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DEPARTMENT OF CIVIL ENGINEERING AND ENVIRONMENTAL TECHNOLOGY

A PROJECT REPORT ON

"DEVELOPMENT OF A SIMPLE ROAD SAFETY AUDIT PROCEDURE SUITABLE FOR ROAD CONDITION IN RWANDA"

Submitted by:

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Under the Guidance of:

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Submitted in partial fulfillment of the requirements for the award of

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CERTIFICATE

This is to certify that the Thesis Work entitled **"*Development of a Simple Road Safety Audit Procedure Suitable for Road Condition in Rwanda*"** is a record of the original bonifide work done by ***Hadelin VERJUS*** **(Reg.No: PG 2011581)** in partial fulfilment of the requirement for the award of Master of Science Degree in Transportation Engineering and Economics of College of Science and Technology during the academic year 2011-2012.

	……
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Submitted for the final defense of the thesis held at College of Science and Technology on……

DECLARATION

I hereby declare that the thesis entitled "Development of a simple road safety audit procedures suitable for road condition in Rwanda" submitted for the Degree of Master of Science is my original work and the thesis has not formed the basis for the award of any Degree, Diploma, Associateship, Fellowship of similar other titles. It has not been submitted to any other University or Institution for the award of any Degree or Diploma.

Place: Kigali ……...

Date: September 2014 Hadelin VERJUS

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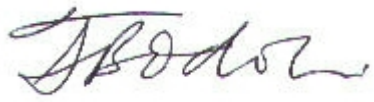
BONAFIDE CERTIFICATE

Certified that this thesis titled **"*Development of a Simple Road Safety Audit Procedure Suitable for Road Condition in Rwanda*"** is the bonafide work of ***Hadelin VERJUS*** **(Reg.No: PG 2011581)** who carried out the research under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion for this or any other candidate.



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ABSTRACT

Over the years, road safety has become a principal concern of many transportation agencies. The rapid growth of the highway network, changing vehicle population, mixes of vehicles on the roads (smaller vehicles and motorcycles sharing the road with larger trucks), number and age of drivers, economic constraints in road construction, and technological advances, have contributed to an environment of increased accident potential. Furthermore, the three principal elements which contribute to highway accidents driver, vehicle and road are also affected by the social and political environment under which they interact. Statistics show that accidents in Rwanda increase from year to year. From 2002 to 2012 accidents have increased by 1,808 and over 4000 accidents occur each year in Rwanda.

Rwanda already has many road safety issues, such as substandard cross sections, mixing of different road users and roadside obstacles. The roads designs should be audited in order to reduce accident risk and improve road safety on new road project. In the first place, this means that people are prevented from being killed or injured on the roads before highway authority react. In the second place, it is cheaper and easier to correct projects on the drawing board than it is after they have been implemented and promote awareness of safe design practices.

To make successful the work some data were collected from different institutions ie Rwanda National Police, Rwanda Transport Development Agency. The accidents data were considered and analyzed critically in relation to road characteristics and vehicle characteristics also the traffic characteristics. The research is stipulated as a qualitative, observational research where by the development of a simple road safety audit procedures suitable for road condition in Rwanda was based on data collected in textual form in different government institution. The approaches used was to review current road safety audit manuals; identify the source of road network condition including road classification, road network size, pavement types, road condition; vehicle fleet characteristics; traffic characteristics; drivers; road safety and accidents data; to collect data; to analyze data; development of a road safety audit procedure for Rwanda and the guidelines on how to apply the procedure then the conclusion on findings

The accidents in Rwanda are ascending; the registered vehicles increase, a high number of accidents occurs on the national paved road with a big number of daily traffic (ADT) and the geography of Rwanda affect the geometric designs. Therefore, in order to reduce a number of accidents a simple road safety audit procedures suitable for road condition in Rwanda were developed. The road safety audits have to be conducted at different stages in the course of a road project from initiation to pre-opening of the road project. The road safety audits in Rwanda shall be performed at the following stages: Preliminary Stage, Draft design Stage, Detailed design Stage, Construction Stage and Pre-opening Stage.

We conclude by saying that in order achieve the objectives of safer roads for sustainable development. The roads shall be constructed by respecting the road safety audits procedure at each stage of the road project from feasibility study to pre-opening the road. Also, the road safety audit procedure in Rwanda shall lead to many benefits, such as safer new roads through accident prevention and crash severity reduction, safer road networks, reduced whole life costs of road schemes, a reduced need to modify new schemes after they are built, a better understanding and documentation of road safety engineering, eventual safety improvements to standards and procedures, more explicit consideration of the safety needs of vulnerable road users. Note that Safe design practices and the safety needs of all road users are important considerations in attracting donor funding.

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List of abbreviations

RSTMP	Rwanda strategic transport master plan
IMS	Incident management system
RSI	Road safety inspection
RRA	Rwanda revenue authority
RNP	Rwanda National Police
MININFRA	Ministry of infrastructure
DR	District road
IRI	International roughness index
NR	National road
WHO	World health organization
RTDA	Rwanda Transport Development Agency
DT	Daily traffic
ADT	Average daily traffic
EDPRS	Economic development poverty reduction strategy
GOR	Government of Rwanda
NISR	National institute of statistics of Rwanda

CHAPTER 1 INTRODUCTION

1.1 Background

The procedures to enhance road safety will lead to many benefits, such as safer new roads through accident prevention and crash severity reduction, safer road networks, reduced whole life costs of road schemes, a reduced need to modify new schemes after they are built, a better understanding and documentation of road safety engineering, eventual safety improvements to standards and procedures, more explicit consideration of the safety needs of vulnerable road users. Safe design practices and the safety needs of all road users are important considerations in attracting donor funding. Many roads in Rwanda are being upgraded and new roads will be built as vehicle ownership will increase.

Rwanda already has many road safety issues, such as substandard cross sections, mixing of different road users and roadside obstacles. The design of upgrades and new roads should be audited to ensure improving road safety.

The road safety audit manuals are mostly based on Australian and European manuals. The Tanzanian Guide to road safety auditing, 2009 does not adapt these manual for African conditions. Existing manuals provide little guidance on how to evaluate the safety of design elements. The evaluation is typically left to the judgment of the experienced road safety auditor. Rwanda has few experienced road engineers that can challenge to designs of consultants.

1.2 Problem definition

Infrastructure development and improving road transport services are the main strategic policy of the Government of Rwanda in terms of economic development and poverty reduction. To this end the government continues to invest heavily in road infrastructure. To develop a vibrant private sector, Rwanda is investing in Roads with the intent of dramatically reducing the cost of transport to businesses and individuals.

On many occasions, completely new road projects have been designated as black spots after just a few years. There may be many reasons for this including insufficient consideration of road safety measures in design road standards and implementation of infrastructure projects. A road safety

audit can be expected to correct this and thus, to reduce the number of such black spots on new roads. It will help to minimize need for remedial work, reduce project's life cycle costs, improve the awareness of safe design practices lead to improve standards and management practices.

1.3 Aim and Objectives of the research

The aim of the research is to reduce accident risk and improve road safety on new road project. In the first place, this means that people are prevented from being killed or injured on the roads before highway authority react. In the second place, it is cheaper and easier to correct projects on the drawing board than it is after they have been implemented. The specific objectives to be achieved are:

- To produce a designs that reduce the number and severity of crashes
- To reduce costs by identifying safety issues and correcting them before projects are built
- To promote awareness of safe design practices
- To integrate multimodal safety concerns

1.4 Scope of the study

The scope of the study is limited to the roads classified as National paved roads. The size of National paved roads is **1210.8 km**. The National paved roads under the scope are: Kigali-Muhanga-Huye-Akanyaru road (NR1: this road links Rwanda and Burundi); Kigali-Musanze-Rubavu road (NR2: this road links Rwanda and DRC); Kigali-Gatuna road (NR3: this road links Rwanda and Uganda); Kigali-Kayonza-Rusumo road (NR4: this road links Rwanda and Tanzania); Kicukiro-Nyamata-Nemba road (NR5: this road links Rwanda and Burundi); Huye-Nyamagabe-Nyamasheke road (NR 10: this road links NR1 and NR11); Ruhwa-Bugarama-Rusizi-Nyamasheke-Karongi-Rutsiro-Rubavu road (NR11: this road links Rwanda, Burundi and DRC); Muhanga-Nyange-Rubengera road (NR15: this road links NR1 and NR11); Muhanga-Ngororero-Mukamira road (NR16: this road links NR 2 and NR15); Musanze-Cyanika (NR17: this road links Rwanda and Uganda); Musanze-Kinigi-Busogo-Kora-Kabuhanga (RN18: this is the road towards Volcano Park) and Kayonza-Kiramuruzi-Rwimiyaga-Kagitumba road (NR24: this road links Rwanda and Uganda).

1.5 An outline of the content of the thesis

The logical structure of the thesis is organized into four stages where in first stage, we review the current road safety audit manuals, in this stage the international best practice in road safety audit has been reviewed in order to identify the gaps between the international best practice and the current local practice in Rwanda. Secondly, we conducted data collection on (i) the road network characteristics including road classification, road network size, pavement types, road condition, (ii) vehicle fleet characteristics, (iii) traffic characteristics, (iv) Drivers, (v) road safety and accidents data.

Thirdly, in order to successfully meet the objectives of the study, we analyzed the data by basing on the interpretation of the statistics, graphics (figures) and tables.

Last stage consisted of development of a simple road safety audit procedure suitable for road condition in Rwanda and the guidelines on how to apply these procedures given in form of checklists in Appendix. Then the conclusion has been given.

1.6 Benefits and beneficiaries of the research

Road Safety Audits have the following benefits if implemented as part of the road safety management plan of a road authority:

- A reduction in the likelihood of accidents on the road network
- A reduction in the severity of accidents on the road network
- An increased awareness of safe design practices among traffic engineers and road designers
- A reduction in expenditure on remedial measures
- A reduction in the life-cycle cost of a road.

The beneficiaries of the research are:

1. The road authority because the road safety audits increase safe design practice among traffic engineers and road designers; reduce expenses on corrective measure and life cycle cost of a road.
2. Road users are prevented for being killed on the roads this has a positive social-economic impact to the road users and

3. The country in general because when the road safety audits are performed successful the accidents reduce, this contribute in achievement of economic development and poverty reduction objectives as formulated in strategic policy guidance such as vision 2020 and EDPRS.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

Over the years, road safety has become a principal concern of many transportation agencies. The rapid growth of the highway network, changing vehicle population, mixes of vehicles on the roads (smaller vehicles sharing the road with larger trucks), number and age of drivers, economic constraints in road construction and technological advances have contributed to an environment of increased accident potential. Furthermore, the safety of road transportation involves many factors including driver, vehicle and road.

In an effort to increase highway safety, some transportation agencies have introduced safety programs specifically designed to address some of the more prevalent elements contributing to highway accidents. At the same time, engineering design has greatly improved in terms of incorporating safety into road building.

Road safety audits help to ensure that issues associated with road safety are specifically addressed and are given equal importance as the other factors in a design project. In cases where the facility is already in service, a road safety audit can identify problems that, if properly addressed by the owner, would improve the safety of that facility. It should be emphasized that this is perhaps the weakest application of the procedure. Mitigative measures to compensate for poor design and potential safety problems are often disruptive and expensive for in service roads and are consequently less cost effective. However, a keystone to the road safety audit process is that prevention of a safety problem is more effective than a cure. Traffic accidents can be reduced by proactively addressing road safety issues at the time the road is conceptualized, designed, constructed or in service.

Therefore, one mechanism of addressing roadway safety is the implementation of road safety audits. This chapter presents the definition and concept of road safety audit, road safety in Rwanda, road safety audit in Rwanda, international best practice in road safety audit. The comparison of international practice with the current situation in Rwanda is provided in this chapter and the summary of findings of this chapter is also provided.

2.2. Definition and concepts of road safety audit

A road safety audit is a formal examination of a new or upgrading project where interaction with road users takes place in which an independent and qualified team identifies potential road safety problems and suggest measures to mitigate those problems. (South African Road Safety Audit Manual, second edition, May 2013, page 5).

Its purpose is to make new and reconstructed roads as safe as possible before construction is started and before accidents occur. When conducting a road safety audit, individual projects are examined through "road safety glasses". Any inappropriate designs are revealed and proposals for improvements are formulated. Auditing can be carried out at one or more specific stages during the course of a project. The systematic approach taken means that consideration for road safety can be incorporated into a project at the earliest possible stage. Road safety audit should be a self-evident phase of our highway authorities' quality management and it can be applied to all road projects new constructions, as well as reconstructions. Road safety audit can also be applied to operating and maintenance activities on existing roads, to the extent that such activities can influence road safety.

