together, point to road design being a probable inherent variable responsible for high incidence of road crashes and carnage along black spots on the highways. All roads and highways are designed, executed and maintained to take into account vehicles,

drivers (human) the roadway and environmental parameters that may compromise road safety and induce road crashes.

5.3 Conclusion

Based on the study finding, the study made the following conclusion:

The study concluded that the nature of the incidence of accidents that occur within the black spot, morbidity affected the victims the most. The study further concluded that drivers are the main cause of road accidents at the black spots. Additionally, the study concluded that driving behaviours such as speeding, experience and drunkenness were the major reasons associated with incidence of road traffic accidents.

The study concluded that road surface conditions greatly influence incidence of road accidents at black spots. In addition, the study concluded that, to a moderate extent road conditions, vision, speeding, bad brakes or tyres, and trees along the roads correlated with the factors that influence incidence of traffic road accidents.

The study concluded that road design affects traffic speed, flow and road safety of motorway. In addition, the study concluded that T-access junctions influence incidence of road traffic accidents to a moderate extent.

5.4 Recommendations

The following recommendations were made based on the study findings:

i. Stakeholders in the transport and communication sector should establish a well-coordinated and funded road safety research and development programme(s) in Kenya to provide the information needed for necessary decision-making process in road safety measures. This will assist in coming up with essential stop gap measures and road improvement/rehabilitation to eliminate or reduce incidence of road traffic accidents in designated black spots in Kenya as well as other major road network.
ii. Vehicle standards should be developed and enforced through regular inspection of the PSVs to ensure they meet them in order to operate

iii. The influence of road design and standards, on accidents and road safety needs to be investigated.

iv. The PSV drivers and conductors should be trained on safety rules especially those being introduced to improve on the awareness and use of the related tools and equipment hence improve their knowledge on road safety

v. The government should implement rules that will govern the conduct of the drivers especially on drunk driving and over speeding which have been found to be the main contributors of most of the accidents in Kenya

5.5 Areas for Further Research

The current study focused on Mombasa-Malaba road. The reason for this was that it was most affected in terms of incidence of road traffic accidents compared to other road networks in Kenya and convenient for the researcher. Despite the fact that Mombasa-Malaba road contains a high number of vehicles, a research needs to be carried out on other road networks in Kenya. In this case, future researches on this topic should concentrate on other sections of Kenyan road network.

The inferential statistic conducted on factors that influence the incidence of road accidents in Kenya amounts to 54.5% of the road incidence that occur on Kenyan Highways. This illustrates that some additional factors (45.5%) cause road accidents in Kenya, thus this study recommends that a comparative study of the P(RTA at a Black Spot) in Kenya with cases of global best practices in transport engineering, management and economics be conducted to provide for comparison purposes and for the ministry implementation.

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APPENDICES

Appendix I: Research Questionnaire

I am a student at JKUAT Main campus pursuing a master of science in construction project management and this questionnaire is intended to collect information on factors that influence the incidence of road accidents in Kenya with focus to black spots along Mombasa-Malaba road. The source and entire information will be confidential and will be confined to the intended research purpose. Kindly provide accurate and honest information as guided by the instructions**.**

Section A: General Information

1. Name of black spot.....

2. Nearest market/urban centre/town.....

3. Kindly indicate the category that you are in the options provided below

a. Police department [ ]
b. Pedestrian [ ]
c. Neighbour [ ]
d. Driver [ ]

4. Kindly specify type of vehicle that you drive/operate

a. *Matatu* PSV [ ]
b. Saloon Vehicle [ ]
c. Motorcyclist [ ]
d. Freight /Haulers [ ]

5. How long have you been working/using/staying along this road?

a. 1 - 5 years [ ]
b. 6 - 10 years [ ]
c. 11 – 15 years [ ]
d. 6 – 10 years [ ]
e. Above 16 years [ ]

6. What is the approximate length of the black spot stretch in Kilometres? .....

Section B: Incidence of Road Accidents In Black Spots Along Mombasa-Malaba Road

1. How frequent does the incidence of road accidents occur in this black spot?

a. Frequently [ ]
b. Often [ ]
c. Rarely [ ]
d. Daily [ ]

2. How would you describe the nature of the incidence of accidents that occur in this area to the victims?

a. Fatal accident [ ]
b. Morbidity [ ]
c. Severe injuries [ ]
d. Lost lives [ ]

