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"EVALUATION OF ROAD ACCIDENT COST FOR RWANDA: CASE STUDY NR1 (Kigali-Muhanga-Huye-Akanyaru road)"

A THESIS

Submitted by

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Under the Guidance of

Dr. Alphonse NKURUNZIZA

Submitted in partial fulfillment of the requirements for the award of

MASTER OF SCIENCE DEGREE

IN

HIGHWAY ENGINEERING AND MANAGEMENT

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COLLEGE OF SCIENCE AND TECHNOLOGY
SCHOOL OF ENGINEERING

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DEPARTMENT OF CIVIL ENVIRONMENTAL AND GEOMATICS ENGINEERING (CEGE)

DECLARATION

I, HAGENIMANA Jean Damascene, with Reg. No 221027986, from University of Rwanda College of Science and Technology, School of Engineering; Department of Civil, Environmental and Geomatics Engineering, following studies of Master of Science in Highway Engineering and Management Programme, hereby declare that this work is of my original and has never been submitted for any academic award in any other University or Institution or anyone else where he/she had the same purpose.

Name: HAGENIMANA Jean Damascene

Signature:

Date: ……/……. /2025

CERTIFICATION

This research proposal has been submitted with approval from the University supervisor (Main supervisor).

Main Supervisor

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ABSTRACT

The study on Road Accident Cost for paved roads with a case study of NR1, focused on the main purpose to evaluate road traffic accident costs for Rwanda. This research was carried out in partial fulfillment of the requirements for the award of a degree of Master of Science in Highway Engineering and Management at the University of Rwanda, College of Science and Technology. A population of paved roads in Rwanda with a sample of NR1 was used for the sample. The methodology adopted was descriptive research method employing secondary data collected from RTDA, district hospitals along NR1, insurance companies and traffic police in charge of road crashes. Findings of the research indicated that the most vulnerable of the road accidents were pedestrians who accounted for 5.4% of the total road accidents followed by passengers who accounted for 34.9% of the total accidents and riders accounted for 19.8%. On the other side, the most Hotspot that accounted most of the road accidents were Nyabugogo that accounted for 20.8%; other Hotspots 19.8% and Mukobwamwiza accounted for 15.7% of the total road accidents. The Hotspots that accounted the least road accidents were Nkoto; Kivumu and Ntenyo that accounted for 9.8%; 10.1% and 11.6% respectively, while Musambira accounted for 12.2% of the total road accidents. The minimum cost percentage was 18.7% of the total costs in 2021 while the maximum cost percentage was observed as 21.8% of the total costs of the road accident in 2024. accident by component reveals that the most contributing factor was the insurance cost that comprised of 59% of the total road cost accidents cost and the least contributing factor was the police intervention that contributed to 10% of the total road accident cost. This clearly shows that in 2020 road wasted the amount of $ 1,498,450 on road traffic accidents, and in 2021 road accident cost was estimated to $ 1,347,434 and in 2022 the amount of $ 1,323,259 were spent on the same, in a year of 2023 the amount of $ 1,348,513 were spent on the same while in year 2024 amount of 1,379,061 were spent on road accident cost. Research objective Three was about to assess road traffic accident costs level, model development and give the significance of traffic accidents for policymakers. The total road crash cost was composed by medical costs covering transportation, medication, surgery, bed charges rehabilitation and mortuary covering a total of $ 948,985 representing 33.8% of the total crash cost recorded for a period of 5 years from 2020 to 2024 along the highway NR1.The property damage costs were categorized into vehicle repair cost; detention period cost, and both public and private damage costs with a total of $ 1,162,728 comprising of 41.4% of the total road crash cost while the traffic police activities covered wages of policemen in the field of traffic accidents Cost of police vehicles, and police administration costs relevant to traffic accidents. The total cost for the same period of time was amounted for $ 697,000 which represent 24.8% of the total cost of the NR1 road crash costs for the same period of time.

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Key Words

ROAD ACCIDENT: This is an **unintended and unforeseen incident** that occurs on a public road, involving one or more vehicles, pedestrians, cyclists, or animals, which results in: **Injury, Death, Property damage,** Or a **combination of these.**

RTDA: Rwanda Transport Development Agency
RNP: Rwanda National police
RMF: Rwanda Maintenance Fund
HDM-4: Highway Development and Management Model Version-4

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LIST OF SYMBOLS AND ABREVIATION

UR: University of Rwanda

CST: College of Science and Technology

REG No: Registration Number

RNP: Rwanda National Police

RTDA: Rwanda Transport Development Agency

RMF: Rwanda Maintenance Fund

HDM-4: Highway Development and Management Model Version-4

KABCO:

K: Killed

A: Suspected Serious Injury

B: Suspected Minor Injury

C: Possible Injury

O: No Apparent Injury

DEDICATION

I dedicate my research work to my family and many friends. A special feeling of gratitude to my workmates and classmates whose words of encouragement and push for tenacity ringing in my ears.

I dedicate this research to my friends and church family who have supported me throughout the process. Their prayers have been listened by almighty God.

Thank you to everyone who supported me in one way or another. May the Almighty God bless you abundantly.

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CHAPTER ONE: GENERAL INTRODUCTION

1.1 Introduction

The rapid population growth and increasing economic and technological activities have resulted in the tremendous growth of motor vehicles and motorized transport as well. The enormous growth of the automobile sector leads to more accidents, then injuring and killing millions of people (Gebresenbet and Aliyu, 2019). The road accident has been estimated that over 1.3 million persons die and 50 million persons get injured every year in road accidents throughout the world (Gebresenbet and Aliyu, 2019; Ingabire et al., 2015).

In developing countries, millions of unemployed people migrate to big cities every year. Population growth and their economic development increase the purchasing power and it leads to more vehicle usage. This growth of private vehicles continues to increase road traffic accidents such as crashes at hotspots or bottlenecks (Wang et al., 2020). The vehicle movements disturbed by disproportionate speed, frequent interruptions and violation of traffic rules lead to blocking and accidents. It leads to cause injury, death, loss of property, and damages to vehicles. All these causes huge economical loss to humanity.

In developing countries, road accidents are generally given less attention among other transportation accidents compared to developed countries (Honelgn and Wuletaw, 2020). The rationale behind that road accidents seem to be less dramatic is their frequent occurrence in comparison to air crashes for example which occur rarely but, in most cases, result in involving the death of all occupants (passengers and crew members).

1.2 Background of the Research.

In the last couple of decades, predicting accidents has been a major topic in traffic safety (Cavadas et al., 2020). (Eun, 2020) in his research said that road traffic mortality and injury can be influenced by different ages, periods, and cohorts as few studies have demonstrated. Road traffic accidents are the main cause of death and premature death worldwide. Socioeconomic changes that include education for all, economic development, the implementation of road safety, and public health policies are known to lower the rate of mortality and traffic accidents related to death. However, as found in Korea, road traffic accidents and mortality remain high. Perhaps if nothing special is done, mortality might increase in the future.

Road safety, public health policies have to address these issues. In highway development and management tool (HDM-4) (Bagui and Ghosh, 2015), road accident costs have been included in its model

analysis, however, local calibration on road traffic accidents cost is still missing because no aggregated data to be used. (Gebresenbet and Aliyu, 2019) found that among enormous global health public problems, road traffic accidents are on lead, killing approximately 1.25 million people and injuring 20 to 50 million yearly. Road traffic accidents are categorized into three categories: Fatal, Injury, and Property damage only (Hejazi et al., 2013).

Any of this category or form should be assessed and costs are categorized accordingly. Some models developed involve parameters such as the number of traffic accident fatalities, number of traffic accident injuries, and finally 'blood price' or 'blood money' or 'cost of living'. However, they miss important parameters such as police records and operations cost, and insurance companies. Road traffic accidents are the 10th leading cause of death universally and the number one cause of young population mortality between the ages of 5 and 29. A road traffic accident is predominantly affecting the economically active young population. Most of the accidents on road were attributed to non-use of seat-belt and non-worn by bicycle/ motorcycle drivers on the use of the helmet (Siebert and Lin, 2020).

1.3 Research problem.

After (Hejazi et al., 2013) researches, the road accidents cost in many countries is said to be about 1% of the gross national income. This is a rule of thumb that ignores the level of economic development and the rate of motorization. (Honelgn and Wuletaw, 2020) stated that government transport police in collaboration must put due attention to road traffic accidents as well found to be the major public health problem. For instance, (Ingabire et al., 2015) in their research in Rwanda, found that motorcycle injuries constitute major public health in developing countries. In some countries including Rwanda, males were more affected than female sex, about 53% of motorcycle accident youths were involved (Gebresenbet and Aliyu, 2019; Ingabire et al., 2015).

However, in their studies, (Ingabire et al., 2015) found that motorcycles are still increasing and continue to take a high portion in traffic movement of Kigali roads. Few studies have been conducted on the severity of road traffic death and injuries in Rwanda but almost no studies on road traffic accidents costing to detailed road traffic accidents forms and include all possible operation costing to deal with road traffic accidents in Rwanda. The objective of this study is to conduct an assessment of road traffic accident costs and to develop a model for future prediction if the situation is left unsolved or become worse than the current situation.

1.4 Research Objectives.

This research study was guided by both main objective and specific objectives.

1.4.1. The General objective

The general objective of this research is to evaluate road traffic accident costs for Rwanda.

1.4.2. Specific Objective

To well conduct this research, the following three study specific objectives will be achieved

1. To assess accident fatal, injury, and property damage levels for NR1 highway with 157Km long.
2. To assess traffic police activities, medical services and insurance costs all related to road traffic accidents;
3. To analyze road traffic accident costs over time and, model development and give the significance of traffic accidents for policymakers.

1.5 Research Questions

The research generally answers the question of what is the monetary value or cost of road traffic accident for Rwanda. To achieve this, we need to answer the following specific questions:

1. At which level are the fatal, injury and property damage accidents for National Roads in Rwanda?
2. What is the cost of traffic police activities, medical services and insurance related to road traffic accident costs?
3. What is the trend of road traffic accident cost overtime, the suitable projection tool and awareness of traffic accident by policy-makers?

1.6 Significance of the study

1.6.1. Road users

The road users shall benefit from this study as adequate policies and strategies regarding road safety shall be developed and their implementations shall reduce road accidents, their costs both economic and social costs as well as the promotion of effective use of roads as platform of all road users

1.6.2. Transport policy makers

Transport policy makers shall benefit from the findings of this study as they shall rely on current issues of road accidents, their root causes, improve and save both lives of road users, both public and private properties damages that cost much Rwandan economy as whole.

1.6.3. Transport infrastructure developers

Transport infrastructure developers shall benefit from this study as the root causes including infrastructure designs is approached to various road sections. Hence infrastructure design improvement so as to meet standards requirement for road accident reduction

1.6.4. Insurance companies

Insurance companies shall benefit from this study since road accident costing methodologies are approached and this shall give them opportunities to improve their road accident costing methodologies.

1.6.5. Traffic Police

The Rwanda National Traffic Police shall benefit from this study as road accident costing includes methodology to cost police activities in relation to road accident, that include vehicle costs, personnel costs and administrative costs so as to value the total cost of road accident. Again, they shall benefit from this study as they shall manage their scarce resources in optimum allocations so as to benefit from trade-off between road accident costs and preventive cost, hence to optimize police traffic activities related to road accident costs.

1.7 Scope of the Study

1.7.1. Content

The research study was focused on the evaluation of road accident cost in Rwanda by accident types and severe using KABCO classification.

1.7.2. Geographical coverage

This study was limited to the National roads with a focus on NR1 highway with 157Km that touches on Nyarugenge, Kamonyi, Muhanga, Ruhango, Nyanza, Huye, and Nyaruguru districts

1.7.3. Time coverage

The research study covered road accident data for a period of 5 years from 2020 to 2024. A data-set for 5 years was enough for road accident modelling so as for the future predictions.