A road safety audit is carried out by one or more road safety auditors. One crucial factor is that the auditors be impartial. A road safety auditor must take no part in project design and it is not the auditor's task to weigh road safety considerations, for instance, against economic consideration that is the responsibility of the client. A road safety auditor must not question the justification for a project but must illuminate its consequences on road safety and endeavor to ensure that the project as presented in the brief is as safe as possible. Road safety audit must be conducted with due consideration for the abilities, knowledge and needs of the road users and from the standpoint of all groups of road user. Road safety audit is not a check on the engineering quality of the project and nor is it any form of approval the project.

2.3 Road Safety in Rwanda

Road safety has been taken into consideration as part of Rwanda strategic transport master plan (RSTMP) taking into account the latest road accident statistics as well as international best practices that relate to road safety in Rwanda. The outcome is a proposed **"High-Level" Road Safety Strategy for Rwanda** and respective short term implementation projects aimed at

promoting a more functional and safer road network in the country. The road safety in Rwanda is therefore structured as follows:

- **Rwanda Road Safety Context** provides the *status quo* of aspects that influence and determine the context in which road safety has to be managed in Rwanda, i.e. the location, the vehicle fleet as well as an overview of current road accident rates in Rwanda and in neighbouring countries.
- The **Road Accident Statistics Overview** provides a brief overview of accident statistics worldwide and in Rwanda.
- The **Rwanda Road Safety Environment** contains information on the status of the road safety environment in Rwanda. It also highlights issues which have been identified and which need to be addressed in the Road Safety Strategy.
- The **Incident Management System (IMS)** provides an introduction to IMS and identifies what is involved and the prerequisites of an IMS in order to minimize the direct and secondary effects of accidents, as well as to restore normal capacity and safety levels to all affected road facilities as quickly and efficiently as possible;
- The proposed **"High-Level" Road Safety Strategy** proposes mitigating measures for the challenges identified in the previous sections, by using common interventions on road safety and road safety related infrastructure as well as education and communication strategies and programmes. These aspects, are addressed under the following Pillars, as per the *UN Global Plan for the Decade Action for Road Safety 2011 - 2020*:
    - Road Safety Management;
    - Safer Roads and Mobility;
    - Safer Vehicles;
    - Safer Road Users; and
    - Post-Crash Response or Emergency Services.
- Finally, the **Way Forward** summarizes the proposed "High-Level" Road Safety Strategy projects for the implementation of the Rwanda Strategic Transport Master Plan.

2.3.1 Rwanda Road Safety Context

2.3.1.1 Rwanda's road-safety transformation

Many years ago Rwanda had one of the worst road-safety records in the world. But once the government recognized that making roads safer could help with the rehabilitation of a nation traumatized by the 1994 genocide, its efforts have won international acclaim.

This transformation has been far from easy to achieve, however. A World Bank situation report, commissioned in 1996, concluded that one accident was taking place every two and a half hours on Rwanda's roads, almost all of which left people injured and 10% of which resulted in deaths.

Urban centres, such as the capital Kigali, saw frequent violent collisions, sometimes because drivers refused to respect others' right of way, according to Dominique Rurangirwa in 2004, who works on transport and road safety in Rwanda's Ministry of Infrastructure. Night-times were particularly hazardous "because of the excess speed resulting generally from alcohol consumption," he recalled. In rural areas, where roads are in a far worse condition than those in urban centres, drivers regularly went too fast to maintain control on the uneven carriageway surface. Rurangirwa said the number of road deaths in Rwanda for a country of some nine million people was found by the World Bank to be among the world's highest in 1996.

But, according to Rurangirwa in 2004, the severity of the situation also presented an opportunity. "After the genocide which plunged Rwanda into mourning in 1994, the country knew that one method of rehabilitation was [improving] its road infrastructure, which was damaged during the genocide, leading to many road traffic deaths," he explained.

The 1996 World Bank report echoed this view that Rwanda's incentive for improving road safety was about moving the country forward from responding to a humanitarian crisis after the genocide to efforts focused on development, of which improving infrastructure and road safety were key parts. The desire for post-genocide rehabilitation and development were the major factors behind the big push on road safety.

After reviewing the World Bank situation report, the Rwandan government started a new road-safety programme, financed by the World Bank, and embarked on a complete revision of the

country's laws on road conduct. Ministers re-examined the regulations governing the traffic police and the requirements for drivers, consulting widely among transport stakeholders, including unions and regular road users. "We also spoke to pedestrians, in particular the schoolboys and students, to make sure that we consulted at the level of communities," said Rurangirwa.

New regulations, which started to be strictly enforced after 2001, included mandatory wearing of seatbelts, speed limits, vehicle inspections to ensure standards of roadworthiness and limits on blood-alcohol concentrations. These legislative changes were followed up in 2003 by a public awareness campaign and a law introducing further penalties for lack of seatbelt use or failure to wear helmets on motorcycles.

Since 2004, the World Health Organization (WHO) has been working with the Rwandan government to help raise community awareness of road safety, according to WHO Country Health Information Officer Jean Bosco Gasherebuka, 2004. He said that WHO has negotiated with schools and unions through a campaign organized by the ministries of health and infrastructure, the police force and WHO. "We have held conferences in the secondary schools through the country and distributed material on the road safety," he said

The new laws had an almost immediate effect, as the number of deaths dropped by about 30%: "Before the strict observation of the law, 1995–2001, the number of deaths per annum reached between 450 and 550 people," explained Rurangirwa in 2004. "But under the new law, the deaths dropped to between 320 and 370."

The types of accidents also changed. Before the new law came into force, excessive speed resulted in high rates of pedestrian injuries and deaths. But speed limits and penalties for drunk-driving reduced these incidents. "The installation also of pavements and crossings for pedestrians also contributed to the reduction in these types of accidents," Rurangirwa in 2014 added.

Enforcement of these substantial changes was a challenge for Rwanda's under-resourced police force. Early success was accompanied by fears that corruption would increase among traffic police, with individuals attempting to bribe their way out of paying harsh fines (the fine for not wearing a seatbelt is equivalent to 20% of a civil servant's monthly salary). Combating these rumours, the

government instigated a parallel crackdown on police corruption in 2004, in which more than 100 officers were sacked for taking bribes.

Six years on from the tightening of regulations, most Rwandan citizens are used to the new rules. Now, Rwanda's traffic police, whose ranks have swelled to between 450 and 500 officers, is turning its attention to foreign coach companies, which are frequently involved in crashes in Rwanda. Coach drivers ferrying passengers to Kigali from Kenya and Uganda object to Rwanda's recently introduced national speed limits of 60 kilometres an hour, which is 20 kilometres an hour lower than in neighbouring east African countries.

Countries in WHO's African Region have 40% more road deaths per 100000 population than other low- and middle-income countries and 50% more than the world average. The worst rates of road traffic deaths in the WHO Region are among the under-25s, according to WHO's *Youth and road safety* report of June 2007.

WHO's 2006 *African Regional Health Report* held up Rwanda as an example of how African countries can improve road safety. "Rwanda has very good, focused leadership in road safety – political will is key," said Dr Olive C. Kobusingye in 2006, regional advisor on violence, injuries and disabilities at WHO's Regional Office for Africa.

Rwanda's plans for extending its success in road safety include further reinforcements for the traffic police to better enforce the law, as well as more public education about how to prevent accidents and observe good road conduct. Gasherebuka, 2004, believes Rwanda's continued commitment to road safety – exemplified by its signing of the Accra declaration on road safety in Africa in February – shows its determination to further reduce road casualties and deaths

2.4 Road Safety Audit in Rwanda

2.4.1 Introduction

Infrastructure development and improving road transport services are the main strategic policy of the Government of Rwanda in terms of economic development and poverty reduction. In order to support programs and projects on rehabilitation and development of infrastructure the RTDA (Rwanda Transport Development Agency) is undertaking road safety audit and road safety strategy

development as part of a comprehensive program to improve the safety performance of infrastructure and transport services.

It is found that a large number of accidents on the classified road network which causes include:

- Insufficient consideration of road safety measures in design road standards and implementation of infrastructure projects;
- Lack of analysis of accidents records in order to map black spots and take action to improve the safety level of roads.

These Terms of Reference (TOR) has been prepared to select a consultant that will perform a road safety audit on the road network and develop road safety strategy. The audit will focus on road safety aspects of existing and classified road network (comprising urban sections) and of international corridors while the strategy will be for the entire road sector.

The audit and strategy report, to be drafted, will be a document to, on the one hand, make the necessary technical improvements to the existing classified road network, and secondly, implement security measures on standards of future programs and implement road safety action and programmes and projects on road infrastructure in Rwanda.

2.4.2 Objective and expected results

The objective of the audit is to reduce the number of personal injuries accidents and damages throughout the classified road network in Rwanda, while the strategy and action plan setout key road safety policies and actions to be implemented in the future to make Rwanda's road network safer. It will enable the improvement of road safety for all road users (pedestrians, motorists and passengers), and therefore the understanding of the causes of accidents on roads of the country.

Thus, the audit, strategy, and action plan shall:

- Highlight all the gaps in safety on the whole classified road network (traffic engineering, traffic signing and road marking), that is to say, evaluate the potential insecurity of the existing classified road network;

- Offer on the one hand, corrective measures to increase the safety level of the existing network and, on the other hand, necessary measures to be considered in standards of projects and programs of national and community road infrastructures.

- Carry out a detailed review of existing accident black spot lists;

- Identify the worst accident black spots and prioritize accident black spots by potential accident

- Reduction and cost-effectiveness;

- Carry out a detailed analysis of each site and design cost-effective measures to rectify the problems;

- Assess the expected accident reduction impact of the program;

- Develop a computerized monitoring system to measure the actual impact of various remedial measures to accident spots and to determine the corresponding coefficient of reduction in accidents;

- Outline enforcement strategies and action plans that would improve road safety in Rwanda, and

- prepare complete bidding documents and cost estimates to implement the action plans.

Therefore, after the safety audit, it is expected that particular road safety measures will be considered in planning, design and implementation stages of future programs and projects related to road infrastructures throughout the country.

2.4.3 Activities to achieve

The audit and strategy development tasks are to conduct the evaluation of safety deficiencies of the existing classified road network and to propose measures to improve the safety of all road users now and in the future. The audit report will be conducted on the entire National road Network namely:

National paved road network of 1172 Km
National unpaved road network of 1648 Km
Classified District road network of 1836 Km.

For this purpose, the following tasks shall be undertaken:

- analysis of existing documents on traffics (counts and surveys), vehicles transport fleet, roads, and studies on road accidents, to determine respectively: (i) the amount and distribution of traffic in different categories of vehicles (ii) sizes and authorized loads of vehicles, (iii) length, functional and administrative distribution, as well as the level of service of the classified road network, (iv) contribution of the classified road network in road accidents;

- a collection of information about accidents and about all the facts linked to them, about road and traffic parameters and other related circumstances (e.g. driver behaviour and his/her impairment, weather and light conditions, etc.);

- an assessment of the accident distribution on the road network, on the particular road or road section/location;

- a detailed data analysis of accidents and their circumstances in the targeted spots/sections of roads by using collision diagrams;

- A determination of the road related deficiencies and elaboration of suggestions for their suppression or treatment;

- investigation of road accidents records elaborated by the police in charge of traffic control and road accidents observations, and setting up of reliable statistics on damages and corporal injuries accidents over these last five (5) years;

- Physical exploration of the existing classified road network to identify all black spots (on road sections). The exploration will be based on the results of analysis of official accidents records and on interviews with the road network operator, local authorities, transport operators (transport unions, unions of drivers, transportation agencies, shippers) and other road users;

- consider all relevant matters that have an adverse bearing on road safety under all operating conditions;

About black spots, in addition to the mapping that it will have to produce; the execution manual of remedial works will be prepared and for all identified black spot on roads,

- the amount and distribution of traffic in different types of vehicles;
- a site plan;

- a longitudinal section;
- cross-sections;
- an improvement plan.

A computerised accident database shall be developed, accident analysis and monitoring system to measure the actual impact of various remedial measures to accident spots and to determine the corresponding coefficient of reduction in accidents. The system will also predict the impact of accidents the road network of Rwanda under different operating conditions.