3. In your opinion what could be the main cause of road accidents in this black spot? (You can choose more than one reason)

a. Police interferences [ ]
b. Pedestrian []
c. Local residents [ ]
d. Drivers [ ]
e. Motorist [ ]
f. Cyclist [ ]

4. What are the major possible reasons associated with traffic accident incidencein this black spot? (You can choose more than one reason)

a. Speeding [ ]
b. Drunk driving [ ]
c. Fatigue driving [ ]
d. Road users ignorance [ ]
e. Environmental factors [ ]
f. Roadway [ ]

g. Vehicle conditions [ ]
h. Overloading [ ]

5. Do you think drivers' personal characteristics influence incidence of road accidents in the specified black spot?

a. Yes [ ]
b. No [ ]

a. If yes, kindly specify the possible personal characteristics that may influence incidence of road accidents. (You can choose more than one characteristic)Driver experience [ ]
b. Driver's impairment [ ]
c. Age [ ]
d. Sex [ ]
e. Level of education [ ]
f. Level of income [ ]
g. Driver inattention [ ]
h. Driver's judgements [ ]
i. Driver's manoeuvres [ ]
j. Negligence [ ]

6. Does environment condition influence incidence of road accidents in this black spot?

a. Yes [ ]
b. No[ ]

7. If yes, kindly indicate the major environmental condition that causes incidence of road accidents in this black spot.

.....

8. When does the incidence of road accidents occur mostly?

Condition	**Yes**	**No**
During the day		
During the night		
In the evening		
During the weekend		
During misty season		
Any other (please specify) ……..... …….. .		

9. Are there cases of drivers causing accidents when drunk?

a. Yes[ ]

b. No[ ]

10. If yes, kindly rate the frequency of incidence of road accidents caused by drunk driving?

a. Very low [ ]

b. High [ ]

c. Low [ ]

d. Very high [ ]

e. Moderate [ ]

Section C: Factors Influencing Incidence of Road Accidents in Kenya

1. Kindly indicate the extent to which the following factors influence incidence of road accidents in the said black spot. Use a scale of 1-5

1=Very low extent; 2=Low extent;3=No influence; 4=Large extent; 5=Very large extent

No.	Influencing Factors	1	2	3	4	5
A.	Road design geometry					
B.	Human factors					
C.	Environmental factors					
D.	Vehicular factors					
E.	Road surface conditions					
F.	Road safety measures					

To what extent do the following factors influence incidence of road accidents in this black spot. Use a scale of 1-5

1=Very low extent; 2=Low extent; 3=No influence; 4=Large extent; 5=Very large extent

A. Road Design Geometry		**1**	**2**	**3**	**4**	**5**
i.	Road markings and signs					
ii.	Skid resistance					
iii.	Road conditions					
iv.	Speed barriers					
v.	Warning and guide signs					
B. Human Factors		**1**	**2**	**3**	**4**	**5**
i.	Driver's inattention					
ii.	Distraction					
iii.	Drink-driving					
iv.	Visibility					

v.	Speeding					
vi.	Road users indiscipline					
vii.	Road users judgement					
viii.	Incompetence of drivers					
ix.	Continuous use of head lights at night					
C. Environmental Factors		**1**	**2**	**3**	**4**	**5**
i.	Rainy weather					
ii.	Foggy weather					
iii.	Trees and over grown bushes					
iv.	Steep slope					
v.	Power posts					
vi.	Unfamiliar terrain					
vii.	Wild animals					
viii.	Encroachment on road reserve					
ix.	Buildings along the road					
D. Vehicular Factors		**1**	**2**	**3**	**4**	**5**
i.	Mechanical failure such as failure of brake					
ii.	Flattened tyre treads					
iii.	Bad brakes or tyres					
iv.	Anti-crash devices					
v.	Faulty seat belts					
vi.	Faulty speed governors					

Section D: Road Design

1. Do you think road design affects traffic speed, flow and road safety of motor vehicles?
   a. Yes[ ]
   b. No[ ]
2. To what extent do the following characteristics of road design influence incidence of road accidents in this black spot? Use a scale of 1-5

   1=Very low extent; 2= Low extent; 3=No influence; 4=Large extent; 5=Very large extent

Road Design	**1**	**2**	**3**	**4**	**5**
Carriage width in metres					
Curvatures whether horizontal or vertical					
Super elevation measured in degrees					
Road markings					
Road signage					

Pedestrian lanes					
T- access junction					
Road lighting					
Sight distances					
Pavement width					
Road margin					
Road side features					
Border lines					
Sign boards					
Cyclist lanes					
Footbridges					
Steep slopes					
Flyovers					
Sag curves					
Crest curves					
Speed bumps					
Road bumps					
Pedestrian crossing					
Rumble strips					
Highway pavements					
Shoulder width dimensions and type					
Verges overgrown with shrubs					
Roughness of road surface					

3. What are the measures that the government has put in place to minimise the cases of the road accidents in this area?

.....