1.8 Theoretical Framework.

As described by (TRB, 2008) Crash costs can be divided into internal (damages borne by the individual vehicle user), external (damages and risks borne by other road users), and insurance

compensation (damages compensated by insurance). Insurance compensation costs are external at the individual level but internal to premium payers as a group. When non-market costs such as pain or lost quality of life are compensated by insurance or litigation, they become market costs. As mentioned earlier, such compensation rates are generally not a good indication of the full value of reducing road accident damages.

The main way of evaluating the costs of road traffic accidents mostly adapts a method called the Human Capital method. The Human Capital method posits two broad categories of costs (Osterhaudt, 2002): Direct and Indirect. Direct costs represent the actual dollars spent or anticipated to be spent providing medical care to the injured or ill person and administrative costs for delivering medical care and delivering indemnity benefits. Direct costs are frequently referred to as “accounting” or "out of pocket" costs. Indirect cost is the other hand are not “accounting” or "out of pocket" " they represent forgone opportunities for the injured or ill person, their family, employer, co-workers, and society at large (Osterhaudt, 2002).

This research will be focusing primarily on this Human Capital method of road traffic accident costs including other traffic services costs. All costs for accidents will be estimated for a period of five years from 2020 to 2024.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Everyone in this world travels mostly from different origins to various destinations, however, safety perception during the journey to a destination and from origin brings impact on safety behavior. People need safety climate, environment, and route safety is very important because road accidents affect people's economy, psychology (trauma), and pose long-term consequences and frequently death and are a burden to the country (Xia et al., 2020). (Yuan et al., 2020) described on road traffic accidents that frequently happens and is human behavioral dependent, side crash, Side crashes between vehicles usually lead to high casualties and property loss. Injury severity of side crashes at intersections and factors associated were provided and countermeasures developed using the Bayesian approach and bivariate model were proposed (Yuan et al., 2020). Correlation between striking and struck vehicles inside crashes was found. Yuan et al continued describing how drivers are the most important factors causing crashes. In this research, the focus will be put on how road traffic accidents cost analysis will be done given aggregated data, information on economic loss due to road traffic accidents will implicate proposed countermeasures such as strengthening safety, education, and training of drivers re-invested in. The latter measures were found of great importance (Yuan et al., 2020).

2.2 Overview and causes of road traffic accidents

In their research in Kigali city, (Wang et al., 2020) found that road traffic crashes were in the city center with high motor vehicle density. High crush risk locations were unpaved roads and narrow roads with about 42% and those locations were also more likely not to have pedestrian walkways. As traffic service is vital to boost the economy and has socio-economic benefits, road accidents costs are needed to be evaluated to reveal tangible information and provide model and countermeasures establishments, and to evaluate their significance. In their study, (Sagberg et al., 2020) found that crashes occur on approaching or entering of junction, bridges, and countermeasures against these accidents crash are attention to be paid to the approaching zones and to design barriers.

Major sources of accidents in manual driving are alcohol consumption; false understanding of driver's responsibility pose the risk of accidents even in the new automated driving system. Thus, the approach of road traffic cost evaluation is needed to be thought at each level of highway development and management to the local situation on an updated basis (Wiedemann et al., 2018). After (Rolison et al., 2018), for young drivers, inexperience, lack of skill, and risk-taking behaviors are factors while visual cognitive and mobility impairment have been associated with the collisions of older drivers. They revealed that potential underreporting factors contributing to road accidents such as possible inadequacies

in law enforcement practices for investigating driver distraction, drug, and alcohol impairment, uncorrected or defective eyesight.

In developed countries such as the US, improving roadways gave a solution for motor vehicle crashes in the US and as a whole has decreased over past few years, however, fatality among vulnerable road users have increased, what a situation! In one way or another, this increase in fatality accidents continues to burden transportation specialists, public health professionals, and community stakeholders. All around the world, road accidents cost has been increasing and brings struggle due to uncertainty on policy planning, and provide measures to reduce this fatal challenge. Drug usage, driver's irresponsibility, overtaking, and speeding is major causes of road accidents, and those questions need to be addressed by policymakers, infrastructure planners, and educationalists (Thomas et al., 2020).

In their research, (Stipancic et al., 2020), their model confirmed the positive relationship between pedestrian and vehicle volumes and pedestrian injuries. Human life is the costliest and brings emergency care services to save lives. Considering road geometric features, curb extensions raised medians, and exclusive left-turn lanes were all found to significantly reduce pedestrian injuries. (Siebert and Lin, 2020) concluded in their research that safety issues continue to arise as long as bicycles and motorcycles are the main forms of transportation. Training on bicycle and motorcycle helmet use needs to be reinforced through different campaigns.

With the evaluation of road traffic accidents cost, all actions and inputs towards transportation facilities improvement will be assessed and quantified regarding saving lives and extreme reduction of accident costs.

2.3 Valuing Accidents

Traffic accidents (also called crashes or collisions) can impose various types of costs (TRB, 2008): Property damages; Emergency services; Traffic delays; Medical and rehabilitation care; Lost productivity and disability compensation costs; Pain, suffering, and grief.

Some of these are market (also called economic) costs, which involve goods commonly traded in competitive markets such as vehicles and repair services. Others are non-market costs, which involve goods not normally traded such as pain, suffering, and grief. In some crashes, a portion of non-market costs is compensated, which makes them market costs, for example, if insurance pays for pain and suffering damages. A comprehensive evaluation should include all of these categories of costs.

Crash cost analysis involves two steps. First, quantify physical impacts, such as the number of crashes that occur, the number and severity of vehicle damages, human injuries, disabilities, and deaths. Second, monetize (measure in monetary values) these impacts, based on techniques described below.

Most transportation agencies have established standard values to be assigned to human injuries and deaths. These should generally be used in economic evaluation. However, these standard values sometimes only include "market" (or "economic") values and so do not reflect the full value that people place on an incremental change in safety, as described below. More recent research tends to place a higher value on crash costs and therefore safety benefits. It may therefore be useful to report the official values plus more comprehensive estimates that include non-market values when evaluating transportation projects (TRB, 2008).

2.4 Monetizing Human Life and Health

Various techniques are used to monetize human health and life (EDRG, 2002; TRB, 2008): Human life is not a commodity: most people place virtually infinite value on their lives (they would not willingly die for any size payment), but many decisions involve trade-offs between marginal changes in risk and money. For example, vehicle purchasers must sometimes decide whether to pay extra for safety equipment, such as airbags, that provide small safety gains. Such trade-offs indicate the value consumers place on marginal changes in risk, described as *willingness-to-pay or willingness-to-accept*. For example, if consumers pay an average of $100 for optional safety equipment that reduces their chances of crash injury by one-millionth, then other strategies that provide equal safety benefits for the same financial investment can be considered cost-effective.

Willingness-to-pay usually results in lower values than willingness-to-accept due to budget constraints. For example, consumers may value increased safety but cannot afford to pay for it, so willingness-to-pay values are low, yet they would be unwilling to accept reduced safety in exchange for a financial reward, so their willingness-to-accept values are relatively high. Assuming that people have a right to live without injury from others, crash cost values should be based on *willingness-to-accept*, that is, the compensation a person would require before he or she would volunteer to experience such damages.

Society's willingness-to-pay to avoid crash damages tends to be greater than what is reflected by simply summing crash compensation or vehicle insurance payments since many crash damages (particularly for non-market damages such as pain, suffering, and lost-quality of life) are not fully compensated. For example, if a person with no dependents dies in a crash, minimal financial compensation may be paid. Similarly, injuries to drivers considered legally responsible for a crash (such as a drunk driver) are often uncompensated, yet society still considers these lives to have value and devotes resources to preventing such crashes and reducing such injuries. Many jurisdictions have injury claim limitations and various types of no-fault insurance systems which effectively limit crash claim payments below what the legal system would otherwise deem fair compensation, to make vehicle insurance more affordable. Willingness to pay to avoid traffic fatalities is generally much greater than average crash fatality compensation.

Rather than just measuring human deaths, some studies evaluate risks based on Potential Years of Life Lost (PYLL) or Disability Adjusted Life Years (DALYs), which account for age differences in when people are harmed. Vehicle crashes tend to injure people at a younger age than other common health risks such as heart disease and cancer (the average age of death from motor vehicle crash is 39 years, compared with 71 for all causes), and so impose a relatively high cost per death or disability (EDRG, 2002; Osterhaudt, 2002; TRB, 2008).

Two general perspectives are used in crash cost studies, reflecting the scope of impacts that are considered (Osterhaudt, 2002): The Human Capital method measures only market costs (property damage, medical treatment, and lost productivity). This typically places the value of saving human life at $0.5-1 million, with lesser values for injuries.

The Comprehensive approach adds non-market costs, including pain, grief, and reduced quality of life, as reflected by people's willingness-to-pay for increased safety (i.e., reduced risk of crashes and reduced crash damages), or willingness-to-accept increased crash risk and damages. It is a more appropriate measure of the true cost to society of crashes, and the appropriate value to use when assessing crash prevention.

There is some variability in these cost values since analysis results depend on how research is conducted and the economic and demographic attributes of the population under consideration (for example, values are generally considered higher for people in the prime of life than for people who are older and so can expect to live fewer years). (Blincoe et al., 2002) state that the value of a fatality lies in the range of $2-7 million, and assign a "working value" of $3,366,388. This suggests that a reasonable range is from about 40% lower to about 200% higher than their assigned values, at least for crashes involving significant non-market (quality of life) damages (EDRG, 2002; Litman, 2003).

2.5 Crash Cost Distribution

How crash costs are distributed is an important issue for some types of analysis (Baratian-Ghorghi et al., 2016; TRB, 2008). Individual actions and public policies sometimes shift crash costs from one group to another. For example, motorists who purchase larger vehicles may increase their safety, but increase risks to other road users. Public policies may reduce compensation provided to crash victims, which reduces insurance costs but increases uncompensated damages borne by individuals.

It is important to track these economic transfers. Crash costs can be divided into internal (damages borne by the individual vehicle user), external (damages and risks borne by other road users), and insurance compensation (damages compensated by insurance). Insurance compensation costs are external at the individual level but internal to premium payers as a group. When non-market costs such as pain or lost

quality of life are compensated by insurance or litigation, they become market costs. As mentioned earlier, such compensation rates are generally not a good indication of the full value of reducing crash damages. The more appropriate indicator of non-market crash costs is individuals' willingness-to-accept marginal changes in crash risk. The table below indicates the distribution of various crash costs.

2.6 Crash Costs for Highway Safety Analysis

Table 1. Crash Cost Categories (TRB, 2008)

Distribution	Market	Non-Market
Internal	Safety equipment expenditures. Uncompensated property damages, lost income, and medical treatment costs to users. Insurance deductibles.	Uncompensated pain and lost quality of life to crash victims.
External	Uncompensated property damages, lost income, and medical costs to nonusers. Emergency response and crash prevention expenditures.	Uncompensated pain and lost quality of life borne by nonusers. Uncompensated grief to victims' loved ones. Reduced non-motorized mobility.
Insurance	Property damage lost income and medical treatment compensated by insurers.	Pain, grief, and lost quality of life are compensated by insurers.

This table indicates how various crash costs are categorized. Some are market, others are non-market. Some are internal, others external. Insurance compensation costs are external to individuals but internal to motorists as a group.

When crashes involve different vehicle types, such as pedestrians hit by automobiles or automobiles hit by trains, it is common to consider the larger vehicle responsible for most crash costs, since it imposes greater damages, regardless of which driver is legally responsible. (Elvik, 2011) defines three types of crash externalities: System externalities: crash damage costs impose on society: property damages, emergency, and medical services lost productivity, etc. Physical injury externalities: costs larger vehicles impose on smaller vehicles and pedestrians. Traffic volume externalities: marginal changes in crash risk from changes in traffic density

In many countries, the Road accident fatality cost estimates are calculated based on taxonomy of valuation methods developed by (Krupp et al, 1993). In the report by (Krupp et al., 1993), where a distinction was made between three varieties of the human capital approach: the gross loss of output approach, the net loss of output approach, and the value of time approach. Two varieties of the willingness to pay approach were identified: The individual willingness to pay approach, and the social willingness to pay approach. The cost components are grouped into three categories: the human cost category (loss of productivity, quality of life, and medical cost), the property damage cost category (vehicle and non-vehicle damage), and the general traffic accidents cost category (administration cost, environmental impacts cost and travel delay cost).