In addition, a report on road accidents statistics shall be produced (personal injuries accidents and damages) from accidents data on these last five (5) years that it will analyze. This additional report will set forth:

- Statistical data on: (i) monthly and annual number of damages and personal injuries accidents (ii) accidents sites, (iii) causes of accidents, (iv) users involved, (v) seriousness in number of deaths and injuries. The results will be presented in tables and graphs easy to read;
- Analysis of the current collection and processing system of road accidents data; any proposals to improve the current collection and processing system of accident data.

An assessment of the accident data collection system in Rwanda shall be made including institutional, human resources and regulatory issues. The proposals to improve the system especially the data collection shall be given.

A comprehensive accident data base that will enable all concerned services to analyze and update shall be established. The system shall be web based to collect information and it will be multi-login.

2.4.4 Road safety strategy development

Based on the findings of the auditing exercise, a strategy document that will contain road safety improvement measure will be produced. The tasks include:

- analyze the causes for road accidents identified at the audit stage and propose mechanisms for prevention of accidents;

- assess the state of road safety education and awareness creation practices and propose mechanisms of improvement;

- assess the adequacy of existing road safety policies and regulations, as well as enforcement and identify areas of improvement. Further, the Consultant shall propose appropriate policies and enforcement mechanisms;

- assess road design standards and practices and propose areas of improvement that shall be consider when a new roads and bridges design standard and specifications will be developed;

- assess the practices in trauma management, identify areas of improvement and propose the way forward;

- evaluate the existing institutional arrangement for road safety and propose options that would help to put in place efficient and effective lead institution;

- propose options for availing adequate funding for roads safety actions;

- identify road safety monitoring indicators and framework.

2.4.5 Road safety action plan and programmes

Based on the findings of the auditing exercise, the Road Safety Action Plan and Programmes will be produced in order to enhance the capability to develop, implement and oversee improvements in road safety and traffic management nationwide.

2.5 International best practice in road safety audit

2.5.1 Road Safety Audits

2.5.1.1 Definition

In report D4.1 of Ripcord-Iserest (Matena, Löhe, Vaneerdewegh, 2005) several definitions for road safety audits are given. Taking into account the common practice, one can define a road safety audit as a formal systematic road safety assessment of a road scheme carried out by an independent, qualified auditor who reports on the project's accident potential for all kinds of road users.

The comparison of different approaches (Best Practice Guidelines on Road Safety Audit, D4 Doc., page 4) in several countries indicated the need for a clear differentiation between road safety audits on the one hand and road safety inspections on the other. The boundary between these two instruments sometimes appears blurred and can therefore lead to misunderstandings. In contrast to road safety inspections which are sometimes called road safety audits of existing roads, the original road safety audit refers to examinations conducted in the planning and the design stages of road projects (which include new projects but also re-design projects) before or shortly after a road is opened to traffic or the measure is completed. The existence of road schemes is therefore an important pre-requisite for road safety audits.

The aim is to ensure that all new road schemes operate as safely as possible for all road user groups. During a road safety audit, which is usually carried out before relevant administrative decisions are taken in the design process, an independent road safety expert (auditor) or team of experts checks the road schemes for any elements which might have a negative impact on road safety. These elements have to be reported to the responsible road authorities. The benefit of auditing is that it allows decision makers to include safety considerations in all their decisions and should therefore be an integral part of the planning process.

In contrast to road safety inspections, road safety audits are intended to increase road safety by avoiding accidents before a road is (re-)opened to traffic.

2.5.1.2 Reasons for carrying out road safety audits

In most countries design guidelines are applied which only implicitly consider road safety issues and usually reflect a compromise between other road transport issues.

For this reason, accidents can also occur on new roads despite the application of effective guidelines. This is caused by a number of reasons. First, as indicated above, design guidelines often contain minimum requirements regarding road safety. An inauspicious combination of design elements with minimum standards can therefore lead to hazardous road stretches. Furthermore, during the design process, a road designer has to keep several issues in mind which have an effect on the design itself. Besides the environment, the project costs and the topography, often political restraints or the opposition of pressure groups and concerned residents force the

designer to make compromises. These compromises do not always lead to a design with the highest level of safety. To avoid negative effects on road safety, alternatives or compensatory measures have to be found.

For this reason, road safety audits are carried out in order to give road safety issues a higher weight in the planning process and to avoid road accidents before they happen. At first sight, one may consider audits as checks for possible errors in design. The fear of being controlled is therefore one possible reason why in the implementation phase some designers seem to reject the idea of road safety audits. To find errors is, however, not the primary aim of audits. The independent safety check carried out by the auditors should provide information on the detected safety deficiencies and can give hints how the design can be improved with regard to road safety. These hints do not necessarily concern errors only; i.e. safety relevant deviations from existing standards but should also outline any reasonable improvement.

Most guidelines and design standards imply a correct behaviour of the road users. But more than 90% of all road accidents are caused by human errors. Therefore, a user friendly and safe road design does not only have to comply with standards and the latest road safety research but it must also consider human behaviour.

Road safety audits should therefore be carried out by specialists, experienced in road safety and traffic behaviour research in order to help road designers and road owners to design roads which are as safe as possible for all road user groups.

Results of the ROSEBUD project (ROSEBUD, 2003) as well as of other international studies made in the UK (Surrey County Council Survey, 1994), Denmark (Danish Road Directorate, 1995) and Australia (Austroads, 2002) regarding the effects and benefits of road safety audits generally show that conducting audits is inexpensive and highly effective.

An often quoted study dealing with the evaluation of road safety audits has been carried out in Denmark (Danish Road Directorate, 1995) and came to the result that road safety audits amortise within 8 months which means that applying road safety audits is cost effective already within the first year. Although a later assessment came to the result that the estimates were too optimistic, the

revised figure also supported the effectiveness of road safety audits. This effectiveness is also recognised by ROSEBUD (2003), Elvik/Vaa (2004), the Surrey County Council Survey (1994), Austroads (2002), BASt (2001) and many others. It is internationally accepted that road safety audits are a success.

Apart from the direct safety effect of auditing, another side-effect is the rising awareness of road safety in the road design process. As the number of audits increases, also the knowledge of clients and designers on road safety issues increases. Furthermore, if the audit reports are evaluated regularly, typical safety deficits can be identified. This knowledge can be used to an improvement of design guidelines and further education programmes for auditors and designers.

2.5.2 The Audit Process

2.5.2.1 The participants

Mostly three different parties are involved in the audit process: the client, the designer and the auditor. The roles and responsibilities of the different parties can sometimes differ.

Client: The organization responsible for the project which is sometimes also called the project manager, or project sponsor. Often the road authority or local stakeholders are the clients but also private investors can be responsible for road projects.

Designer: A person or team commissioned by the client to develop the road schemes. The design team can be part of the client's organization.

Auditor: A person or team commissioned (or approved) by the client to carry out the audit. In order to ensure an unbiased judgment, the auditor ought not to be involved in the design process or in the operation of the road.
It is recommended that the auditors are independent from the designer's organization. Irrespective of the qualification of the auditors, apart from small projects, all audits should be conducted in teams of at least two persons. These auditors should at best provide experience from different fields of work, e.g. design and road safety engineering in order to complete each other with their expertise.

2.5.2.2 Stages of audits

Audits ought to be carried out at different stages in the development of road projects.
A description of the different stages is given below. Usually audits are carried out before relevant administrative decisions are taken. The audit stages 1-3 take place during the planning and design phase of the project while the stages 4 and 5 take place shortly before and after traffic opening.
There is clearly a need to audit road or traffic related projects at different stages in the course of a road project. Otherwise it is likely that important safety issues are not considered or even identified before it is too expensive to change the project design. Also in relation to road safety it is better to prevent than to cure. Usually audits are carried out at these stages:

Feasibility stage (1): At this stage the road project itself and possible alternatives are evaluated. After the feasibility stage the route will be determined. A stage 1 audit can influence general design issues such as route choice, general road layout, number and types of intersections and operational aspects.

Preliminary design stage (2): At the preliminary design stage the general alignment is worked out. Audits deal with horizontal and vertical curves as well as cross section dimensions and the general junction layout prior to land acquisition procedures.

Detailed design stage (3): Detailed schemes are worked out at this stage prior to contracting the construction. The schemes contain detailed information on any road elements, installations, traffic signs and signals as well as regulation, markings and roadside equipment. Audits check the safety implications of these aspects.

Before opening stage (4): Audits at this stage take place after completion of the construction, shortly before the road is opened to traffic. Auditors inspect the sites at different daytimes in order to check if the safety of all road user groups has been considered.

After opening stage (5): Audits at this stage are carried out after completion of the construction, shortly after the road has been opened to traffic. Auditors check if the road users make use of the

road as intended. Since the goal of audits is to prevent accidents before they happen, the audit should be carried out within the first 6 months after the traffic opening.

Although some countries have included an after opening audit, the practice shows that these audits are usually not audits in the sense of the definition but are more comparable to road safety inspections (Schermers, 2007). Other procedures can be seen as a kind of quality control which checks if the new road actually operates safely. Although this quality control for new road projects can be recommended for increasing knowledge in road safety, this process is by definition no road safety audit anymore as the procedure and its goal differ from auditing at earlier stages. Because of the pro-active nature of road safety audits, after opening audits must not be mistaken for accident analyses or black spot management and should not be dependent on a retrospective analysis of accident data.

The most important information that can be acquired by an after opening audit is if the road users make use of the road as intended and, if this is not the case, which countermeasures can be taken before accidents occur. If road safety audits are carried out in all four design stages and road safety inspections (RSI) are regularly carried out on all existing roads the need for audits after traffic opening is reduced (If the after opening audit was not carried out, the next periodical road safety inspection should reveal the deficit). Nevertheless as long as RSI is not carried out regularly on the whole road network, it is recommended to carry out audits also at stage five.
Because each audit stage deals with different safety issues at different levels of detail it is very important to carry out audits at every stage. The earlier audits are carried out the easier it is to adapt the schemes. An analysis of the rate of acceptance of the 13 pilot audits in Denmark showed that about 2/3 of all recommendations were accepted.
A survey carried out in the German state of Brandenburg (Bakaba, 2005) showed similar results. The comparison, however, also showed that the rate of acceptance strongly diminished in later audit stages. This can be easily explained by the fact that it is easier to make changes in a scheme than to alter road infrastructure, which has already been completed.

2.6 Comparison of international practice with the current situation in Rwanda

Taking into account that the road safety audit is carried out at different stages of the development of road project; the international best practice in road safety audit is not applied in Rwanda. No road safety auditor is hired at any stage; only the road design and topographer carry out the detailed road design of the road project from feasibility, preliminary design and detailed design, before opening and after opening stages.

The gaps existing between international best practice in road safety audit and current local practice in Rwanda are based on road safety audit stages. The table below shows the gaps:

Table 1: International best practice and current practice in Rwanda

International best practice	**Current local practice in Rwanda**
Feasibility stage (1): At this stage the road project itself and possible alternatives are evaluated. After the feasibility stage the route will be determined. A stage 1 audit can influence general design issues such as route choice, general road layout, number and types of intersections and operational aspects	No road safety audit is being carried out at this stage (1) for road project in Rwanda.
Preliminary design stage (2): At the preliminary design stage the general alignment is worked out. Audits deal with horizontal and vertical curves as well as cross section dimensions and the general junction layout prior to land acquisition procedures.	No road safety audit is being carried out at this stage (2) for road project in Rwanda.
Detailed design stage (3): Detailed schemes are worked out at this stage prior to contracting the construction. The schemes contain detailed information on any road elements, installations, traffic signs and signals as well as regulation, markings and roadside equipment. Audits check the safety implications of these aspects	No road safety audit is being carried out at this stage (3) for road project in Rwanda.

Before opening stage (4): Audits at this stage take place after completion of the construction, shortly before the road is opened to traffic. Auditors inspect the sites at different daytimes in order to check if the safety of all road user groups has been considered	No road safety audit is being carried out at this stage (4) for road project in Rwanda.
After opening stage (5): Audits at this stage are carried out after completion of the construction, shortly after the road has been opened to traffic. Auditors check if the road users make use of the road as intended. Since the goal of audits is to prevent accidents before they happen, the audit should be carried out within the first 6 months after the traffic opening.	No road safety audit is being carried out at this stage (5) for road project in Rwanda.