.....

..What should the stakeholders do to mitigate the incidence of road accidents on black spots?

.....

.....

THANK YOU FOR YOUR PARTICIPATION

Appendix II: Observation Check List

Kindly observe whether the following items are available at the black spot identified:

1. Alcohol blow

(a) Yes [ ]

(b) No [ ]

2. Roadways surveillance cameras

(a) Yes [ ]

(b) No [ ]

3. Road signs

(a) Yes [ ]

(b) No [ ]

4. Access junctions

(a) Yes [ ]

(b) No [ ]

5. Cyclist lanes

(a) Yes [ ]

(b) No [ ]

6. Traffic police roadblocks

(a) Yes [ ]

(b) No [ ]

7. Road markings

(a) Yes [ ]

(b) No [ ]

8. Pedestrian crossings facility

(a) Yes [ ]

(b) No [ ]

9. Road signs or sign boards

(a) Yes [ ]

(b) No [ ]

10. Roughness of road

(a) Yes [ ]

(b) No [ ]

11. Bushes along the road

(a) Yes [ ]

(b) No [ ]

12. Potholes in road

(a) Yes [ ]

(b) No [ ]

13. Broken edges

(a) Yes [ ]

(b) No [ ]

14. Speed barriers

(a) Yes [ ]

(b) No [ ]

15. Warning and guide signs

(a) Yes [ ]

(b) No [ ]

16. Road verge surface

(a) Yes [ ]

(b) No [ ]

17. Straight stretch

(a) Yes [ ]

(b) No [ ]

18. Long steep slope

(a) Yes [ ]

(b) No [ ]

19. Horizontal curves

(a) Yes [ ]

(b) No [ ]

20. Vertical curves

(a) Yes [ ]

(b) No [ ]

21. Elevation of curve

(a) Yes [ ]

(b) No [ ]

22. Intersection/Junctions

(a) Yes [ ]

(b) No [ ]

23. Enforcement of traffic rules

(a) Yes [ ]

(b) No [ ]

24. Encroaching Landmarks

(a) Yes [ ]

(b) No [ ]

25. Any other traffic control instrument available

……

……

……

……

Appendix III: Budget

No.	ITEM DESCRIPTION	TOTAL (KES)
1.	Proposal writing and submission	16,000
2.	Defence at department level	5,000
3.	Correction of proposal	8,000
4.	Research permit application	6,000
5.	Research permit/approval issue	8,000
6.	**Data collection** **A-** Pilot Testing of research instruments Questionnaire Checklist Measurement of Road parameters in field **B-** Actual data collection	120,000
7.	Data analysis	50,000
8.	Thesis corrections	20,000
9.	Defence	10,000
10.	Final thesis (4 thesis copies)	12,000
11.	Publication 2 or 3 copies	30,000
12.	Graduation	42,000
TOTAL		**327,000**

Appendix IV: Schedule Gantt Chart

Activity	Jan 2016	February	March	April	May	June	July	August	September
Tool development									
Proposal Pre-defence									
Proposal Defence									
Proposal completion									
Research permit application									
Pre-test									
Sensitisation									
Training of research assistants									
Data collection									
Data analysis									
Discussion/Conclusion/ Recommendation									
Thesis defence									