2.7. Loss of Productivity for fatalities

This type of road crash cost is estimated using the loss output formula as in equitation (1) as follows:

$$\text{Loss output} = \sum_{i=1}^{n} \frac{W(1+g)^{I}}{(1+r)^{I}} \qquad (1)$$

where W is the average yearly per capita GDP, r is the discount rate, g is the growth rate of the economy, and I is the average number of years of loss output per fatality accident.

2.7.1 Serious Injuries, Slight Injuries

The loss of productivity of the serious injuries or slight injuries are estimated by multiplying the off-work period in days by the average gross earning per day. This reflects pain, grief, and suffering experienced by victims of traffic accidents, and by their families and friends. According to (Silcock and TRL, 2003) the cost component for pain, grief, and suffering are estimated as: Fatal Accidents: 28% of loss of productivity of fatalities; Serious Injuries: 50% of loss of productivity of serious injuries; and Slight Injuries: 8% of loss of productivity of slight injuries.

2.7.2 The medical costs

This includes in-hospital patient costs covering operations, x-rays, medicines, doctor services, food and bed. On the side of Property damage costs, this covers vehicle damage Cost which is calculated as the average cost of vehicle repairs multiplied by the average number of vehicles involved in the crash; the non-vehicle damage cost which includes traffic Signs; traffic signals; concrete Barriers; and lampposts.

2.7.3 The general accident costs

This type of cost covers administration costs (police service and insurance administration cost). Due to the complexity in the estimation of this cost, the equation recommended by (Silcock and TRL, 2003) is used to calculate this value in this study. Total resource cost = Human Cost Category+ Property Damage Cost Category.

Fatal accidents 0.2% of total resource cost, serious injury accidents 4.0% of total resource cost, slight injury accidents 14 % of total resource cost, PDO -Property Damage Only- accidents 10 % of total resource cost.

2.7.4 Environmental impact costs

This includes the damage on trees and palms that used to decorate streets and roundabout.

2.7.5 Travel delay costs

Travel delay cost is the cost incurred to travelers due to the delay caused by traffic accidents. A traffic accident may partially or fully block the carriageway. Even if there is no blockage, some drivers may reduce speed or may stop to offer assistance. After accident investigations and clean-ups would also restrict traffic flow. Three factors are found to affect traffic accident travel delay costs which are level of road blockage, traffic flow conditions, and clearance and emergency response time.

$$C_t = T^2 x V x L x X x W \qquad (2)$$

Where: CT-Travel Delay Cost for each accident (KD/accident), T-Travel Time Lost (Minute), V-Traffic Flow (Ve/Hr/Lane), L-Level of Blockage (Lane), O-Occupancy Rate (Passenger/Vehicle), W - Average Wage Rate (KD/Hour)

Hence, the total Traffic crash accident by human capital approach is estimated by the equation

TC=Human Costs Category + Property Damage Costs Category +General Crash Costs Category (3)

2.8 Research gap identification

Road traffic accidents cost depends on traffic police operation costs during accident emergency, hospital and medical services, insurance, and compensation costs. The compensation costs depend on the country's GDP. Local researches on road traffic accidents still have a gap on this subject of costs as whole concerns and it is still not applicable to model and do project analysis to quantify road users' benefits and reduction in road accident costs through highway development and management tools such as HDM-4.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

With the fast growth of traffic, the road accident rate in India is increasing at an alarming rate (Ingabire et al., 2015; Wang et al., 2020). Road accidents cause huge economic loss to society by way of loss of output by fatal and injured victims; expenses incurred in medical treatment; administrative costs of police, insurance companies, and accident claims tribunals; and damages to vehicles and property. The study roads are main bituminous paved roads or urban and national roads where often mixed traffic occurs with haphazard traffic movement to collect traffic composition and movement characteristics. This study aims to evaluate road traffic accident costs, estimate accidents cost ranges per accident category, and provide a model to predict accident costs.

The presented methodology for accounting for the costs caused by road accidents is based on the fact that a person who died or was injured in a traffic accident will not contribute to the economic welfare of the country anymore or his/her contribution will reduce. Broken vehicles, damaged cargoes, or defected road constructions cause huge losses to the state. A financial assessment of material losses caused by road accidents enables providing a feasibility report concerning the efficiency of newly introduced traffic safety measures. The aim of the presented methodology is an establishment of the road accident costs that would conform to today's economic level of Rwanda. The developed methodology for accounting road accident costs will enable a more precise assessment of the necessity, perspectives, and priorities of investment projects in the transport system as well as an accomplishment of funding allocation tasks.

3.2 Research design

In this chapter, there is a methodology that was used to achieve the aim and objective of this research, literature review is discussed above to give an overview of road traffic accident costs experience in different countries and Rwanda. It also described the way data collection and analysis has to be conducted.

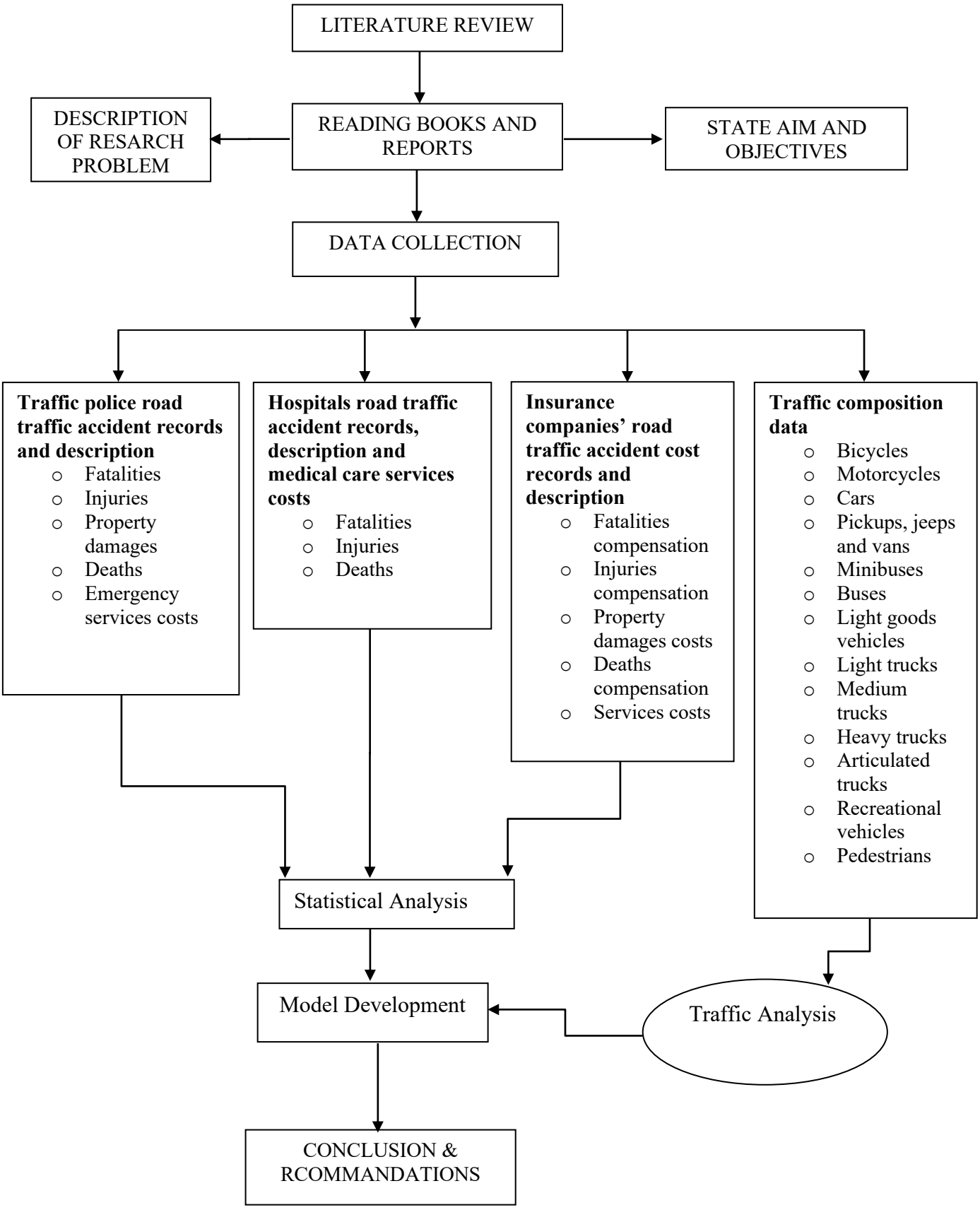
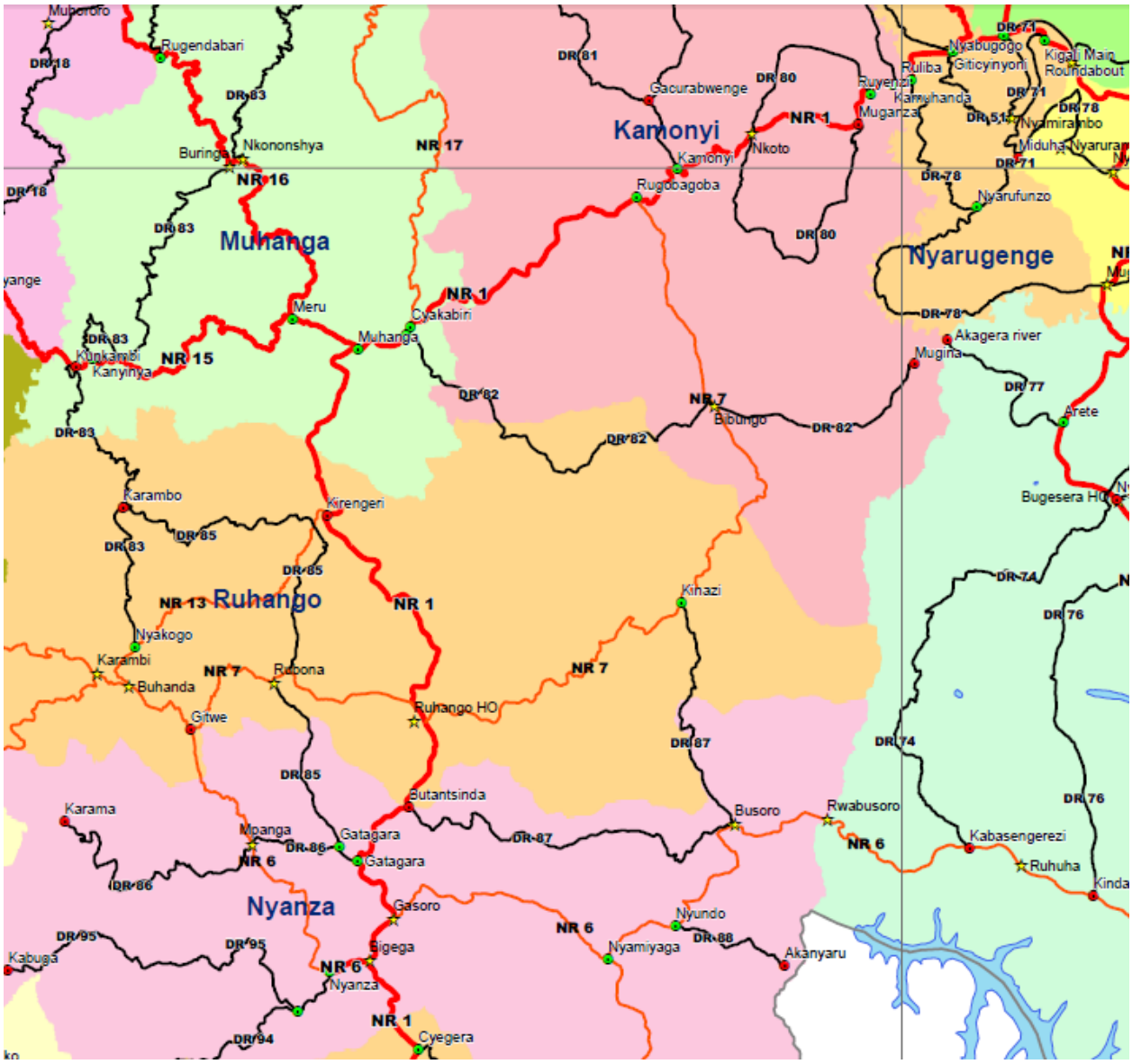