2.7 Summary of findings

It was found that the road safety audit is a formal examination of a new or upgrading project where interaction with road users takes place in which an independent and qualified team identifies potential road safety problems and suggest measures to mitigate those problems.

Its purpose is to make new and reconstructed roads as safe as possible before construction is started and before accidents occur. When conducting a road safety audit, individual projects are examined through "road safety glasses". Any inappropriate designs are revealed and proposals for improvements are formulated. Auditing can be carried out at one or more specific stages during the course of a project. The systematic approach taken means that consideration for road safety can be incorporated into a project at the earliest possible stage. Road safety audit should be a self-evident phase of our highway authority quality management and it can be applied to all road projects new constructions, as well as reconstructions. Road safety audit can also be applied to operating and maintenance activities on existing roads, to the extent that such activities can influence road safety

The road safety has been taken into consideration as part of Rwanda strategic transport master plan (RSTMP) taking into account the latest road accident statistics as well as international best practices that relate to road safety in Rwanda. The outcome is a proposed **"High-Level" Road Safety Strategy for Rwanda** and respective short term implementation projects aimed at promoting a more functional and safer road network in the country. Furthermore, in order to improve the safety performance of infrastructure and transport services, RTDA (Rwanda Transport Development Agency) has prepared the terms of reference to select a consultant that will perform a road safety audit on the road network and develop road safety strategy. The objective of the audit is to reduce the number of personal injuries accidents and damages throughout the classified road network in Rwanda, while the strategy and action plan setout key road safety policies and actions to be implemented in the future to make Rwanda's road network safer. It will enable the improvement of road safety for all road users (pedestrians, motorists and passengers), and therefore the understanding of the causes of accidents on roads of the country

Finally, it was found that the international best practice in road safety audit is not applied in Rwanda. No road safety auditor is hired at any stage; only the road design and topographer carry out the detailed road design of the road project from feasibility, preliminary design and detailed design, before opening and after opening stages. There are gaps between international best practice in road safety audit and current local practice in Rwanda.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Introduction

Development of road safety audit procedure requires a methodological analysis merged with the well-defined sequence of steps in order to come-up with evidence based overview of the situation.

This section of the thesis describes the general approach of the research and different methods used during data collection, data analysis and interpretation of the results. This is the core portion of this study as it describes the main pillars of the work and arranges them in logical relationship.

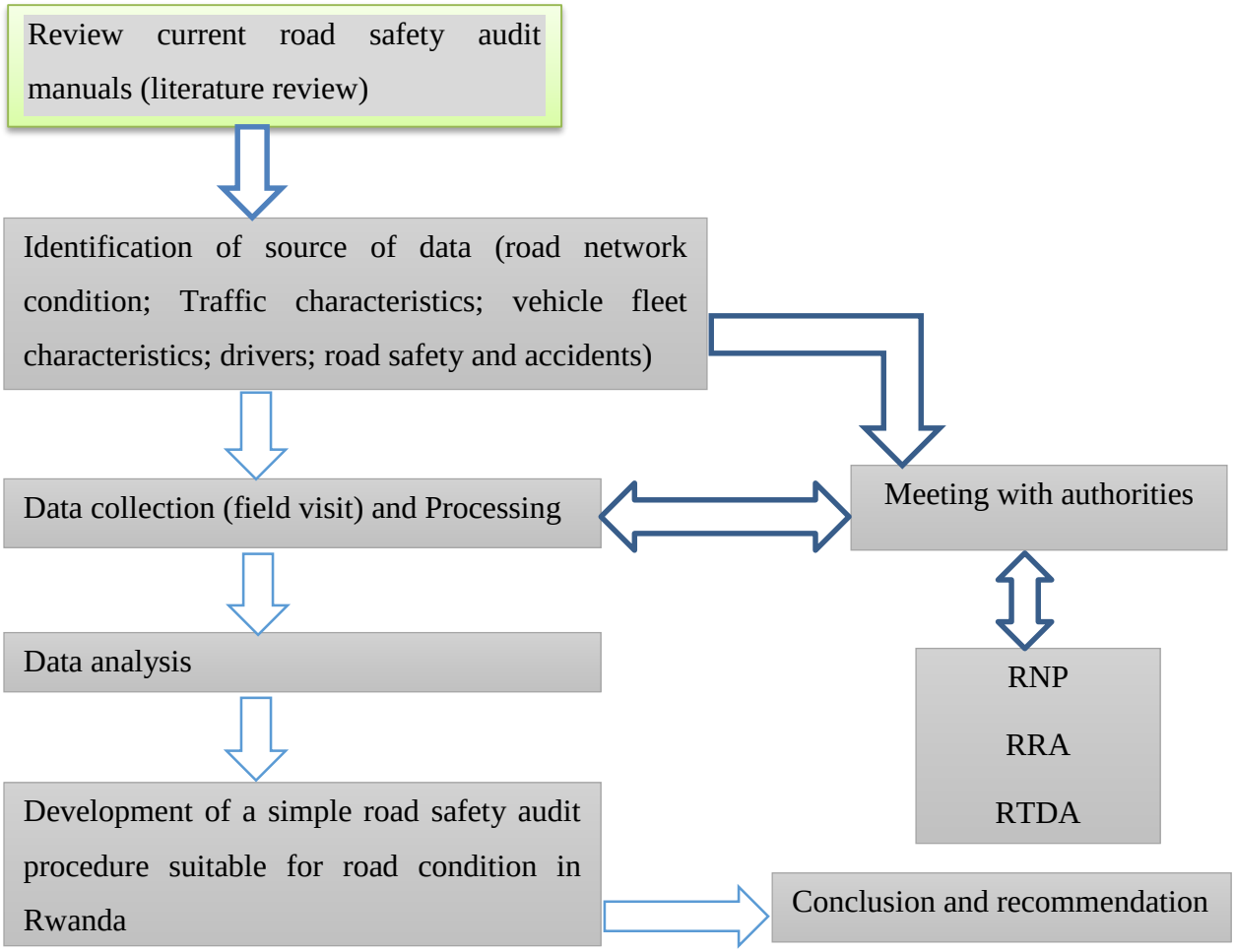
3.2 Research design

3.2.1 Research approach

The current research is stipulated as a qualitative, observational research where by the development of a simple road safety audit procedures suitable for road condition in Rwanda is based on data collected in textual form in different government institution such as Rwanda Transport Development Agency (RTDA), Traffic Police/ Rwanda National Police (RNP) and Rwanda Revenue Authority (RRA). This chapter intends to describe methods and techniques used to respond to the objectives of this research. It presents the approaches used to review current road safety audit manuals; identify the source of road network condition including road classification, road network size, pavement types, road condition; vehicle fleet characteristics; traffic characteristics; drivers; road safety and accidents data; to collect data; to analyzed data; development of a road safety audit procedure for Rwanda and the guidelines on how to apply the procedure will be given.

3.2.2 General overview of the research approach

Figure 1: Methodological framework to respond the objectives of this research.



3.3 Literature review

Conducting a literature review of current road safety audit manuals is helpful to achieve objectives of the research project. The road safety audit manuals are mostly based on Australian and European manuals. The Literature reviews will provide me with a handy guide to my thesis. It will give an overview as a stepping stone on what is current in the field of road safety audit. Also, it will provide a solid background in road safety audit and will give a theoretical basis for the research.

3.4 Identification of source of data

This step consisted of listing possible sources of each data type. Government institutions often make valuable documents, reports, data sets and other written artifacts that include transport data and information on road safety and accidents. The list of documents include government publications such as (a) Acts of Parliament, (d) Consultancy reports, (e) statistical publications, (f) ministerial or departmental annual reports etc. They include also international road safety audit manuals such as Australian road safety audit manual, European road safety audit manuals and South African road safety audit manual.

The identification of possible sources of each transport and road safety data type require the knowledge of Institutions' responsibilities or missions which help to determine transport data that would be available in an institution.

Following are the main sources of traffic engineering data, transport data, road safety and road traffic accidents data in Rwanda:

1. Rwanda Transport Development Agency (RTDA) which is the implementing agency of the Ministry of Infrastructure (MININFRA). Using consultants and its engineers, RTDA generates traffic engineering data. Through the Unit of road safety and environment, RTDA may also provide some accident data obtained from national police.

2. Statistics on road traffic crashes ("accidents") in Rwanda are based on information collected by the Traffic Police of the Rwanda National Police. The data related to road safety and accident would be obtained from Traffic Police.

3. Rwanda Revenue Authority has the mandate to register all vehicles in Rwanda. The vehicle fleet characteristics can be obtained from RRA

4. National Institute of Statistics of Rwanda (NISR) plays the role to use evidence-based information for decision-making for the benefit of Rwanda. It accomplishes these goals by coordinating national efforts to collect and compile reliable data and to analyze, disseminate and archive data within an integrated and sustainable framework

3.5 Data collection and processing

To make successful the project the data related to road network condition including road classification, road network size, pavement types, road condition; vehicle fleet characteristics; traffic characteristics; drivers; road safety and accidents data collected.

3.5.1 Road network characteristics

3.5.1.1 Road classification

The law n°55/2011 of 14/12/2011 governing roads in Rwanda states that the Road Network of Rwanda are classified as follows:

- National roads
- Districts and City of Kigali roads and that of other urban areas - Class One
- Districts and City of Kigali roads and that of other urban areas - Class 2
- Specific roads

Table 2: Road Classes Identified in the Road Act, 2011 governing roads in Rwanda

Class	**Description**	**Minimum road width (m)**	**Minimum road reserve width (m)**
National roads (NR)	1. International roads that links Rwanda with a neighbouring countries;	The minimum viable widths of roads, the District and City of Kigali Roads not including the side drains and embankments shall be **7 meters.**	The road reserve on which run National roads, District and City of Kigali roads class one, is delimited by two parallel lines at **twenty two (22) meters** on each side
	2. Roads that link Districts or a District and the City of Kigali		
	3. Roads that link areas of tourist significance and facilities of national or international importance such as ports or airports.		

District and City of Kigali Roads – Class one (DR)	These are roads with a local significance linking different headquarters of Sectors within the same District, or within the same Sector	The minimum viable widths of roads, the District and City of Kigali Roads not including the side drains and embankments shall **be 7m**	of the centre line of the road.
District and City of Kigali Roads-Class 2 (DR)	These are arterial roads that connect Districts roads to rural community centres that are inhabited as an agglomeration	The minimum width of the roadway in Districts and City of Kigali roads and other urban areas - Class 2, not including drainage ditches and embankments shall be six (6) metres. Around and at the entrances of towns, communities or villages, the width of roads should be increased as the need shall be. Over and above this width, each road should have the necessary land extension for drainage ditches, embankments, and areas for storage of materials and, if there is space for sidewalks, which constitute integral part of the road.	The public reserve on which run District and City of Kigali Roads -Class 2 shall be of not less than **12 meters** on each side from the centre line of the road.
Specific road	These are roads specifically constructed	Not specified.	Not specified.

	to connect National Roads or District roads to Kigali City and other urban areas to the centres for private sector's activities such agricultural production, natural resources processing or to tourist sites		

3.5.1.2 Road network size

The total road network length of Rwanda is estimated at almost 14,000 km, the classified road network has a length of 6,655 km. As a result of a recent re-classification exercise, the National Roads class (under RTDA jurisdiction) has been slightly reduced to 2,749 km (from 2,838 km before).

The total length of classified District and Kigali (and other urban) Class 1 Roads has been considerably extended to a total of 3,906 km (more than doubled from 1,839 km).

The data collection related to my research will be concentrated to the roads classified as National paved roads. The size of National paved roads is 1210.8 km.

3.5.1.3 Pavement types

The National road networks have two types of pavement: Paved (asphalt roads) and Unpaved roads. In my research I concentrated myself on 1210.8 km of National Paved roads.

3.5.1.4 Road condition

The condition of the National road have been assessed on National paved road by using international roughness index measured by the bump integrator. A road is said to be in "good condition" if the average roughness measured on its surface is less than or equal to IRI 4 m/km for a paved road. The data related to road condition has been collected in Rwanda Transport

Development Agency (RTDA) in maintenance division/ road maintenance programming unit.

3.5.2 Vehicle fleet characteristics

Rwanda Revenue Authority has the mandate to register all vehicles in Rwanda. Since there is no manufacturing or assembling plant in the country, all vehicles are imported. An information system to record the registration of vehicles in the country was introduced in 2003. Additionally, as of 2003, a new number plate system was introduced in Rwanda, which meant that all vehicles registered prior to that year, had to be re-registered. This process ran parallel with new vehicle registrations. All data regarding vehicle fleet has been collected from Rwanda Revenue Authority.