Appendix V: List of Black Spots along Mombasa-Malaba Road

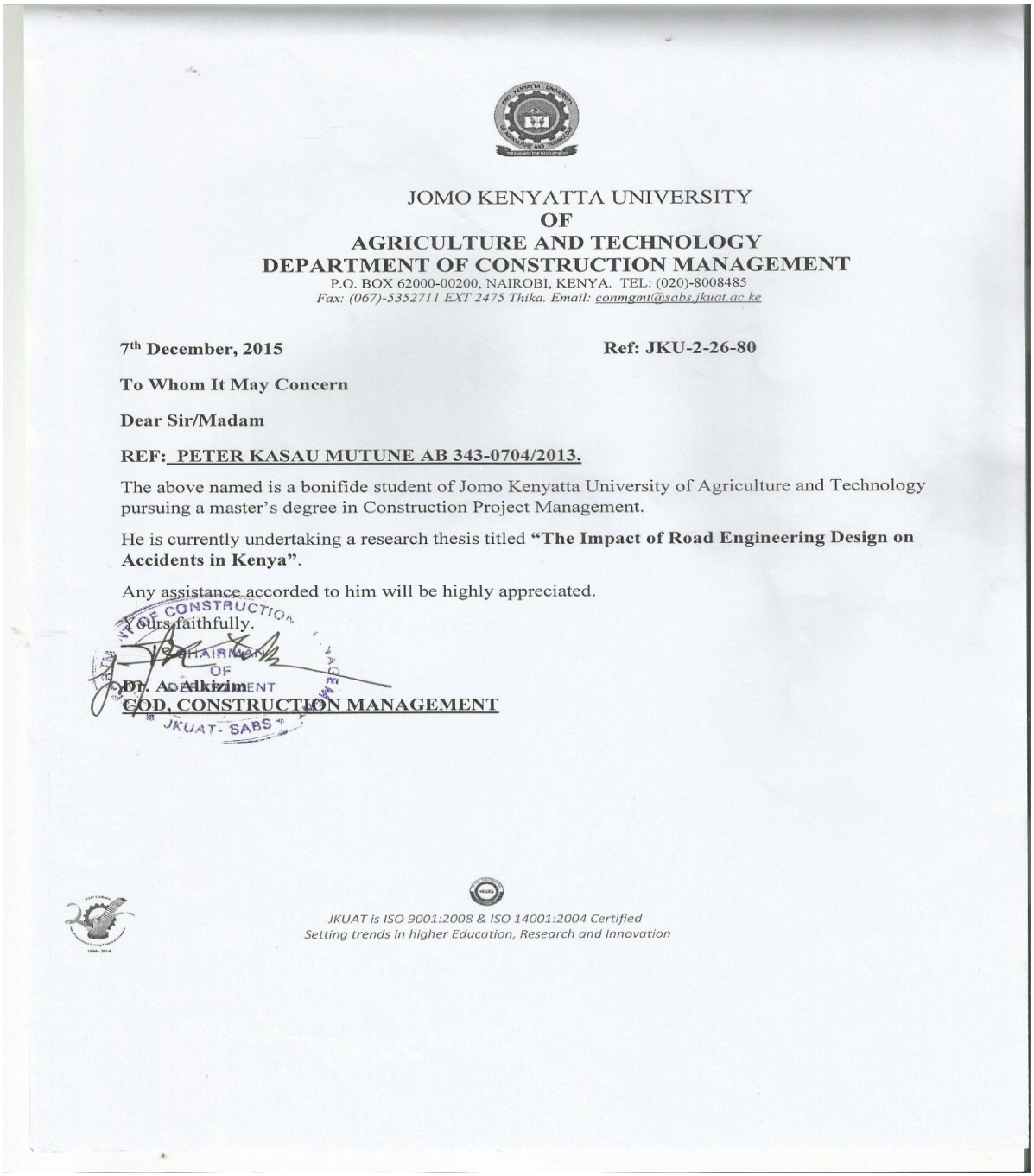
S/No	Black Spot Name
1.	**Acre Tano**
2.	**Annex Stage (Nakuru)**
3.	Bellevue
4.	Burnt Forest
5.	Chamowanga
6.	Chumvi Market
7.	Chyulu area
8.	Danger Corner
9.	DarajaMbili
10.	Delamare
11.	**Delamare (Near Delamare shop)**
12.	Doshi Corner
13.	Emali/Loitokitok Junction
14.	Equator-King'eero
15.	**Free Area (Nakuru)**
16.	General Motors (Nairobi)
17.	**Gilgil Junction**
18.	Gilgil Junction-St Mary's Hospital
19.	Gitaru
20.	GSU camp

21.	Hotel Kunste
22.	Hunter's Lodge
23.	Ikapalok-Malaba
24.	IkoyoMakindu stage
25.	Ikoyo township
26.	**Kabete Police station**
27.	KahoyaTimboroa
28.	Kangemi Market
29.	Kasarani-Voi
30.	Kenani area
31.	**Kenya Meat Commission (Athi River)**
32.	Kianda School
33.	**Kibwezi Junction**
34.	Kilimbini Market
35.	Kimende area
36.	Kimende Forest
37.	Kinale
38.	**Kinungi Steeps**
39.	Kirima area
40.	**Konza Junction**
41.	Lanet area
42.	**Lukenya Junction**