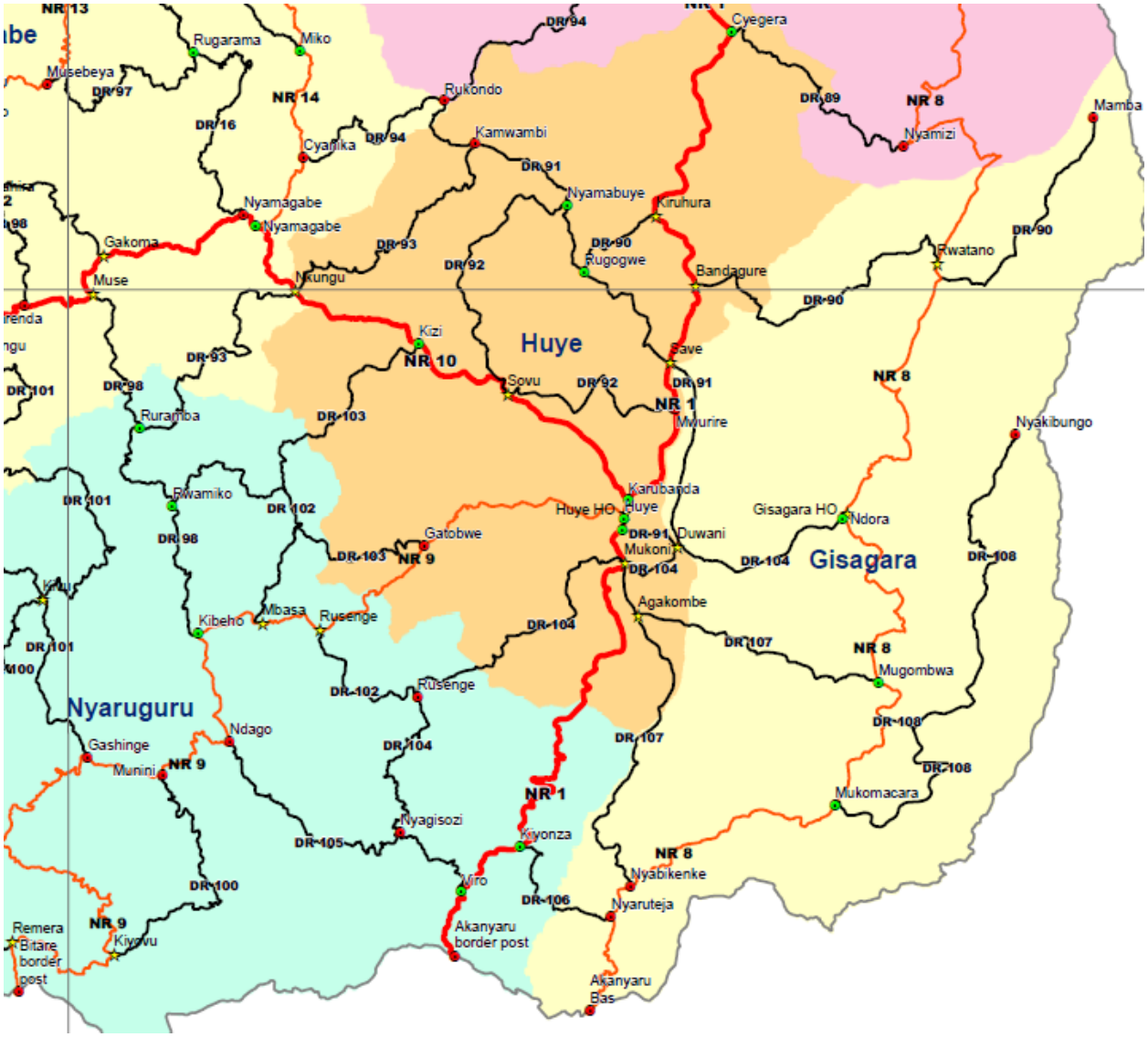
Figure.1 Chronology of research methodology

3.3 Area of study

This thesis concerns the bituminous paved roads in Rwanda extrapolated from identified hotspots zones on NR1 (Kigali-Muhanga-Huye-Akanyaru, 157km paved road).



Source:
Rwanda Road Network map 2015 from RTDA (Section from roundabout, Nyarugenge District to Cyegera, Nyanza District).



Source:
Rwanda Road Network map 2015 from RTDA (Section from Cyegera, Nyanza District to Akanyaru border post, Naruguru District).

3.4 Data sources and Materials

During this research, desk review from the road agencies like Rwanda Transport and Development Agency (RTDA), traffic police department, district hospitals of which NR1 connect districts were reviewed as secondary data and property damage payment and compensation were collected from insurance companies.

3.5 Sample size

The required number of data was based on traffic recording periods. The Time interval of data to be collected was made by calculations using statistics formulas. The calculation of sample size depends on the sampling design and the indicator as well as the size of the population in study. The width of the confidence you have to achieve to meaningfully interpret your estimate. To prevent bias, the authors tried

not to achieve higher precision at the expense of introducing bias. Better we had a smaller sample size with less precision but much less bias (www.alnap.org, 2012). The time interval was taken from 2020 to 2024. To determine the sample size for road sections, the following formula was used:

$$N = (\frac{Z x S}{d})^2 \quad (3.1)$$

Where N is the sample size, Z is linked to a 95% confidence interval (use 1.96), S is sample variance and d is relative desired precision (Washington et al., 2011). The assumption of low flow variation (CV=0.05).

3.6 Sampling strategy

The simple random sampling techniques was used to obtain the paved national road recording high road accidents compared to other paved national roads. This technique was used as it gives equal chances to all expected individual paved national road. So, NR1 was used from other ten paved national roads due to its length and number of road accident recorded for a period of 5 years (Rwanda Road Network Map, 2015).

3.7 Data analysis

The statistical analysis adopted was the use of statistical analysis tool such as SPSS version 12, variables will be defined and tested, and multiple linear regression analyses will be done to analyze variable correlation and develop multiple linear models that are the best fit using R squared value and gives high confidence level (Washington et al., 2011).

3.9 Results

The results have been presented in tables, graphs and diagrams in chapter four of this thesis report. The main outcome of this research to satisfy the main objective is the best fits models to predict accident cost and an establishment of the road accident costs that would conform to today's economic level of Rwanda.

3.10. Limitations of the study

From the research questions, some technical terms used were explained in brackets for better understating for the respondents, the sample size of NR1 comprising of 117 Km out of the total number of paved roads comprising of 2, 038 km that should not reflect the accurate road accidents in Rwanda and this required very much accurate findings for the sample used of 117km. There was a limitation of proper methodology to estimate the road cost accident for traffic police crash cost component, and this was done by estimating the number of police officers involved in road accident, their salaries, vehicles used and respective costs as well as administrative cost estimated by 20% of each crash accident.

CHAPTER FOUR: RESEARCH RESURTS AND DISCUSSION

4.0 Introduction

This chapter depicts both demographic characteristics of the road accidents, by age group, gender, and road accident by gender, education and their job occupations as well as road accident characteristics by hotspot. It again presents the crash types using KABCO injury classification and their root causes. This chapter estimates the crash cost per year for a period of Five years from 2020 to 2024, whereby crash costs are estimated both in causality related costs and other accident-related costs for the same period of time. From this chapter, crash cost estimation model including human costs and other related crash cost so as to compare the crash cost estimates that should be recorded.

4.1. Demographic data analysis

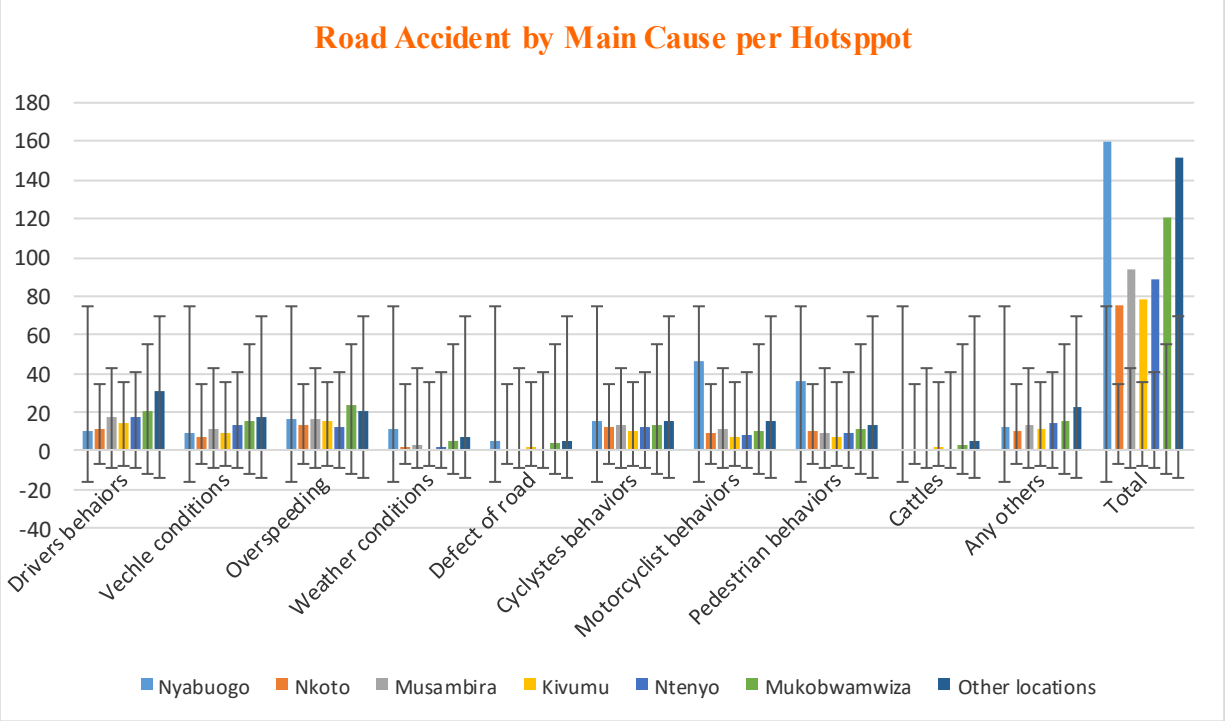


Figure 2: Demographic Characteristics of the road accidents for a period 2020-2024 per Hotspot

Source: Researcher's secondary data Analysis 2025

From Fig.2. summarizes the demographic characteristics of root causes of the road accidents per Hotspot for NR1(2020-2024).Results revealed that the most contributing factor to the total road accidents for that period were drivers behaviors and over-speeding that accounted for 15.7% and 15.1% respectively, followed by motorcyclist behaviors that contributed 13.7% of the total accident, and any other factors that were not identified that accounted for 12.7% and pedestrian behaviors that contributed 12.3% and

cyclists behaviors contributed 11.6% of the total accidents for that period of time. Vehicle conditions contributed 10.5% of the total accidents while the least root cause of the road accident were cattle, defect of road and Weather conditions that contributed 1.7%, 2.2% and 4.0% respectively of the total road accidents for the period from 2020 to 2024. Again, results of the characteristics of the road accidents per hotspot revealed that the most road accidents were recorded at Nyabugogo Hotspot counting for 20.8%; followed by other locations that accounted for 19.8% and Mukobwamwiza that accounted for 15.7% of the total accidents and Musambira with 12.2% and Ntenyo with 11.6% of the total road accidents that were examined. The least contributing Hotspot were Nkoto and Kivumu that accounted for 9.7% and 10.1% respectively.