3.5.3 Traffic characteristics

The latest traffic counting of 2013 has been collected from Rwanda Transport Development Agency (RTDA) in Planning Division/ road network planning unit. The traffic counts has been conducted on all National paved road. The vehicles were classified into three categories:

- Motorcycles
- Light vehicles (GVWR= net mass + maximum load capacity ≤3.5Tonnes)
- Heavy vehicles (GVWR = net mass + maximum load capacity >3.5Tonnes)

3.5.4 Drivers

The data of drivers has been collected from Traffic Police. These data will be related to the number and ages of drivers involved in road accidents.

3.5.5 Road safety and accidents data

The road safety and accidents data has been obtain in Traffic Police. All data related to the road accident are collected by Traffic Police. The description of the road safety situation in Rwanda as reflected in the official accident statistics published by the Traffic Police of the Rwanda National Police will be given. The analysis covered the years 2009-2013 and these accidents compared the road safety situation year per year. These data included the total number of fatalities, serious and minor accidents. The serious accidents in Kigali with rest of Rwanda in 2010 – 2013 have been analyzed.

The word “accident” refers to road accidents or road crashes. The source to all tables and charts will be the Traffic Police of the Rwanda National Police.

3.6 Meeting with authorities

To meet authorities or professionals is very important. The use of information have to be explained clearly to authorities before they provide them to the researcher. This meeting may allow to have information that could not be found in the different documents or to have further clarification on data. Before collecting data, a brief description of the thesis and its objective have to be presented to authorities; this is the reason why it has been grateful to have this meeting before the data are collected.

Table 3: Presents the titles of officers met in each institution.

No	**Title of officers**	**Institutions**
1	Head of Planning Division	RTDA
2	Head of Maintenance Division	RTDA
3	Traffic Engineer	RTDA
4	Road Maintenance Programming Engineer	RTDA
5	Commissioner of Traffic Police	RNP
6	Directorate of Accidents	RNP
7	Directorate Vehicle registration	RRA

3.7 Data analysis

In order to develop a simple road safety audit procedure suitable for road condition in Rwanda, the analysis of the data collected has been made by basing on the statistics, graphic techniques and tables.

3.8 Development of a road safety audit procedure for Rwanda

The development of a road safety audit procedure for Rwanda has been described in this part. It focused on the objectives of the research including road design. The procedures developed have been presented clearly and guidelines have been given on how to use or apply the procedure. As there was a clearly need to audit road or traffic related projects at different stages in the course

of a road project; the road safety audit procedures have been performed at different stages in the development of road projects by starting from feasibility stage, preliminary design stage, detailed design stage, before opening stage and after opening stage**.**

The guidelines on how to apply these procedures were in form of Checklists which have been applied at each stage of a road project. The checklists have been used as a "memory prompt" and a form of guidance to ensure that all safety issues were considered.

3.9 Conclusion and recommendation

Finally, the conclusion related to the gaps existing between international best practice in road safety audit and current local practice in Rwanda has been given. Also it has been concluded that in order to achieve the objectives of safer roads for sustainable development of the country, the safer roads have been constructed by respecting the road safety audit procedures at each stage of the road project from feasibility study to pre-opening the road which resulted in benefits such as safer new roads through accident prevention and crash severity reduction, safer road networks, reduced whole life costs of road schemes, a reduced need to modify new schemes after they are built, a better understanding and documentation of road safety engineering, eventual safety improvements to standards and procedures, more explicit consideration of the safety needs of vulnerable road users.

With regards to future works some recommendations on research project have been provided such as development of Road safety audit manual for Rwanda; road design and bridge manual comprising safe design practices; other similar works are recommended for Kigali urban roads and urban roads of major towns of Rwanda; deep analysis to know the real cause of a high number of accidents and propose the mitigation measures; deep analysis of a cause of accidents on different black spots and find out the mitigation measures to reduce accidents; improvement of motorcyclists safety as mode of public transport and improvement of safety of pedestrians crossing the road in urban areas of Rwanda.

CHAPTER 4 DATA COLLECTION AND PROCESSING

4.1 Introduction

To complete successful the project the data related to road network condition including road classification, road network size, pavement types, road condition; vehicle fleet characteristics; traffic characteristics; drivers; road safety and accidents data have been collected

4.2 Road network characteristics

4.2.1 Road classification

The law n°55/2011 of 14/12/2011 governing roads in Rwanda states that the Road Network of Rwanda are classified as follows:

- National roads
- Districts and City of Kigali roads and that of other urban areas - Class One
- Districts and City of Kigali roads and that of other urban areas - Class 2
- Specific roads

The National roads (NR) are those comprising the following categories:

1° International roads that link Rwanda with neighbouring countries;

2° Roads that link Districts or that link a District and the City of Kigali;

3° Roads that link areas of tourist significance and facilities of national or international importance such as ports and airports

All the National roads have the minimum viable widths of 7 m not including the side drains and embankments and the road reserve on which run National roads is delimited by two parallel lines at twenty two (22) meters on each side of the centre line of the road.

The District and City of Kigali roads and that of other urban areas class one (DR) are the roads with a local significance linking different headquarters of Sectors within the same District, or within the same Sector. The minimum viable widths of roads, the District and City of Kigali

Roads not including the side drains and embankments is 7. The road reserve on which run District and city of Kigali class one roads is delimited by two parallel lines at twenty two (22) meters on each side of the centre line of the road.

The District and City of Kigali Roads class 2 (DR) are arterial roads that connect Districts roads to rural community centres that are inhabited as an agglomeration. The minimum width of the roadway in Districts and City of Kigali roads and other urban areas - Class 2, not including drainage ditches and embankments shall be six (6) metres. Around and at the entrances of towns, communities or villages, the width of roads should be increased as the need shall be.

Over and above this width, each road should have the necessary land extension for drainage ditches, embankments and areas for storage of materials and, if there is space for sidewalks, which constitute integral part of the road. The public reserve on which run District and City of Kigali Roads class 2 shall be of not less than 12 meters on each side from the centre line of the road.

The Specific road are the roads specifically constructed to connect National Roads or District roads to Kigali City and other urban areas to the centres for private sector's activities such agricultural production, natural resources processing or to tourist sites. Regarding the widths of the road and public reserve are not specified.

All classified roads comprise paved and unpaved roads. My research will be limited to National paved roads. The following are the National Paved roads:

NR1: Kigali-Muhanga-Huye-Akanyaru road (this road links Rwanda and Burundi)

NR2: Kigali-Musanze-Rubavu road (this road links Rwanda and DRC)

NR3: Kigali-Gatuna road (this road links Rwanda and Uganda)

NR4: Kigali-Kayonza-Rusumo road (this road links Rwanda and Tanzania)

NR5: Kicukiro-Nyamata-Nemba road (this road links Rwanda and Burundi)

NR 10: Huye-Nyamagabe-Nyamasheke road (this road links NR1 and NR11)

NR11: Ruhwa-Bugarama-Rusizi-Nyamasheke-Karongi-Rutsiro-Rubavu road (this road links Rwanda, Burundi and DRC)

NR15: Muhanga-Nyange-Rubengera road (this road links NR1 and NR11)

NR16: Muhanga-Ngororero-Mukamira road (this road links NR 2 and NR15)

NR17: Musanze-Cyanika (this road links Rwanda and Uganda)

RN18: Musanze-Kinigi-Busogo-Kora-Kabuhanga (this is the road towards Volcano Park)

NR24: Kayonza-Kiramuruzi-Rwimiyaga-Kagitumba road (this road links Rwanda and Uganda)

4.2.2 Road network size

The total road network length of Rwanda is estimated at almost 14,000 km, the classified road network has a length of 6,655 km. As a result of a recent re-classification exercise, the National Roads class (under RTDA jurisdiction) has been slightly reduced to 2,749 km (from 2,838 km before).

The total length of classified District and Kigali (and other urban) Class 1 Roads has been considerably extended to a total of 3,906 km (more than doubled from 1,839 km).

The data collection related to my research were concentrated to the roads classified as National paved roads. The size of National paved roads is 1210.8 km.

4.2.3 Pavement types

The National road networks have two types of pavement: Paved (asphalt roads) and Unpaved roads. The pavement type subjected to my research was the National paved roads (asphalt roads).

4.2.4 Road condition

The condition of the National road is assessed on National paved road by using international roughness index measured by the bump integrator. A road is said to be in “good condition” if the average roughness measured on its surface is less than or equal to IRI 4 m/km for a paved road. Table 4 presents the road condition in Rwanda:

Table 4: Road condition in Rwanda

Roads	**% Good condition (right lane)**	**% Good condition (left lane)**	**Interpretation of the results**
NR1: Kigali-Huye-Akanyaru	93.30%	95.27%	A section from Huye to Akanyaru starts to present defects on surface layer.
NR2: Kigali-Musanze-Rubavu	99.60%	99.70%	The road is new in point of view rehabilitation, defects were observed at **km 37.400** near RULINDO District office and at **km 50.700** after leaving intersection of NR19 at BASE where a road was cutoff and other defect was observed at GAKENKE where there was a single lane usage.
NR3: Kigali-Gatuna			The survey was not done due to the rehabilitation of this road.
NR4: Kigali-Kayonza-Rusumo	91.10%	63.47%	A section from Kayonza to Rusumo present a bad condition due to the pothole repair and high axle road weight at the left lane from Rusumo to Kigali.
NR5: Kigali-Nyamata-Nemba	100%	100%	IRI is less than 4m/km
NR6: Ngoma round about-Ngoma Hospital(Paved Section of NR6)	37%		Old paved section of NR6 located at Ngoma town.
NR9: Paved section of Huye-Kibeho-Ndago-Bitare Border post	100%	93%	Small section of NR9 located at Huye town
NR10: Huye-Kitabi-Buhinga	96.30%	93.30%	The road present good condition at new rehabilitated section from Crete congo-Nili to Buhinga. Other section which decrease percentage of good condition is waiting for Rehabilitation (Huye-Crete congo-Nili)
NR11: Ruhwa Border Post - Kamembe-Tyazo & Kibuye-Rubengera (Paved Sections of NR11)	98.70%	95.10%	A section from Rubengera to Kibuye is one present high road defects of this whole paved section.
NR15: Muhanga-Rubengera	87.80%	98%	Bad condition due to pothole repair
NR16: Muahanga-Ngororero-Mukamira	100%	100%	Surface layer is in good condition

NR17: Nyakinama-Musanze-Cyanika (Section From Musanze to Cyanika)	76%	64.80%	Section of Nyakinama-Musanze is under rehabilitation and a section from Musanze to Cyanika present bad condition due to the old pavement structure.
NR18: Musanze-Kinigi-Rubavu (Paved section from Musanze to Kinigi and a section from MAJENGU to Petite Barriere)	46.70%	59.30%	Surface layer is in bad condition due to the designed surface layer (Single layer)
NR19: Rukomo-Gicumbi & Ryabega-Nyagatare(Paved Sections of NR19)	48.90%	37.50%	Old surface layer
NR24: Kayonza-Kagitumba	32.20%	31.30%	Bad condition due to pothole repair and old pavement structure.