43.	MaaiMahiu
44.	MaaiMahiu Escarpment
45.	MaaiMahiu-Limuru road inter-change
46.	MailiMbiliNaivasha
47.	Manyani area
48.	Manyani Market
49.	Map Area
50.	Mariakani
51.	Mariakani
52.	Marula-Delamare
53.	Mau Summit
54.	Mazeras
55.	MbarukNakuru
56.	Mikindini
57.	Miritini
58.	Molem
59.	Molo Junction
60.	MtaayaNdege
61.	Mwandeti
62.	Naam-Nzoia
63.	Nation Centre -Mlolongo
64.	Ngata Bridge-Sobea

65.	Njoro road Junction
66.	Nzoia Bridge
67.	Pipeline area (Nakuru)
68.	Riverside Road Junction
69.	**Salgaa (Past Nakuru)**
70.	Salgaa-GSU camp
71.	Sameer Park
72.	Sigona
73.	Simba cement
74.	Taita Village
75.	Taleh Hotel-Mtito
76.	Timboroa
77.	Timboroa Danger
78.	Tsavo East
79.	Tsavo River area
80.	Webuye Market

Appendix VI: Letter of Introduction



JOMO KENYATTA UNIVERSITY
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AGRICULTURE AND TECHNOLOGY
DEPARTMENT OF CONSTRUCTION MANAGEMENT
P.O. BOX 62000-00200, NAIROBI, KENYA. TEL: (020)-8008485
Fax: (067)-5352711 EXT 2475 Thika. Email: conmgmt@sabs.jkuat.ac.ke

7th December, 2015 **Ref: JKU-2-26-80**

To Whom It May Concern

Dear Sir/Madam

REF: PETER KASAU MUTUNE AB 343-0704/2013.

The above named is a bonifide student of Jomo Kenyatta University of Agriculture and Technology pursuing a master's degree in Construction Project Management.

He is currently undertaking a research thesis titled **"The Impact of Road Engineering Design on Accidents in Kenya"**.

Any assistance accorded to him will be highly appreciated.

Yours faithfully.

CHAIRMAN OF DEPARTMENT
CONSTRUCTION
JKUAT- SABS

Dr. Adelkizim
COD, CONSTRUCTION MANAGEMENT

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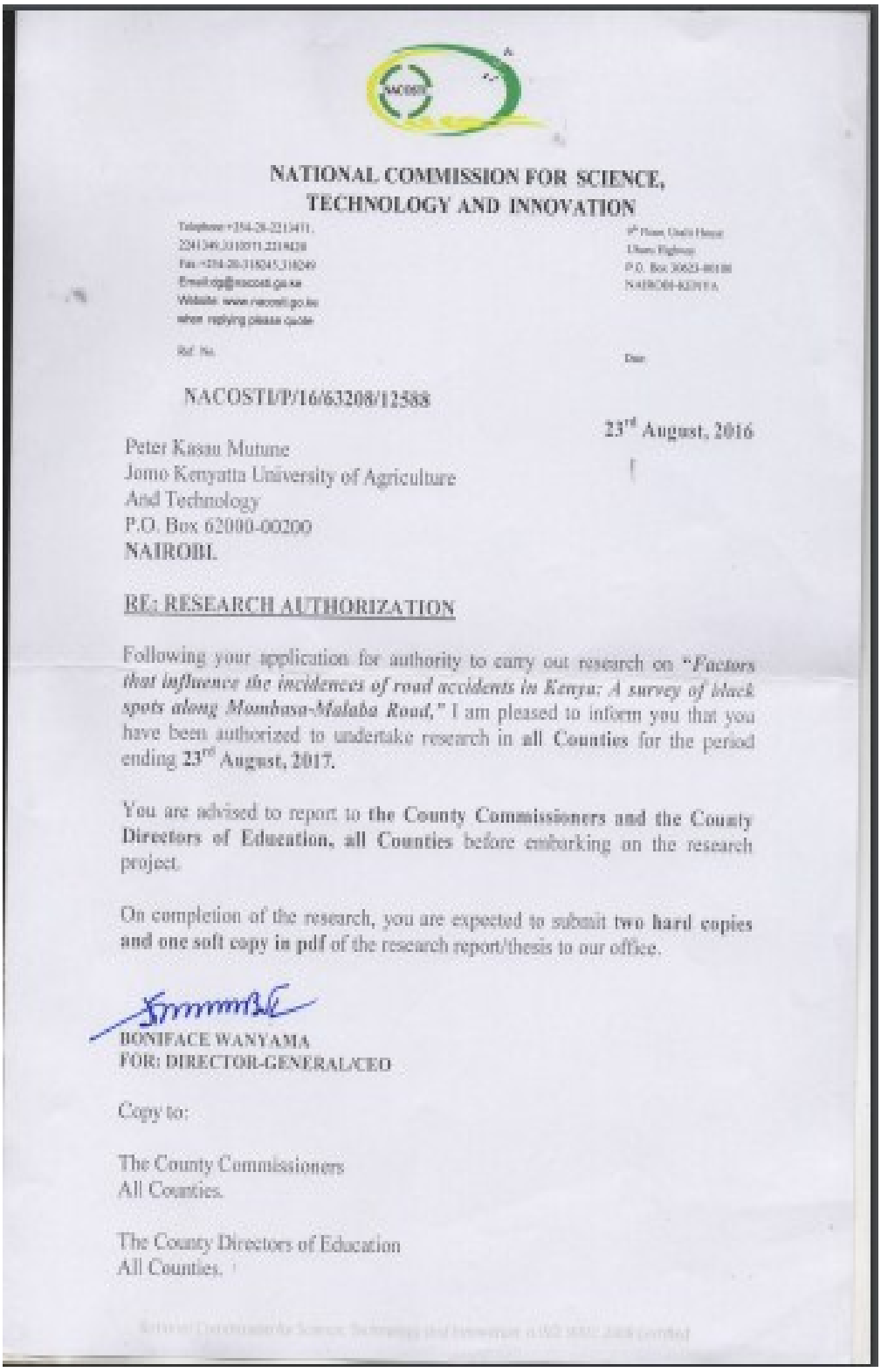
Setting trends in higher Education, Research and Innovation