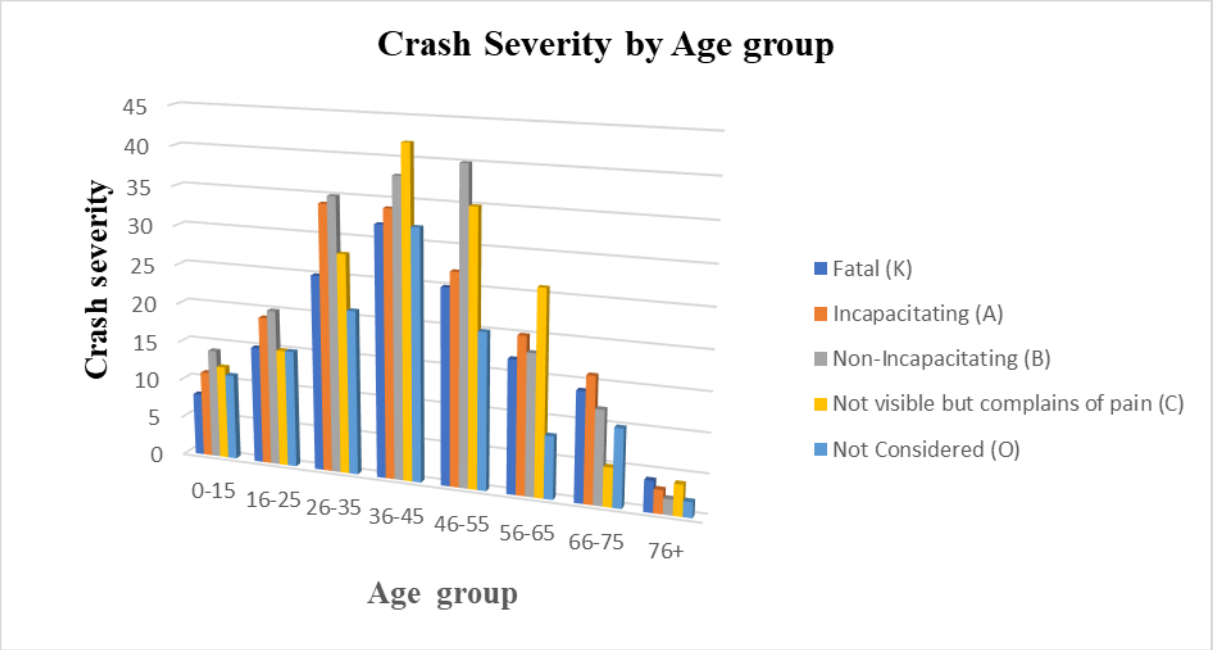


Figure 3 Distribution of road accidents from 2020 to 2024 by Age Group

Source: Researcher's secondary data Analysis 2025

Table 2. Distribution of Crash Severity by Age group

Crash by Age Group	Fatal (K)	Incapacitating (A)	Non-Incapacitating (B)	Not visible but complains of pain (C)	Not Considered (O)	Total	%
0-15	8	11	14	12	11	56	7.3
16-25	15	19	20	15	15	84	11.0
26-35	25	34	35	28	21	143	18.6
36-45	32	34	38	42	32	178	23.1
46-55	25	27	40	35	20	147	19.1
56-65	17	20	18	26	8	89	11.6
66-75	14	16	12	5	10	57	7.4
76+	4	3	2	4	2	15	2.0
Total	140	164	179	167	119	769	100
% of Severity	**18.2**	**21.3**	**23.3**	**21.7**	**15.5**	**100**	

Source: Researcher's secondary data Analysis 2025

From Fig3 and Table 2 representing the distribution of crash severity by age group, results revealed that the most crash severity was non- incapacitating (B) with 23.3% and incapacitating (A) of 21.3% and fatal (K) with 18.2% of the total crash severity while the least crash severity was not considered (O). Again, Table 2. shows that the most crash severity group age was 36-45; 46-55 and 26-35 with 23.1%; 19.1% and 18.6% respectively while the least crash severity was found to be 76+; 0-15 and 66-75 groups with 2.0%; 7.3% and 7.4% of the total crash severity respectively. The crash severity group age of 56-65 and that of 16-25 comprised of 11.6% and 11.0% respectively.

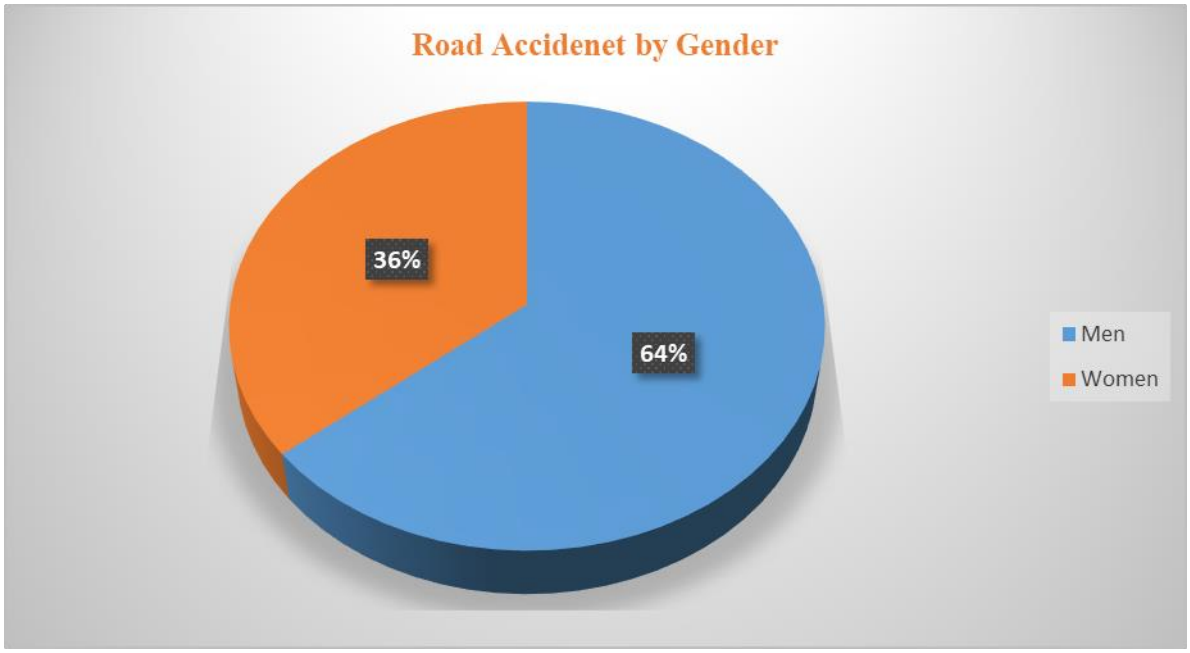


Figure 4: **Distribution of road accidents by Gender from 2020 to 2024**

Source: Researcher's secondary data Analysis 2025

From the fig 4, representing the distribution of accidents by gender over the five years period from 2020 to 2024; results revealed that 64% were men and 36% were women. These results are explained by the fact that men do more trips to find means for survival and family care than women, and they are engaged in riskier behavior than women and they are much involved in driving than women most especially in public transport.

Table 3: Distribution of road accident by gender from 2020 to 2024

Crash by Gender	Total	%
Men	493	64.1
Women	276	35.9
Total	769	100

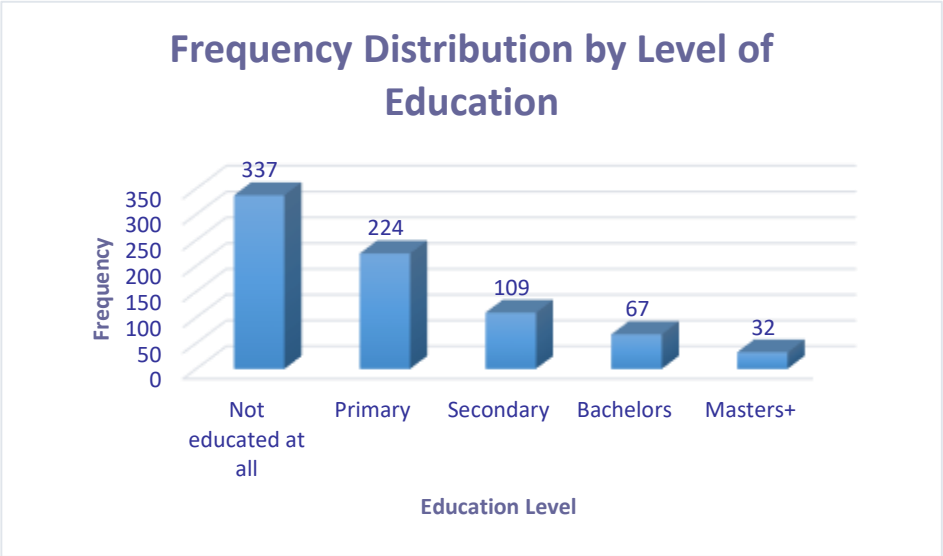


Figure 5 Distribution of Respondents by level of Education

Source: Researcher's secondary data Analysis 2025

Table 4: Distribution of Respondents by level of Education

Education level	Frequency	%
Not educated at all	337	43.8
Primary	224	29.1
Secondary	109	14.2
Bachelors	67	8.7
Masters+	32	4.2
Total	769	100

Source: Researcher's secondary data Analysis 2025

Both Table 4 and frequency diagram Fig 5 show that the most vulnerable of road crashes from NR1 were people who did not attend any level of education with frequency of 337 crashes followed by primary education with 224 crashes and secondary education with 109 crashes. The least crashes were observed from bachelors and master and above. This effect of level of education on road crashes is due to the fact that educated people's behavior is very much attentive to road codes of conduct, and have been mobilized on road safety by different organs, and they are experienced in terms of road use, hence reduces the level of road crashes. On top of that, the level of education to both drivers and non-drivers contributed to the road users' behaviors in a way that low and medium educated drivers recorded many road crashes compared to high educated ones. Regarding non drivers, as age group contributed to road crashes and age group is correlated with level of education, this explains how more educated people did not record many road crashes as compared to low or medium education levels. Again, as level of education correlates to age group and age increases awareness and experiences in terms of road use, and road as a platform of all road users, this gives explanations on the level of education to the reduction of the road crashes.