Table 5: Summary of Road condition

No	**Description**	**Total length (Km)**	**Length inspected(Km)**		**Length in good condition(Km)**		**Percentage in good condition**	
			Right Lane	**Left Lane**	**Right Lane**	**Left Lane**	**Right Lane**	**Left Lane**
1	Classified National Paved Roads	1,210.8	1,074.847	1,070.697	929.247	882.097	86.45%	82.39%

No	**Description**	**Total length (Km)**	**Length inspected (km)**	**Length in good condition**	**% of roads in good condition**
1	National paved roads	1,210.8	1,078.565	905.672	84.42%

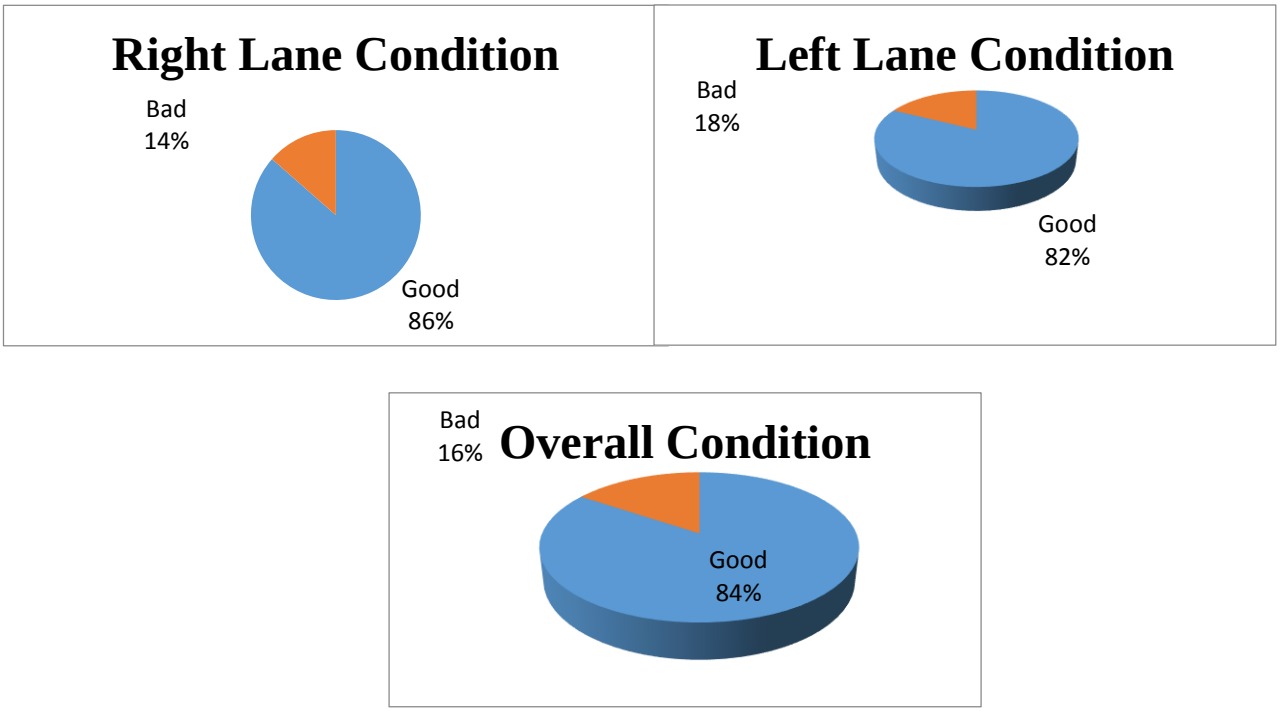


Figure 2: Overall road condition

COMPARISON WITH 2010-2011, 2011-2012 SURVEY RESULTS

Table 6: comparison of survey results

No	Description	% roads in good condition 2010-2011	% roads in good condition 2011-2012	% of roads in good condition 2012-2013
1	National paved roads	97%	97%	84.42%

4.2.5 Vehicle fleet characteristics

Rwanda Revenue Authority has the mandate to register all vehicles in Rwanda. Since there is no manufacturing or assembling plant in the country, all vehicles are imported. An information system to record the registration of vehicles in the country was introduced in 2003. Additionally, as of 2003, a new number plate system was introduced in Rwanda, which meant that all vehicles registered prior to that year, had to be re-registered. This process ran parallel with new vehicle registrations. The available data regarding vehicle fleet was collected in Rwanda Revenue Authority.

Table 7: National motor vehicle fleet size and composition 2004 - 2011

Category	2004	2005	2006	2007	2008	2009	2010	2011
Motorcycle	6,740	11,653	15,224	20,598	28,416	33,121	38,521	49,349
Car	8,513	10,309	11,198	13,003	14,925	16,292	17,220	19,177
Jeep	4,328	6,121	6,797	7,829	9,156	10,387	11,549	13,567
Pick-up	5,763	7,260	8,119	9,409	10,634	11,448	11,932	12,974
Minibus	2,695	3,419	3,698	3,910	4,567	4760	4,853	5,021
Microbus	52	59	61	74	89	115	130	144
Bus	56	71	87	133	224	250	397	469
Truck	1,358	1,634	1,805	2,106	2,304	2,490	2,723	3,134
Semi-trailer	64	77	89	101	124	162	178	186
Trailer	533	389	457	577	626	667	694	733
Special engine	56	82	96	179	241	327	423	548
Unknown	0	0	0	0	0	0	1	4
TOTAL	**30,158**	**41,074**	**47,631**	**57,919**	**71,306**	**80,019**	**88,621**	**105,306**

4.2.6 Traffic characteristics

The latest traffic counting of 2013 has been collected in Rwanda Transport Development Agency (RTDA) in Planning Division/ road network planning unit. The traffic counts has been conducted on all National paved road. The vehicles were classified into three categories:

- Motorcycles
- Light vehicles (GVWR= net mass + maximum load capacity ≤3.5Tonnes)
- Heavy vehicles (GVWR = net mass + maximum load capacity >3.5Tonnes)

Table 8 shows the Traffic characteristics on all National Paved road.

Table 8: Traffic count conducted on National paved roads in 2013

Road ID	Motor-cycles	LV (cars, jeeps, 4wds, minibus)	HV (Coasters to trucks)	ADT/ Road	ADT without motors
NR1 Kigali-Butare-Akanyaru (158 Km)	1,983	2,108	1,119	**5,210**	3,227
NR 2 Kigali-Musanze-Rubavu (150 Km)	469	1,096	556	**2,121**	1,652
NR 3 Kigali-Gatuna (78 km)	566	1,601	862	**3,030**	2,463

NR4 Kigali-Kayonza-Rusumo (166.1km)	570	1,526	913	**3,009**	2,439
NR 5 Kicukiro - Nyamata – Nemba (61.9 km)	593	1,204	311	**2,108**	1,515
NR 10 Huye-Nyamagabe-Nyamasheke (115.3 Km)	371	415	328	**1,114**	743
NR 11 Ruhwa-Bugarama-Rusizi-Nyamasheke-Karongi-Rutsiro-Rubavu (Section Ruhwa-Bugarama-Rusizi-Kibogora-Buhinga 75 Km and Kibuye-Rubengera 16 km)	2067	1966	1045	**5078**	3011
NR 15 Muhanga-Karongi (61.45 Km)	445	332	181	**958**	513
NR 16 Muhanga-Ngororero-Mukamira (98.6 Km)	240	279	74	**594**	353
NR 17 Musanze-Cyanika (25.2 Km)	1,538	835	305	**2,677**	1,140
NR 18 Musanze-Kinigi-Busogo-Kora-Kabuhanga (section Musanze-Kinigi 22 km)	1,072	498	205	**1,775**	704
NR 19 Base-Byumba-Nyagatare(section of Ryabega – Nyagatare 11.1 km and Byumba – Rukomo 11 km)	827	819	422	**2068**	1241
NR 24 Kayonza-Kagitumba (116.3 Km)	298	620	288	**1,206**	908

4.2.7 Drivers

The drivers that have been considered are those who involved in road accidents in 2010, 2012 and 2013. Table 9 presents the drivers involved in accidents by group of ages starting from 16 years to 85 years old. The total number of drivers is 19374.

Table 9: drivers involved in road accidents in 2010, 2012 and 2013

Ages	2013	2012	2010
16 Yrs– 18 yrs	200	81	46
18 yrs – 25 yrs	937	604	455
25 yrs– 30 yrs	2250	1597	1351
30yrs – 35 yrs	1556	1471	1333
35 yrs – 40 yrs	1312	946	944
40 yrs – 50 yrs	1014	1067	993
50 yrs – 60 yrs	282	326	372
60 yrs – 70 yrs	55	75	76
70 yrs – 85 yrs	6	9	16
TOTAL	**7612**	**6176**	**5586**

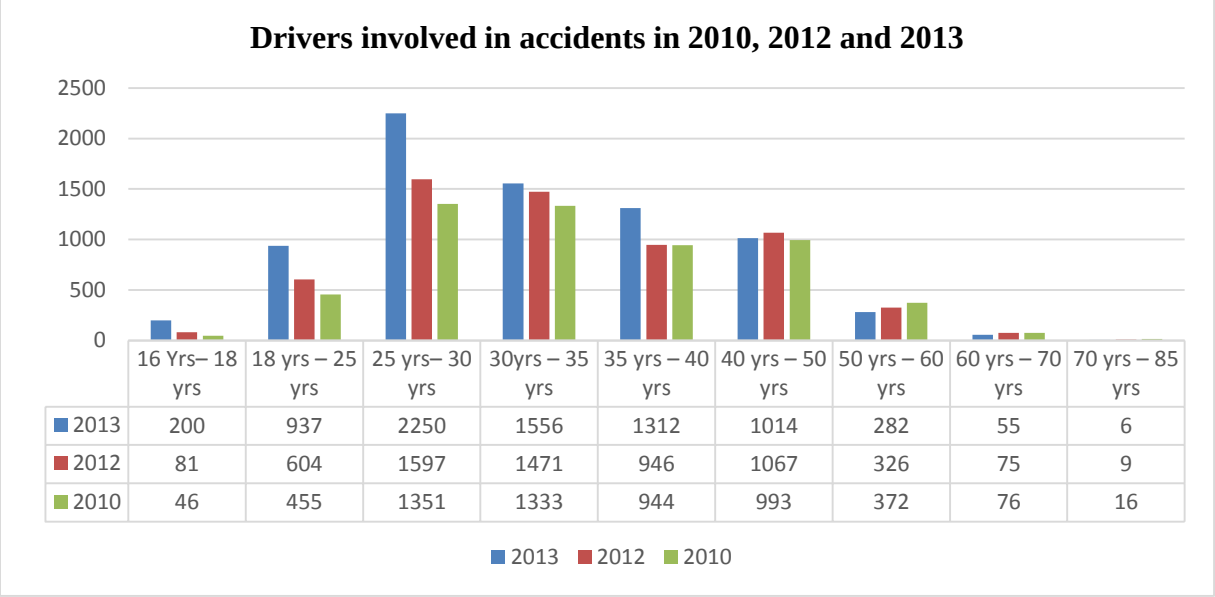


Figure 3: drivers involved in road accidents in 2010, 2012 and 2013

4.2.8 Road safety and accidents data

The road safety and accidents data has been obtained in Traffic Police. The description of the road safety situation in Rwanda as reflected in the official accident statistics published by the Traffic Police of the Rwanda National Police been collected. The analysis cover the years 2009-2013 and these accidents compare the road safety situation year per year. These data include the total number of fatalities, serious and minor accidents. The serious accidents in Kigali with rest of Rwanda in 2009 – 2013 is analyzed.

The word “accident” refers to road accidents or road crashes. The source to all tables and charts is the Traffic Police of the Rwanda National Police.

4.2.8.1 Fatalities

Table 10: represents fatalities per year (from 2009 to 2013)

Year	2009	2010	2011	2012	2013
Fatalities	344	449	392	495	556

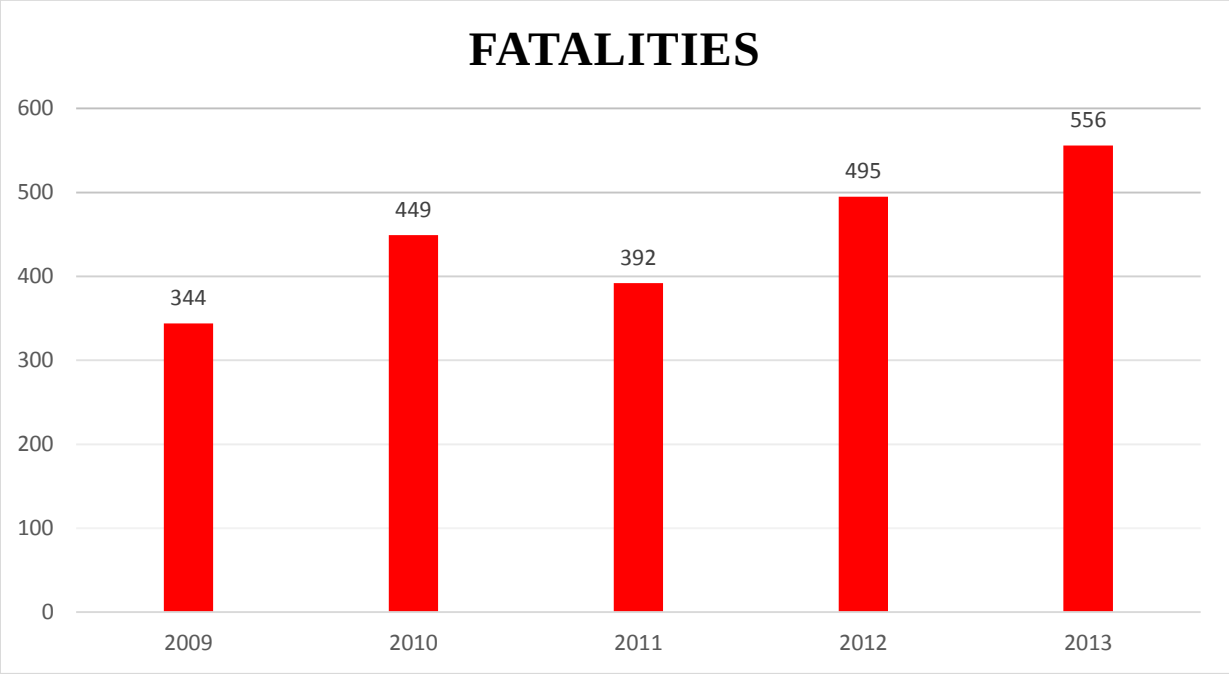


Figure 4: Number of fatalities in Rwanda 2009-2013

4.2.8.2 Serious and Minor accidents 2009 – 2013

Table 11 shows the statistics of total number of accidents, serious and minor which occurred from 2009 to 2013.