Appendix VII: Research Authorization



NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No.

Date

NACOSTI/P/16/63208/12588

23rd August, 2016

Peter Kasau Mutune
Jomo Kenyatta University of Agriculture
And Technology
P.O. Box 62000-00200
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Factors that influence the incidences of road accidents in Kenya: A survey of black spots along Mombasa-Malaba Road,"*** I am pleased to inform you that you have been authorized to undertake research in **all Counties** for the period ending **23rd August, 2017.**

You are advised to report to **the County Commissioners and the County Directors of Education, all Counties** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

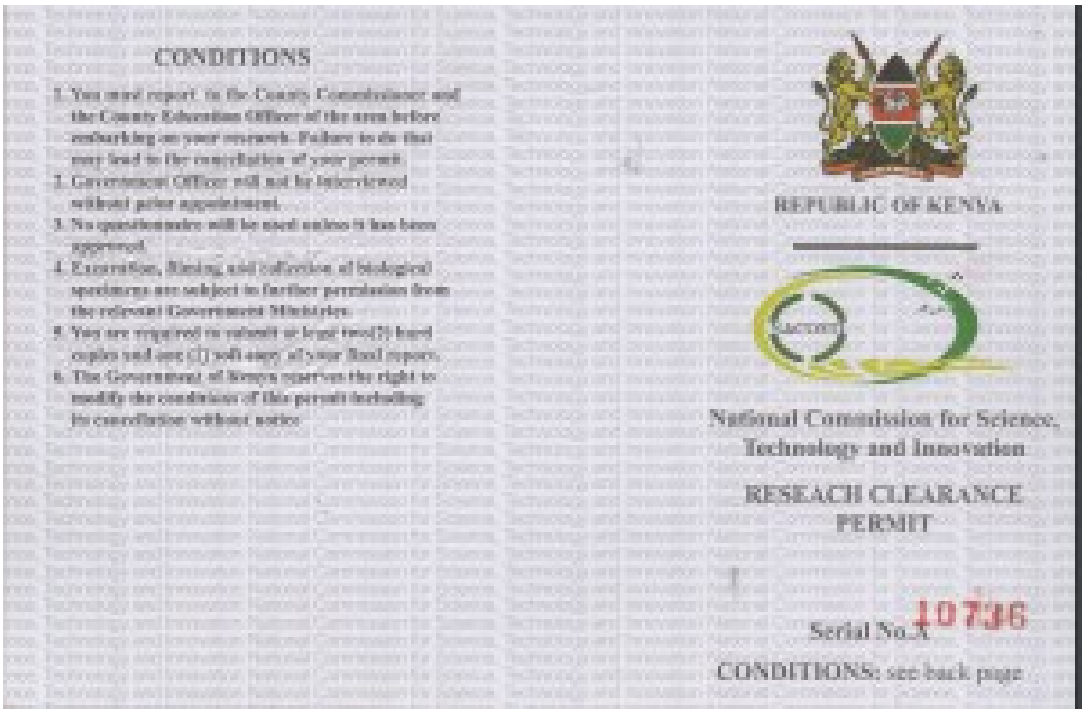
BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioners
All Counties.