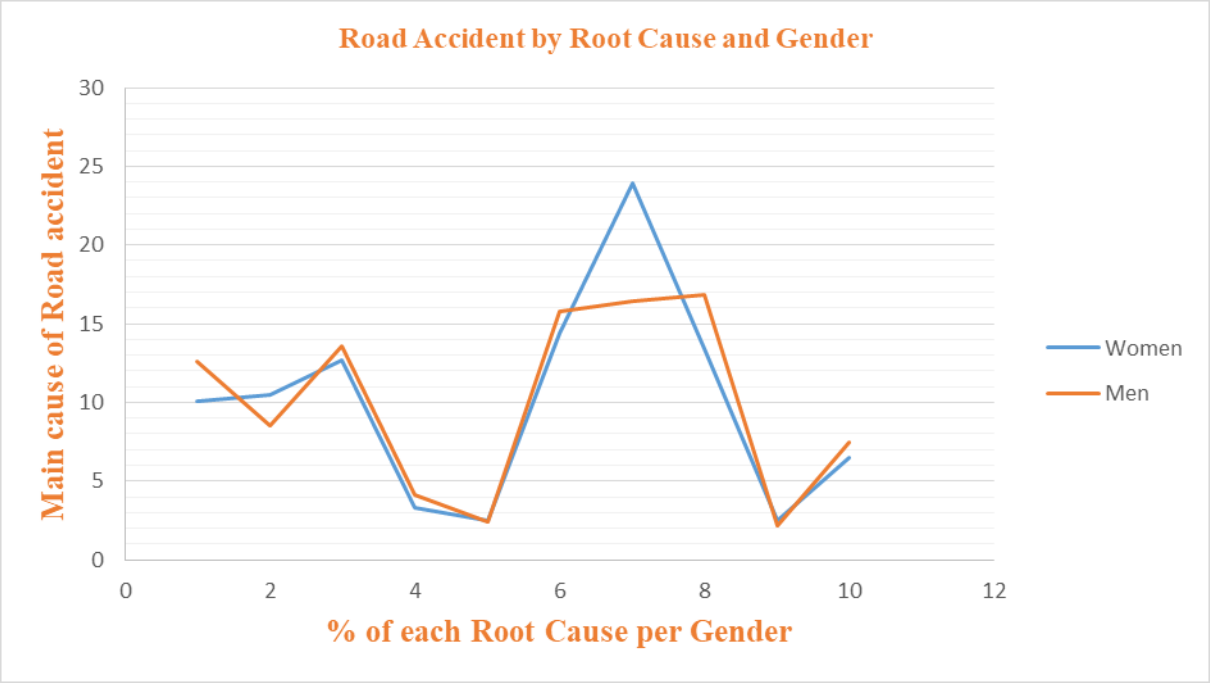


Figure 6: Distribution of road accidents and main cause of accident by Gender from 2020 to 2024
Source: Researcher's secondary data Analysis 2025

Table 5: Distribution of road accidents and main cause of accident by Gender from 2020 to 2024

Main cause of road accident	Men							Women						
	K	A	B	©	O	Total	%	K	A	B	©	O	Total	%
Drivers behaviours	9	16	12	16	9	62	12.58	4	4	9	6	5	28	10.14
Vehicle conditions	7	5	9	11	10	42	8.52	5	3	7	8	6	29	10.51
Overspeeding	9	9	14	19	16	67	13.59	6	6	9	8	6	35	12.68
Weather conditions	6	2	5	4	3	20	4.06	1	2	3	1	2	9	3.26
Defect of road	4	3	2	1	2	12	2.43	2	1	2	1	1	7	2.54
Cyclists behaviors	16	14	20	15	13	78	15.82	4	11	7	9	9	40	14.49
Motorcyclists behavi	13	22	18	17	11	81	16.43	13	13	17	13	10	66	23.91
Pedestrians behavior	14	19	17	19	14	83	16.84	5	9	6	12	5	37	13.41
Cattles	3	2	1	2	3	11	2.23	1	1	2	1	2	7	2.54
Any others	2	3	17	6	9	37	7.51	5	3	3	3	4	18	6.52
Total	83	95	115	110	90	493	100	46	53	65	62	50	276	100

Source: Researcher's secondary data Analysis 2025

From both Table 5 and Figure 6; results show that for both men, the most four root cause of the road accidents were Pedestrian behaviors, Motorcyclist behaviors, Cyclists behaviors, and Over-speeding accounting for 16.8%; 16.4%; 15.8% and 13.5% respectively, while the four most root cause of road accidents for women were Motorcyclist behaviors; Cyclists behaviors; Pedestrian behaviors and Over-speeding accounting for 23.9%; 14.5%; 13.4% and 12.7% respectively. The least root of road accidents for men were Cattle; Defect of road; Weather conditions and Any others root cause that accounted for 2.23%; 2.43%; 4.06% and 7.51% respectively while on the side of the women the least root road cause of

accidents were Defect of road and Cattle that accounted for 2.54% both defects of the road and cattle and 6.52% for any other root causes. Drivers' behavior accounted for 12.6% for men and 10.1% for women while Vehicle conditions accounted for 8.52% for men and 10.5% for women.

4.2. Objective one: This is about to assess accident fatal, injury, and property damage levels for National Roads in Rwanda.

Under this objective, crash types such as fatal, injury, and property damage levels are assessed using KABCO Injury classification Scale by crash type, locations (hotspots); and crash causes. Throughout this analysis, fatal is considered when a victim is pronounced dead at the scene or before the report is completed and the counting period taken to be 30 days with effect from the crash. Incapacitating is recorded when the victim must be carried or otherwise helped from the scene only. Not if the victim does not get help even though medical assistance may have been administered at the scene. Non-Incapacitating: If the victim has visible signs of injury, either in a physical or mental sense (e.g., had passed out), but is judged able to walk away from the scene without help. Not visible but complains of pain: If the victim complains of pain, but there are no visible signs of it, and he or she is able to walk away from the scene of the crash, then this code applies and the case when there is no injury to be recorded. Fatal, injury data were collected from district police stations and property damage data were collected from insurance companies and road owners (RTDA and RMF).

Table 6: Distribution of the victims category of the road accidents per Hotspot for five years from 2020 to 2024

Cathegory of the Victimes	Nyabu-gogo	Nkoto	Musa-mbira	Kivumu	Ntenyo	Mukobwa-mwiza	Other locations	Total	%
Riders	17	12	16	18	21	32	36	152	19.8
Passengers	38	23	28	36	26	56	61	268	34.9
Pedestrians	105	40	50	24	42	33	55	349	45.4
Total	160	75	94	78	89	121	152	769	100
%	20.8	9.8	12.2	10.1	11.6	15.7	19.8		

Source: Researcher's secondar data Analysis 2025

Table 6 summarizing victims category show that the most vulnerable of the road accidents were pedestrians who accounted for 45.4% of the total road accidents followed by passengers who accounted for 34.9% of the total accidents and riders accounted for 19.8%. On the other side, the most Hotspot that accounted most of the road accidents were Nyabugogo that accounted for 20.8%; other Hotspots 19.8% and Mukobwamwiza accounted for 15.7% of the total road accidents. The Hotspots that accounted the least road accidents were Nkoto; Kivumu and Ntenyo that accounted for 9.8%; 10.1% and 11.6% respectively, while Musambira accounted for 12.2% of the total road accidents. The main root causes of

these results were that in Nyabugogo there are many different economic activities that pedestrians are busy with and do not pay attention for road accidents and at Mukobwamwiza, analysis revealed that it was due to the fact that the road geometry was the root cause for that.

Table 7: Distribution of the categories of victims per Severity for five years from 2020 to 2024

Category of the victimes	K	A	B	(C)	O	Total	%
Riders	32	30	31	29	30	152	19.8
Passengers	51	24	77	46	70	268	34.9
Pedestrians	57	110	71	92	19	349	45.4
Total	140	164	179	167	119	769	
%	18.2	21.3	23.3	21.7	15.5		

Source: Researcher's secondary data Analysis 2025

From Table 7 whereby victims are distributed by severity, where findings revealed that the most severity were Non-Incapacitating (B) comprising of 23.3% followed by Not visible but complains of pain (C) comprising of 21.7% and incapacitating (A) comprising of 21.3%. The least severity was Not Considered (O) comprising of 15.5% followed by Fatal (K) comprising of 18.2% of the total severity for 5five years from 2020 to 2024.

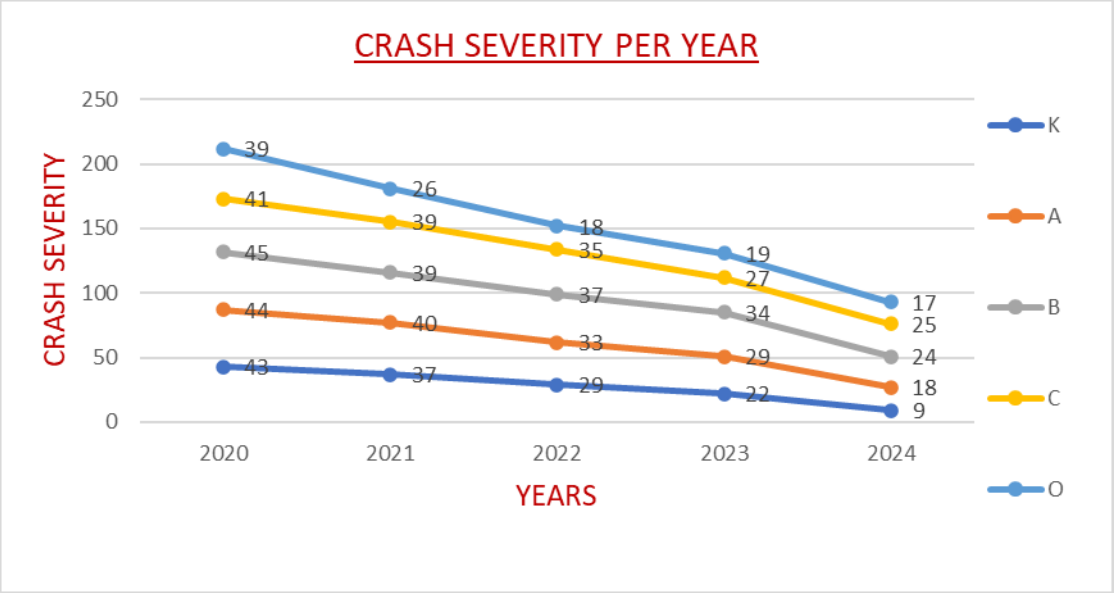


Figure 7: Road Accidents Distribution by crash type per year for 5 years (2020-2024)

Source: Researcher's secondary data Analysis 2025

Table 8: Road Accidents Distribution by crash type per year for 5 years (2020-2024)

Accident per year	**K**	**A**	**B**	**C**	**O**	**Total**	**%**
2020	43	44	45	41	39	212	28
2021	37	40	39	39	26	181	24
2022	29	33	37	35	18	152	20
2023	22	29	34	27	19	131	17
2024	9	18	24	25	17	93	12
Total	140	164	179	167	119	769	100

Source: Researcher's secondary data Analysis 2025

Table 8 and Fig 7 show that in 2020 crash were 28%; in 2021 reduced to 24% and in 2022 was 20% followed by 17% in 2023 and 12. % in 2024 This crash reduction was due to different factors including the implementation of the speed governor's policy, road safety measures improved, etc. all contributed to the road crash gradually.

Table 9: Road Accidents Distribution by crash severity using KABCO index for 5 years (2020-2025)

KABCO index	2020	2021	2022	2023	2024	Total	%
O	29	27	25	23	15	119	15.5
C	29	36	39	40	23	167	21.7
B	40	32	39	37	31	179	23.3
A	38	32	28	34	32	164	21.3
K	29	26	27	32	26	140	18.2
Total	165	153	158	166	127	769	100

Source: Researcher's secondary data Analysis 2025

Table 9 representing road crash severity using KABCO classification index revealed that the most severity was Non-Incapacitating (B) representing 23.3% of the total road crashing followed by a Not visible but complains of pain (C) and incapacitating (A) representing 21.7% and 21.3% of the road crashes respectively and the lest crash class was Not Considered (O) and Fatal (K) comprising of 15.5% and 18.2% of the total road crashes respectively.