Table 11: represent serious and minor accidents

Year	2009	2010	2011	2012	2013
Serious	924	1265	871	943	567
Minor	1842	3580	3432	4470	5411
Total	2766	4845	4303	5413	5978

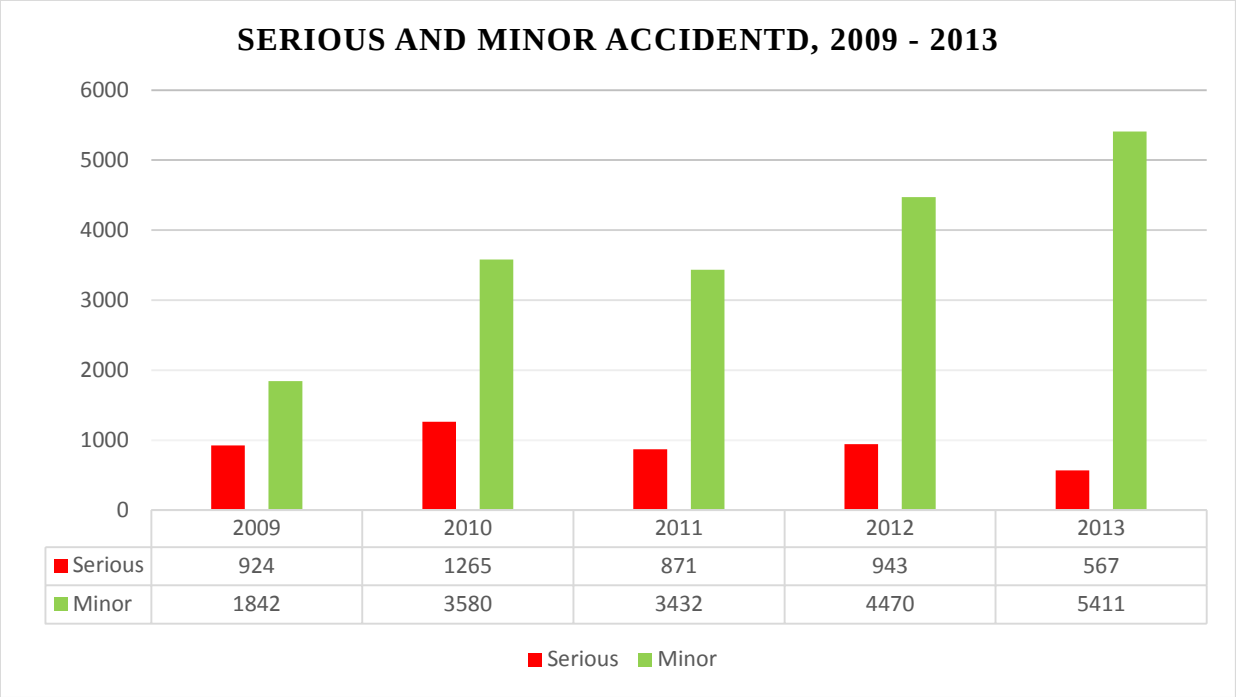


Figure 5: Number of serious and minor accidents

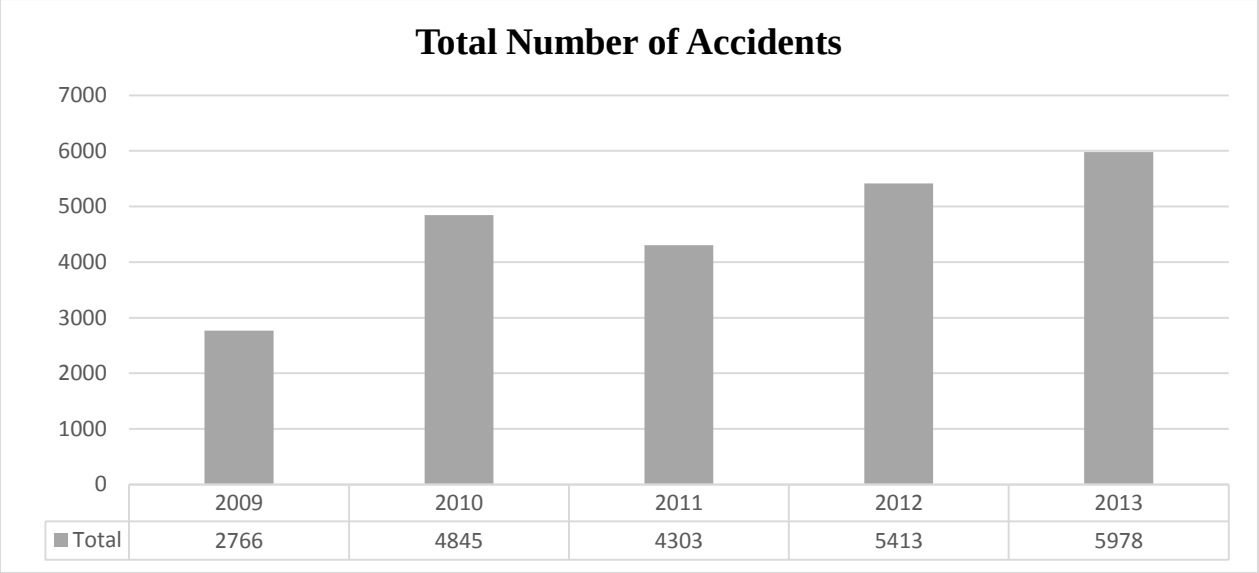


Figure 6: Total number of accidents

4.2.8.3 Serious accidents in Kigali with rest of Rwanda in 2010 – 2013

The figure below shows the percentage of serious accidents in Kigali compared to the rest of Rwanda.

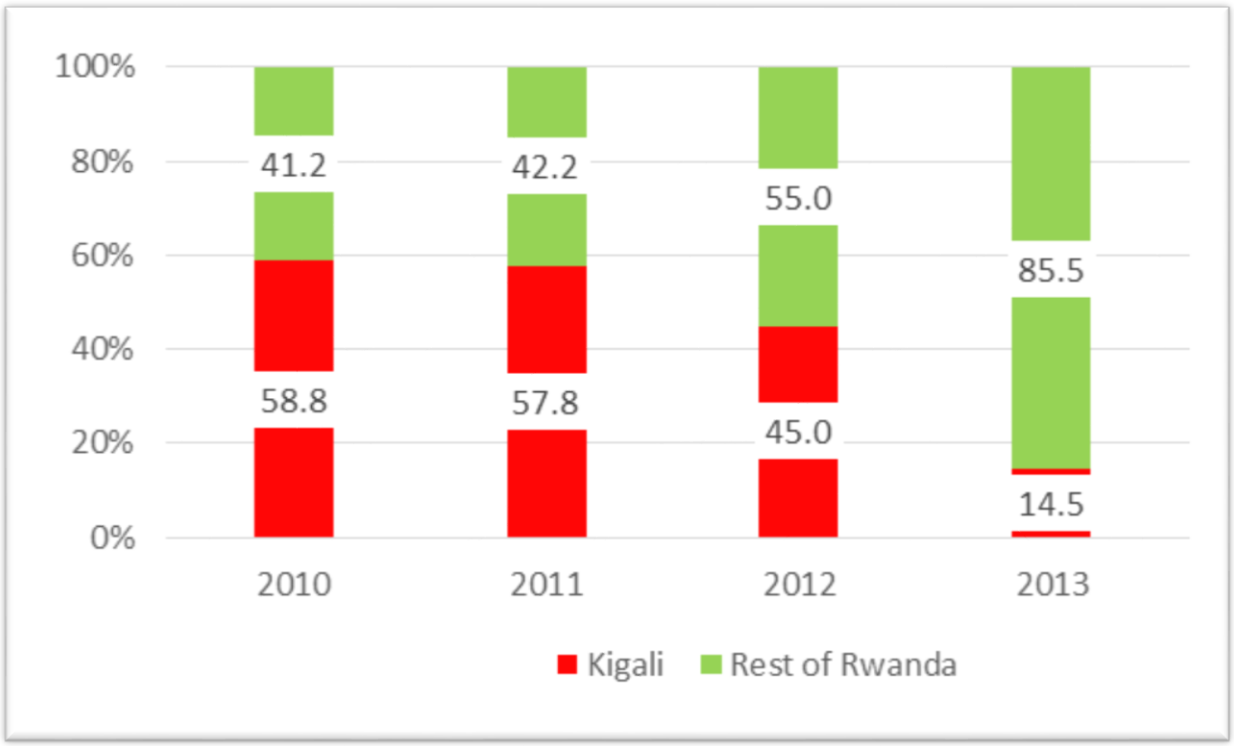


Figure 7: Percentage of serious accidents in Kigali and rest of Rwanda in 2010 – 2013

CHAPTER 5 DATA ANALYSIS

5.1 Introduction

To achieve the objectives of the research the analysis of the data collected in different institutions Government and private, has been made by basing on the interpretation of the statistics, graphics (figures) and tables.

5.2 Road network characteristics

Whilst the total road network length of Rwanda is estimated at almost 14,000 km, the classified road network has a length of 6,655 km. As a result of a recent re-classification exercise, the National Roads class (under RTDA jurisdiction) has been slightly reduced to 2,749 km (from 2,838 km before the law n°55/2011 of 14/12/2011 governing roads in Rwanda).

The total length of classified District and Kigali (and other urban) Class 1 Roads has been considerably extended to a total of 3,906 km (more than doubled from 1,839 km).

This road classification is now up to par with the requirements of the Road Act requirements on 'functionality/connectivity'. It appears a firm basis for comprehensive Rwanda road network management; the management task will be formidable considering the maintenance and upgrading challenges of a network of 6,655 km length. Many problems of safety and accidents do occur on National paved roads which comprise a total length of 1210.8 km.

For safety measures, the Government of Rwanda has put in place the Law governing the road. The Law regulates the road network in Rwanda and determines its reserves, classification and management. The law provides the minimum viable widths of the lane of a roadway of three meters and a half (3.5 m) not including the drainage ditches and embankments for national roads, Districts, and City of Kigali roads and those of other urban areas Class One and the minimum width of six (6) meters of the roadway in Districts and City of Kigali roads and other urban areas Class 2, not including drainage ditches and embankments.

In suburbs and at the entrances of towns, grouped settlements and agglomeration, the width of a road may be increased when it is deemed necessary. In addition to such width, each road must have a large piece of land for drainage ditches, embankments, dumps and sidewalks on all integral parts of the road.

The road reserve on which run the National, District and city of Kigali class one roads is delimited by two parallel lines at twenty two (22) meters on each side of the center line of the road and not less than 12 meters on each side from the center line of District and City of Kigali Roads class 2.

Therefore, during the road studies, the careful consideration of some elements in road design has taken into account by providing a minimum widths of the lane of a roadway of 3.5 m; a minimum widths of shoulder of 1.5 m in rural area; a minimum widths of raised walkway of 1.5 m and minimum widths of drainage system of 1 m.