The County Directors of Education
All Counties.

Appendix VIII: Research Clearance Permit



CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officer will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one (1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

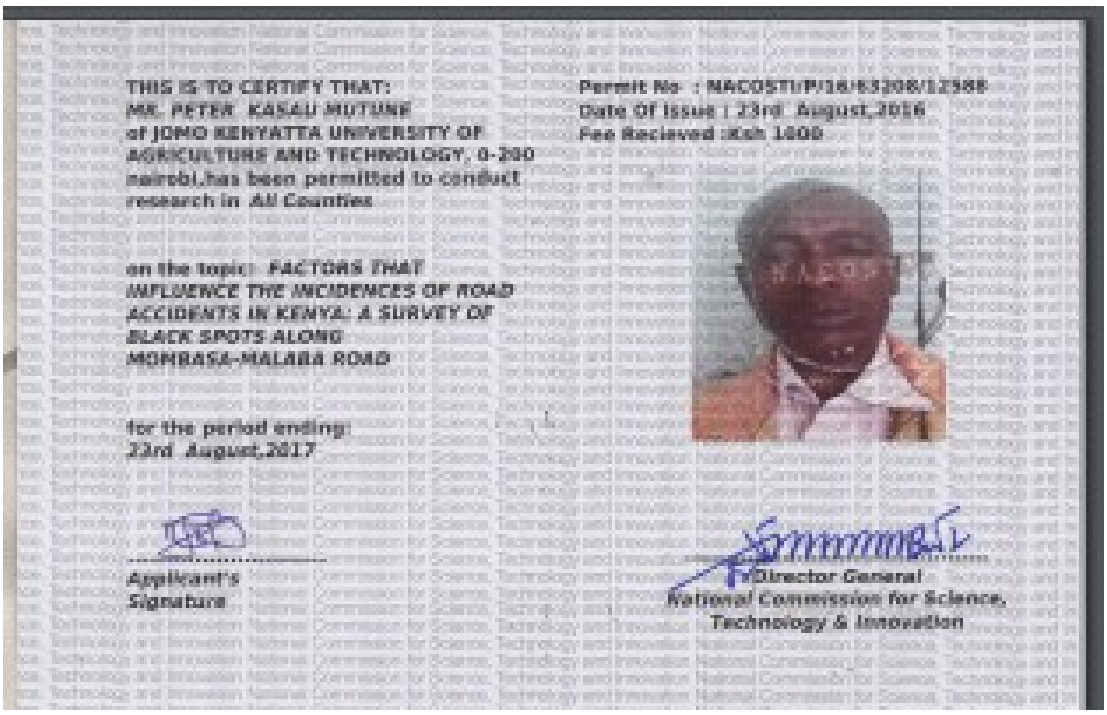
REPUBLIC OF KENYA

National Commission for Science, Technology and Innovation

RESEACH CLEARANCE PERMIT

Serial No.A 10736

CONDITIONS: see back page



THIS IS TO CERTIFY THAT:
MR. PETER KASAU MUTUNE
of JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, 0-200 nairobi,has been permitted to conduct research in All Counties

on the topic: FACTORS THAT INFLUENCE THE INCIDENCES OF ROAD ACCIDENTS IN KENYA: A SURVEY OF BLACK SPOTS ALONG MOMBASA-MALABA ROAD