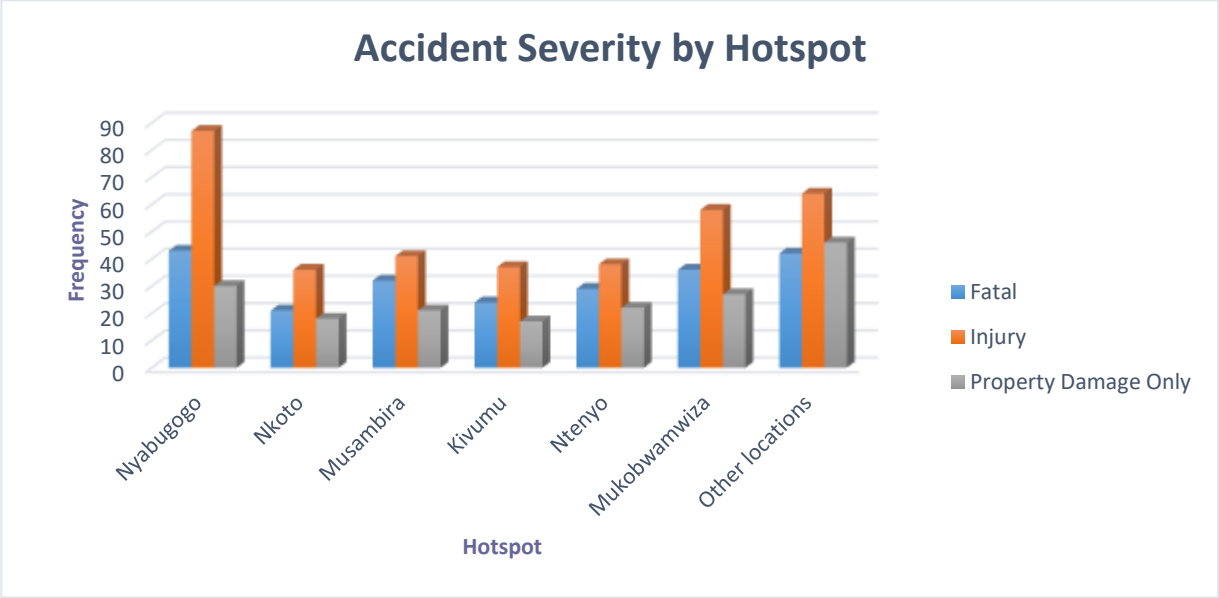


Figure 8: Road Accident Severity per Hotspot

Source: Researcher's secondary data Analysis 2025

Table 10: Road Accident Severity per Hotspot

Accident Severity	Nyabu-gogo	Nkoto	Musa-mbira	Kivumu	Ntenyo	Mukobwa-mwiza	Other locations	%
Fatal	43	21	32	24	29	36	42	29.6
Injury	87	36	41	37	38	58	64	46.9
Property Damage Only	30	18	21	17	22	27	46	23.5
Total	160	75	94	78	89	121	152	100

Source: Researcher's secondary data Analysis 2025

Both Table 10 and Fig 8 on road accident severity distribution per Hotspot show that the most severity accident was injury comprising of 46.9% of the total accident followed by fatal comprising of 29.6% of the total road accidents and the least road accident was the property damage only comprising of 23.5% of the total road accident costs. On the side of road accident per Hotspot, results revealed that the most recorded road accident was Nyabugogo comprising of 160 cases, followed by other locations with 152 cases and Mukobwamwiza with 121 cases and Musambira with 94 cases. The leas cases recorded from other Hotspots were Nkoto, Kivumu and Ntenyo that recorded 75 cases, 78 cases and 89 cases

respectively. The root causes of road accident recorded from Nyabugogo was the big number of economic activities and big number of vehicles, motorcycles and bicycles ownership that increases the road accident costs.

Table 11: Road accident severity distribution per year

Year	Fatal	Injury	Property damage only	Total	%
2020	74	98	59	231	30.0
2021	62	86	44	192	25.0
2022	46	72	35	153	19.9
2023	28	61	27	116	15.1
2024	17	44	16	77	10.0

Source: Researcher's secondary data Analysis 2025

Table 11 reporting the road accident severity distribution per year show that in 2020 30.0% of the total road accident followed by 2021 where 25% of the total road accident and 2022 that recorded of 19.9% of the total road accidents, 15.1% for the year 2023 and only 10.0% for the year of 2024. This trend of road accident cases reduction over time was due to the fact that the traffic police activities related to road safety and other road safety policies and road accident public awareness reduced the road accident cases that contributed to the reduction of road accident cases per year.

Table 12: Road accident Severity distribution by age group

Age Group	Fatal	Injury	Property damage only	Total	%
0-15	17	16	4	37	4.8
16-25	31	40	13	84	10.9
26-35	35	52	23	110	14.3
36-45	58	59	38	155	20.2
46-55	43	64	50	157	20.4
56-65	22	72	23	117	15.2
66-75	17	42	19	78	10.1
76+	4	16	11	31	4.0
Total	227	361	181	769	100

Source: Researcher's secondary data Analysis 2025

Table 12 representing the road accident distribution by age group show that the most vulnerable age group was 46-55 years that comprised 20.4% of the total road accident followed by the age group of 36-

45 comprising of 20.2% of the total road accidents and age group of 56-65 that comprised of 15.2% of the total road accident. The least vulnerable group on road accident was the age group of 0-15 comprising of 4.8% followed by 76 and plus that comprised of 4.0% and the age group of 66-75 that comprised of 10.1% of the total road accidents. These findings clearly show that youth from 25 years to 55 years. This age group is very much active and make many trips for various trip purposes than very older age and very small children who are not very much active to make trips for various purposes including unnecessary trips.

Table 13: Road accident Severity distribution by education level

Education level	Fatal	Injury	Property damage only	Total	%
Not educated at all	71	86	58	337	43.8
Primary	58	79	42	224	29.1
Secondary	41	64	40	109	14.1
Bachelors	39	67	28	67	8.7
Masters+	18	65	13	32	4.2
Total	227	361	181	769	100

Source: Researcher's secondary data Analysis 2025

Table 13 on road accident severity distribution by education level shows that the most vulnerable on road accident were the non-educated and those having primary education level with 43.8% and 29.1% of the total case recorded while those with secondary education level and bachelor's education level ones are 14.1% and 8.7% respectively. The level of education contributes much on level of understanding and referring to the public awareness on road safety and even drivers with some level of education behave differently from non-educated ones or with very low education level.

Table 14: Road Accident Severity by Gender

Accident Severity	Male	Female	Total	%
Fatal	159	68	227	29.5
Injury	271	90	361	46.9
Property Damage Only	56	125	181	23.5
Total	486	283	769	100

Source: Researcher's secondary data Analysis 2025

Findings from road accident by gender as peer Table 14 and Fig 9 show that the most vulnerable on road accidents were male with 486 cases and females recorded 283 cases. This was due to the fact that males are engaged in driving than women and have make many economic activities than women since in Rwanda culture, men are more responsible of the family, hence faces more road accidents than women. The most severity case was injury that comprised of 46.9% of the total accident followed by fatal cases that contributed 29.5% of the total accidentals and the least severity case was the property damage only contributed 23.5% of the total road accidents.

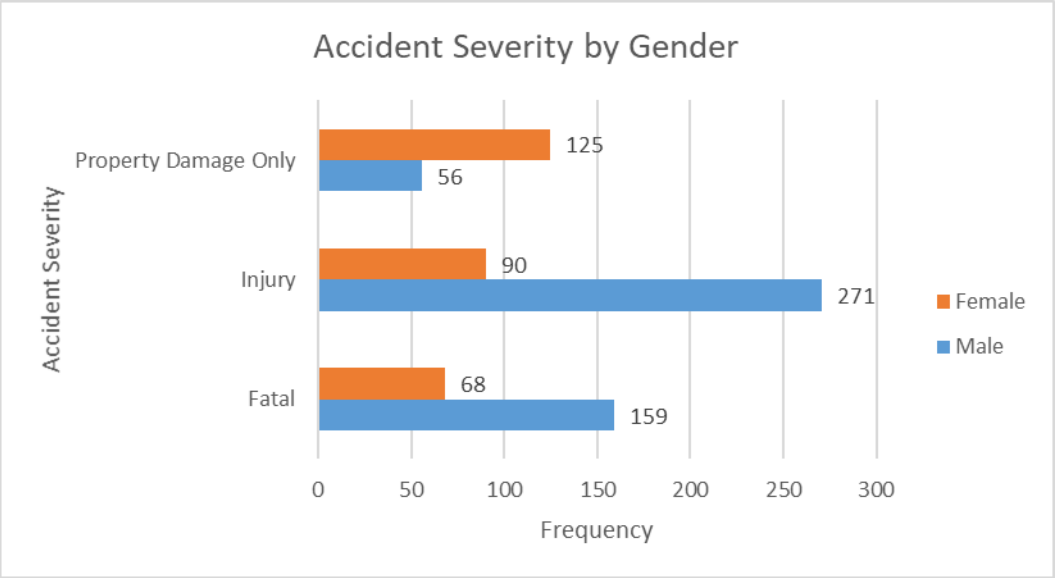


Figure 9: Road Accident Severity by Gender

Source: Researcher's secondary data Analysis 2025

Table 15: Road accident Severity distribution per Road User categories

Accident Severity	Riders	passengers	Pedestrians	Total	%
Fatal	37	71	119	227	29.5
Injury	17	45	299	361	46.9
Property Damage Only	9	39	133	181	23.5
Total	63	155	551	769	100
Percentage	8.2%	20.2%	71.7%	100	

Source: Researcher's secondary data Analysis 2025

Road accident severity distribution per road user category from Table 15 revealed that the most severity case was injury that covered 46.9% of the total accidents, followed fatal cases that covered 29.5% of the total road accidents, and the least severity case was property damage only that covered 23.5% of the total road accidents. On the other side of road accident per user category, the same Table summarizes the

findings showing that the most vulnerable group was pedestrians that covered 71.7% of the total road accidents followed by passengers with 20.2% of the total road accidents and the least vulnerable group was riders. The riders were the least vulnerable group since they are a bit protected compared to pedestrians and they aware on road safety compared to passengers and pedestrians. Hence pedestrians' behavior and awareness on road safety measures that could contribute much on road accidents.

4.3. Objective Two: This was about to assess traffic police activities, medical services and insurance costs all related to road traffic accidents

According to a report of the World Health Organization, road traffic injuries account for almost 1.2 million deaths a year around the world and for 20–50 million injuries or disabilities (Peden, Scurfield, Sleet, 2004). Under this objective, traffic police road accident intervention costs, Hospital service and insurances cost to due traffic accidents are grouped and assessed. To access the traffic police operation cost, yearly data on traffic operations regarding road accidents intervention costs were collected from 7 district police stations along NR1, these costs were estimated basing on the number of police officers involved in each accident and hourly pay calculated from their monthly salaries, number of vehicles allocated in each case and their respective costs, and administrative costs relating to each case calculated basing on the 25% of the traffic police activities related to each case and considered as total traffic activities related to each accident case along NR1. Yearly medical services data related to road accident costs along NR1 were collected from 7 district hospitals while insurance costs regarding road accidents along NR1 were collected from 5 insurance companies for the period of January 2020 to December 2024.

Table 16: Estimated Police Intervention, Hospitals and Insurance Road Accident Costs for the year 2020-2024 (in $)

Year	Police Intervention	Health Care	Property Damage	Total Cot	%
2020	720,000	2,345,000	2,691,500	5,756,500	20.5
2021	970,000	1,922,900	2,368,520	5,261,420	18.7
2022	1,230,000	1,805,650	2,260,860	5,296,510	18.9
2023	1,650,000	1,784,300	2,207,030	5,641,330	20.1
2024	2,400,000	1,632,000	2,099,370	6,131,370	21.8
Total Cost	6,970,000	9,489,850	11,627,280	28,087,130	100.0

Source: Researcher's secondary data Analysis 2025

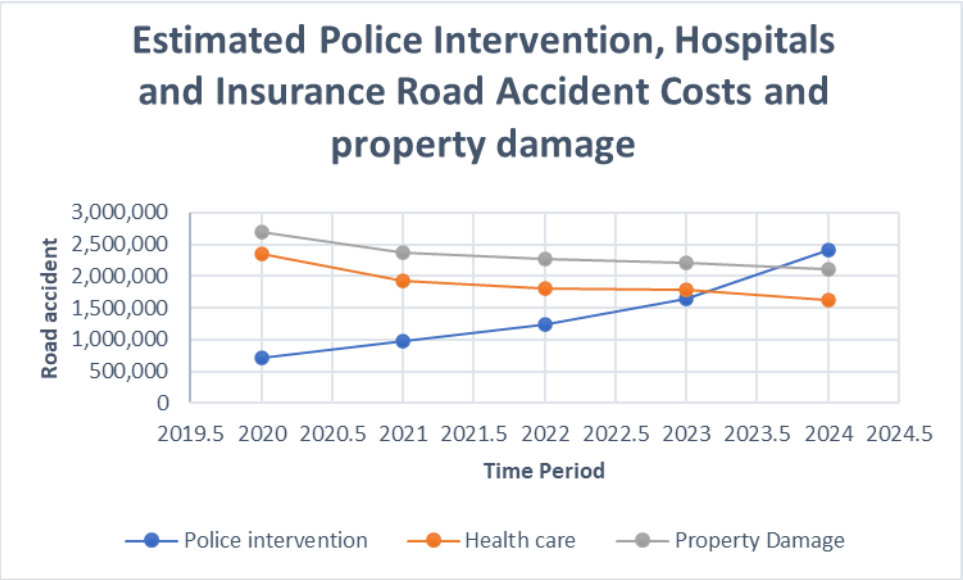


Figure 10: Estimated Police Intervention, Hospitals and Insurance Road Accident Costs for the year 2020-2024 (in $)

Source: Researcher's secondary data Analysis 2025

Results analysis from both Table 16 and Figure 10 on the estimated Police Intervention, Hospitals and Insurance Road Accident Costs for the year 2020-2024 (in $) revealed that as traffic police interventions increases costs, other parameters like healthcare services, insurances and property damage costs reduces gradually. The minimum cost percentage was 18.7% of the total costs in 2021 while the maximum cost percentage was observed as 21.8% of the total costs of the road accident in 2024 before a remarkable intervention of the traffic police and other traffic road safety policies. As per road safety's concern in Rwanda, traffic police and other different organs put efforts in road crashes reduction and this increases the prevention road crash costs, hence reduces healthcare and insurance road crash costs related.