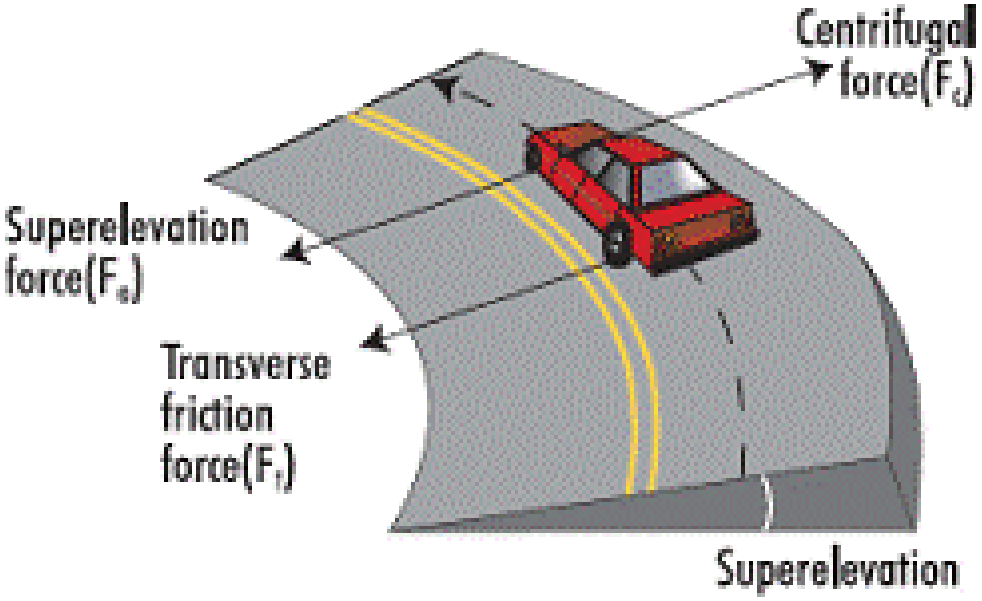
for the period ending:
23rd August,2017

Applicant's Signature

Permit No : NACOSTI/P/16/63208/12588
Date Of Issue : 23rd August,2016
Fee Recieved :Ksh 1000

Director General
National Commission for Science, Technology & Innovation

Appendix IX: Illustration of Elevation



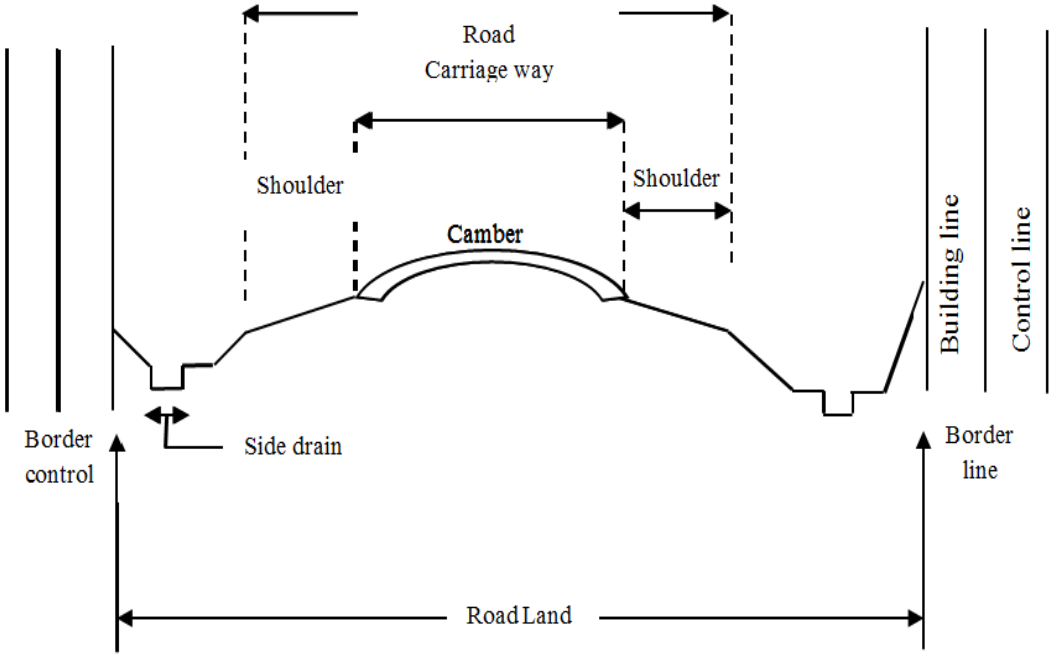
Appendix X: Illustration of horizontal curves

Appendix XI: Vertical Stopping Sight Distance at a Crest Vertical Curve

Appendix XII: Headlight Sight Distance ata Sag Vertical Curve

Appendix XIII: Sight Distance at an Undercrossing on a Sag Vertical Curve

Appendix XIV: Cross-section of a Typical Road



Cross-section of a Typical Road (Researcher own concept, 2015)