Table 17: Yearly Distribution of Road accident cost per Severity

Year	Fatal	Injury	Property damage only	Total
2020	1,844,074	2,442,151	1,470,275	5756500
2021	1,699,001	2,356,677	1,205,742	5261420
2022	1,592,416	2,492,475	1,211,619	5296510
2023	1,361,700	2,966,562	1,313,068	5641330
2024	1,371,581	3,549,976	1,209,813	6,131,370
Total	7,868,772	13,807,841	6,410,517	28,087,130
%	28.0	49.2	22.8	100.0

Source: Researcher's secondary data Analysis 2025

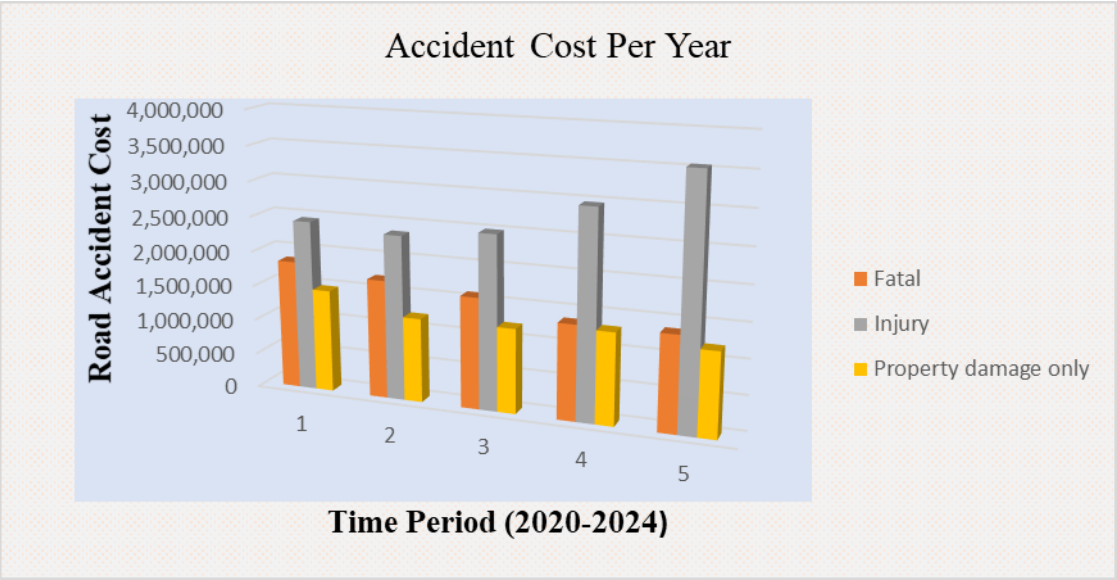


Figure 11: Yearly Distribution of Road accident cost per Severity
Source: Researcher 2025

4.4. Objective Three: Under this objective, the analysis of the road traffic accident costs over time and, model development and give the significance of traffic accidents for policymakers was conducted.

Generally, traffic accident costs are categorized into three forms such as fatal, injury and property damages and total traffic accident costs are divided into two main parts: direct accident costs (DAC) and indirect accident costs (IAC) (Ayati, 2005; Elvik, 1995; Jadaan, 1986; Morden, 1989; Miller 1992; Miller, Lestina, & Galbraith, 1997; Trawen et al., 2002). The 'direct costs' include physical injuries, wasted time, destroyed instruments and official costs, however, this depends on many parameters such as damaged instruments (for example, the price of an automobile), clinical and paraclinical costs, official costs and others; 'wasted time' is estimated by multiplying 'average wage of a person by 'average time wasted in that case, destroyed instruments cost that includes automobile damage costs and road tools damage, while official costs' includes all the expenditures for registration office and court costs etc.. On the other side, the 'indirect costs' include life cost, permanent disability cost and psychology damage, pain and socioeconomic effects, here indirect costs should cover (life cost, permanent disability and psychology damage, and pain and socioeconomic impacts). Under this objective, medical costs data were collected from 7 districts hospitals, property damage costs were collected from 6 insurance companies and police activities costs were collected from 8 police districts stations. Table 1.9 represent the cost breakdown structure by cost component for the period of years from 2010to 2024 along the highway NR1.

Table 18 Theoretical threshold road accident cost ratio to GDP

Year	GDP in USD	Road Accident costs per Road Network	Ration of road costs accidents per GDP
2020	8,697,000,000	74,724,503	0.86 %
2021	9,253,000,000	68,297,923	0.74 %
2022	9,636,000,000	68,753,422	0.71 %
2023	10,350,000,000	73,229,493	0.71 %
2024	10,209,000,000	79,590,650	0.78 %

Source: Researcher's secondary data Analysis 2025.

Table 18 representing the theoretical threshold road accident cost ration per GDP revealed that for the year of 2020, the cost of road accident accounted for 0.86 % and 0.74 %, 0.71% and 0.71%, and 0.78% for 2020, 2021 2022, 2023 and 2024 respectively. This shows that these percentage are under the threshold of road accident costs in the range of no more than 1% as standard threshold used.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.0 Conclusion

Based on the findings of this study, the research objectives were successfully addressed. These objectives were:

1. To assess the levels of fatality, injury, and property damage caused by road traffic accidents.
2. To assess the cost implications of traffic police operations, medical services, and insurance claims due to road traffic accidents.
3. To analyze the overall cost levels of road traffic accidents, develop a cost estimation model, and highlight the significance of traffic accident data for policymakers in Rwanda—specifically along the National Road 1 (NR1).

The research revealed that driver behavior, overspeeding, and motorcyclist behavior were the leading causes of road traffic accidents, contributing 15.7%, 15.1%, and 13.7%, respectively. Other contributing factors included pedestrian behavior (12.3%), cyclist behavior (11.6%), vehicle conditions (10.5%), and lesser factors such as cattle (1.7%), road defects (2.2%), and weather conditions (4.0%).

Among accident hotspots, **Nyabugogo** recorded the highest number of incidents (20.8%), followed by **Mukobwamwiza** (15.7%) and **Musambira** (12.2%). The **least-affected hotspots** were **Nkoto (9.7%)** and **Kivumu (10.1%)**.

In terms of **crash severity**, non-incapacitating injuries accounted for 23.3%, incapacitating injuries for 21.3%, and fatal injuries for 18.2%. The most affected **age groups** were 36–45 (23.1%), 46–55 (19.1%), and 26–35 (18.6%). Men accounted for 64% of accidents, and women 36%. Individuals without formal education were the most vulnerable, with the highest number of crash victims recorded in this group.

5.1 Recommendations

5.1.1 Objective One: Assessment of Fatal, Injury, and Property Damage Levels

The study used the KABCO Injury Classification Scale to evaluate crash severity by type, location (hotspots), and cause. Results show that:

- Fatal injuries were primarily associated with pedestrian victims (5.4%), passengers (34.9%), and riders (19.8%).
- Nyabugogo, Mukobwamwiza, and Musambira were the most accident-prone hotspots.

- The highest crash severity was **non-incapacitating injuries (23.3%)**, while **fatal injuries** represented **18.2%**.
- The crash rate showed a decreasing trend over the five-year period, from **25.5% in 2020 to 12.1% in 2024**.

Recommendation:

- Prioritize targeted interventions at accident hotspots, including road design improvements, increased signage, and enforcement of speed limits.
- Implement community awareness campaigns focusing on vulnerable road users, especially in rural areas and among uneducated populations.
- Strengthen driver training and road safety education, especially for motorcyclists and pedestrians.

5.1.2 Objective Two: Assessment of Traffic Police Operations, Medical Services, and Insurance Costs

Findings revealed that:

- **Insurance costs** were the largest component, contributing **59%** of total accident costs.
- **Medical services** accounted for **33.8%**, and traffic police operations for **10%** of the costs.
- The **total annual accident costs** ranged from **$1.3 million to $1.5 million**, with **2024** recording the highest cost at **$1,379,061**.
- Although traffic police operations appeared limited in cost, this is due to the exclusion of indirect costs such as third-party interventions and administrative expenses.

Recommendation:

- Strengthen inter-agency coordination between the police, hospitals, and insurance firms for better data management and response.
- Expand insurance coverage and streamline claims processing to reduce post-accident financial burdens.
- Increase investment in pre-hospital emergency medical services and trauma centers, particularly in high-risk areas.

5.1.3 Objective Three: Cost Modeling and Policy Significance

The total crash cost over the 5-year period along NR1 was broken down as follows:

- **Medical costs**: $948,985 (33.8%)

- **Property damage costs**: $1,162,728 (41.4%)
- **Traffic police costs**: $697,000 (24.8%)

An econometric model using E-Views showed that while medical, property, and police costs were not statistically significant independently, the adjusted R^2 of **0.992660 (99.2%)** confirms that the model can accurately estimate road crash costs over time. The constant in the model suggests that there are other contributing factors not captured by the independent variables.

Recommendation:

- Utilize the developed model for future accident cost projections and budgeting by the Ministry of Infrastructure and Transport.
- Invest in data systems to collect and monitor accident-related variables not currently captured (e.g., vehicle age, driver experience, time of accident).
- Policymakers should use these findings to inform road safety laws, budget allocations, and infrastructure investments to reduce the economic burden of road traffic accidents.

General Recommendations:

1. **Policy Implementation**: Enforce stricter penalties for reckless driving, overspeeding, and poor vehicle maintenance.
2. **Public Awareness**: Increase community-based road safety campaigns, targeting both urban and rural populations.
3. **Infrastructure Improvements**: Upgrade road signage, lighting, and pedestrian crossings at known hotspots.
4. **Education**: Implement road safety modules in primary and secondary schools to build awareness from a young age.
5. **Data Management**: Establish a centralized database integrating police, medical, and insurance data to streamline accident reporting and analysis

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APPENDICES

Appendix1: Demographic characteristics of main causes of road accidents per Hotspot for NR1(2020-2024).

Table1.

Main cause of road accident	Nyabugogo	Nkoto	Musambira	Kivumu	Ntenyo	Mukobwamwiza	Others	%
Drivers behaviors	10	11	17	14	17	21	31	15.6
Vechle conditions	9	7	11	9	13	15	17	10.3
Over-speeding	16	13	16	15	12	24	21	15.1
Weather conditions	11	2	3	1	2	5	7	4.0
Defect of road	5	0	0	2	1	4	5	2.2
Cyclystes behaviors	15	12	13	10	12	13	15	11.6
Motorcyclist behaviors	46	9	11	7	8	10	15	13.7
Pedestrian behaviors	36	10	9	7	9	11	13	12.3
Cattles	0	1	1	2	1	3	5	1.7
Any others	12	10	13	11	14	15	23	12.7
Total	160	75	94	78	89	121	152	100
% /Hotspot	20.8	9.7	12.2	10.1	11.6	15.7	19.8	

Source: Researcher's secondary data Analysis 2025