The targeted National paved road are:

NR1: Kigali-Muhanga-Huye-Akanyaru road (this road links Rwanda and Burundi)

NR2: Kigali-Musanze-Rubavu road (this road links Rwanda and DRC)

NR3: Kigali-Gatuna road (this road links Rwanda and Uganda)

NR4: Kigali-Kayonza-Rusumo road (this road links Rwanda and Tanzania)

NR5: Kicukiro-Nyamata-Nemba road (this road links Rwanda and Burundi)

NR 10: Huye-Nyamagabe-Nyamasheke road (this road links NR1 and NR11)

NR11: Ruhwa-Bugarama-Rusizi-Nyamasheke-Karongi-Rutsiro-Rubavu road (this road links Rwanda, Burundi and DRC)

NR15: Muhanga-Nyange-Rubengera road (this road links NR1 and NR11)

NR16: Muhanga-Ngororero-Mukamira road (this road links NR 2 and NR15)

NR17: Musanze-Cyanika (this road links Rwanda and Uganda)

RN18: Musanze-Kinigi-Busogo-Kora-Kabuhanga (this is the road towards Volcano Park)

NR24: Kayonza-Kiramuruzi-Rwimiyaga-Kagitumba road (this road links Rwanda and Uganda)

Note that to get an overview of the relative (un)safety of the various (paved) National Roads, is somehow difficult due to the fact that the accident statistics (2009-2013) are not related to the roads on which the accident occurred. Therefore, there is a need to relate the accidents to the individual roads (sections) in the first place and the intensity of their use.

5.3 Rwanda road condition

Table 4 presents the total length (km) of national paved road inspected lane by lane (right and left) and the percentage of road in good condition. Generally, the total length of national paved road is 1210.8 km where 1070.847 km has been inspected on right lane and 1070.697 has been inspected on left lane. The length in a good condition on right lane is 929.247 km and 882.097 km on left lane. It means that the percentage in good condition on right lane is 86.45% and 82.39% on left lane.

The total length of national paved road inspected (km) is 1078.565; the length in good condition is 905.672 (km) this means that 84.42% of national paved road inspected is in a good condition. A decrease in good condition is observed on NR24: Kayonza-Kagitumba National Paved road (IRI >4m/Km) and on the left lane of NR4 (Kayonza-Rusumo). The Increase in bad condition is a result of high charge in axle roads effect; pothole repair works on the section from Kayonza to Rusumo and Kayonza to Kagitumba. Note that the life of pavement design is exceeded.

5.4 Vehicle fleet Characteristics

Table 7 presents the number of registered vehicles in Rwanda by category between 2004 and 2011. The data has been extracted from the National Institute of Statistics of Rwanda (NISR), Statistical Year Book-2012 and illustrates the following:

Motorcycles account for the highest vehicle registrations. Similarly, the number of registered motorcycles increased from almost 6,740 in 2004 to 49,349 in 2011; there were significant registrations of cars, jeeps and pickups; there was a major increase in the total number of registered vehicles from 2004 to 2011. This was as a result of a high period of economic growth in 2006 and the following year managed to register 8% economic growth, a record it has sustained since,

turning it into one of the fastest growing economies in Africa. This sustained economic growth has succeeded in reducing poverty with growth between 2006 and 2011 reducing the percentage of the country's population living in poverty from 57% to 45%.
The country's infrastructure and urbanization has also grown rapidly with connections to electricity going from 91,000 in 2006 to 215,000 in 2011.
Based on the table 7 the total annual number of registered vehicles, increased up to 75,148 vehicles between 2004 and 2011.

5.5 Traffic Characteristics

The traffic count has been conducted on the whole Classified National Paved Roads Network in 2013. The National paved roads are 2-lane carriageway; some sections of national road pass through the urban areas of the Districts, the speed limit in urban or agglomeration and grouped settlement is set at 40 km/h and 80 km/h out of the urban area or agglomeration and grouped settlement. Many of our National roads has a width of 3 m per lane but the new road act governing the roads in Rwanda recommends the width of 3.5 m per lane. Table 8 shows the distribution of average daily traffic on National paved roads in 2013 motorcycles included.

The first most used paved road is NR1 (Kigali-Muhanga-Huye-Akanyaru road) which has ADT of 3,227 without motorcycles (ADT of 5210 with motorcycles) which is followed by other three paved roads such NR11 (Ruhwa-Bugarama-Rusizi-Nyamasheke-Karongi-Rubavu) that has ADT of 3011 without motorcycles (ADT of 5078 with motorcycles), NR3 (Kigali-Gatuna road) that has ADT of 2463 without motorcycles (ADT 3030 with motorcycles) and NR4 (Kigali-Kayonza-Rusumo road) that has ADT of 2439 without motorcycles (ADT of 3009 with motorcycles). All these four National roads are the most used by heavy trucks from Gatuna and Rusumo borders. These heavy trucks coming from Uganda by using NR3 and Tanzania by using NR4 carry the cargo into DRC through NR1, NR10 and NR11. Also NR11 is connected to three most used borders of DRC and one border of Burundi; many public transport vehicles from DRC use the section of NR11 located in Rusizi District as transit road to inter in other side of DRC, this movement results an increase of traffic on NR11.

Two National roads are not used by many vehicles compared to other National paved roads. NR15 (Muhanga-Rubengera road) has ADT of 513 without motorcycles (ADT of 958 with motorcycles) and NR16 (Muhanga-Ngororero-Mukamira road) has ADT of 353 without motorcycles (ADT of 594 with motorcycles). It is understandable to have few flow of vehicles on these National paved roads. This is due to the importance of these roads; they do not link Rwanda with other countries, just they link southern and western provinces (NR15) and Southern, Northern and Western provinces (NR16).

It is not easy to get an overview of the relative (un)safety of these most used National paved due to the fact that the accident statistics are not related to the roads on which the accident occurred.

5.6 Drivers involved in accidents

Figure 3 and table 9 provide an indication of the ages of the drivers involved in road accidents in Rwanda in 2010, 2012 and 2013. In essence about 92 per cent of the drivers (17830 drivers out of total of 19374 drivers) fell in the age groups of 18 to 50 years. Therefore, it is clear that the **high risk population group is the economically active age group**; this means that during their lifetime, individuals function as producers and consumers of economic output. Injured individuals are considered a fundamental part of total societal impact; the value of their decreased production and their decreased consumption play a negative role on their family particularly and on National economy generally.

5.7 Road safety and accident trends

5.7.1 Fatalities in road accidents from 2009 to 2013

Table 10 and figure 4 show the fatalities in road accidents from 2009 to 2013. Fatalities in road accidents has increased at rate of 61.9% from 344 fatalities in 2009 to 556 fatalities in 2013. There has been a sharp increase in the number of road fatalities in Rwanda since 2009. The increase in fatalities is highest for drivers and passengers (of both motorcycles and 4+ wheeled motor vehicles), having almost doubled in 5 years in absolute numbers. Whereas the widespread usage of helmets and seat belts in Rwanda makes a significant contribution to lower fatality rates, increasing number of fatalities among drivers and passengers becomes of even greater concern.

A serious problem in Rwanda is the increasing number of motorcycles on the roads; motorcycles ('taxis') constitute an important component of the urban public transport system (and employment of young adults). Between 2009 and 2011 the number of motorcycles rose by 50% to almost 50,000. This is also reflected in an increased fatality rate which appears to have doubled over the last 5 years. At the same time, Rwanda may have the highest helmet use in the world, thus saving a great number of lives.

5.7.2 Serious and minor accident in 2009 – 2013

Fatal and serious injury accidents are classified as "Serious", whilst "Minor" are light injury and damages only accidents. It is a recommendation for the future that the internationally approved accident classification, "Fatal", "Serious Injury", "Light Injury" and "Damages Only" is followed. **The focus of road safety measures must be to reduce the number of fatal and serious injury accidents, hence it is important to have exact knowledge of trends of the Fatal and Serious Injury accidents in particular.**

The figure 6 and table 11 show that the total number of accidents has more than doubled since 2009, and increased with 3212 in five years between 2009 and 2013.
However, the number of serious accidents shows a dramatic reduction in 2013, while at the same time the number of Minor accidents rose more than proportionally.

5.7.3 Accident trends in Kigali with rest of Rwanda in 2010 – 2013

The figure 7 indicates the percentage where the accidents occurred compared to City of Kigali.
Most of the serious accidents in the early years (2010-2012) occurred in the three Districts of Kigali (City of Kigali is composed by 3 Districts); the percentage of accidents occurred in City of Kigali since 2010 to 2012 are respectively 58.8%, 57.8%, 45.0%. In 2013 something changed as suddenly few serious accidents occurred in Kigali only 14.5% while the vast majority of serious accidents appeared recently in the rest of Rwanda 85.5%.
Was it an increasing traffic congestion in Kigali that made the Kigali roads relatively safer? And/or did the increasing traffic volumes outside Kigali lead to more catastrophic accidents caused by reckless drivers? The answers shall be given by deep research on these questions.

5.8 Comparison of accidents trend and vehicle fleet trend

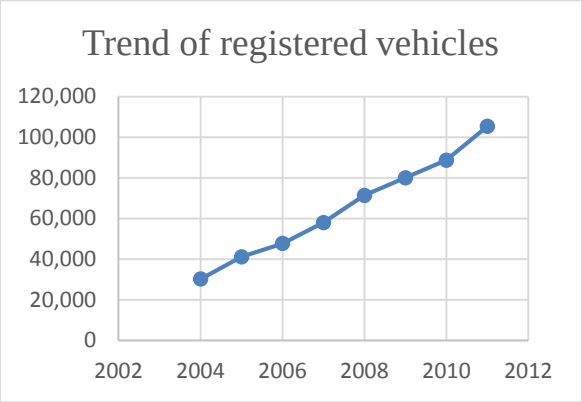
The huge increase of total number of accidents throughout that period (2009-2013) may be wrongly assigned to the total number of vehicle registered by RRA during this specified period of time; however, vehicle registration database from RRA indicates that from 2004 to 2011 total number of registered vehicle increased from 30158 to 105306 (increase of 75148 vehicles). And the same database shows that registered vehicle increased from 80019 to 105306 between 2009 and 2011 (increase of 25287 vehicles). This is shown on the figure 8 (a).

On the other hand, the total number of accident occurred within that interval increases continuously from 2766 in 2009 to 4303 in 2011. This is represented on the Figure 8(b). From these figures we can conclude that there is no direct relationship between number of vehicle in the traffic stream and the rate of accident as driver's behavior and/or road condition contributes significantly to the road accident. The road accident is caused by a combination of factors of which indeed one can be more important than the others but seldom only one. This argument is illustrated by table 12.

Table 12: combination of factors that can cause accidents

Factor	**Effect**
The driver feels unwell	His/Her reactions become slow
The driver takes an aspirin	He/She becomes drowsy
He comes under further pressure	He becomes more stressed and impatient
He is on unfamiliar roads	This adds to the stress
It starts to rain	The windscreen becomes smeared, therefore less visibility
He is late for an important appointment	More pressure making it difficult to cope
A truck comes up close behind him	This distracts him
There is rainwater on the road	The road surface is now slippery
He is at the bend	He considers that he is travelling too fast and brakes too harshly
The brakes of the car lock, it pulls to the near side and skids	He loses control of his vehicle
The car is now out of control	The car hits a lamppost

One or more of these factors not played a role, then the crash would possibly not have happened. Most of the time, there is a combination of factors that lead to an accident, seldom there is a single cause.



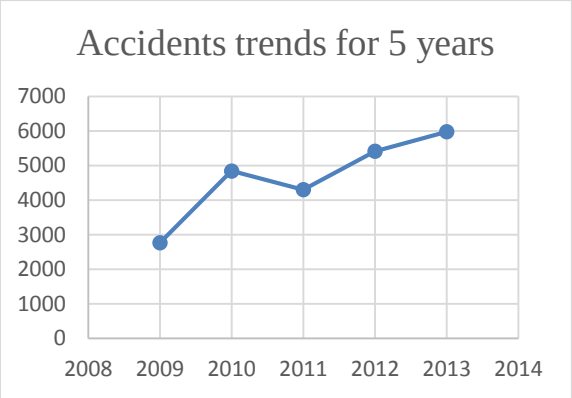


Figure 8 (a) trend of registered vehicles

Figure 8 (b) accident trends for 5 years

The current rate of increase in the motor vehicle fleet per annum would imply that the vehicle fleet of Rwanda will double in just 6 years, posing a big challenge to both transport planning and road safety.

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CHAPTER 6 CASE STUDY THE NATIONAL ROAD 1 (NR1)

6.1 Introduction

The international best practice in road projects is not applied in Rwanda. The road safety audit is not done at any stage of the project such feasibility study, preliminary design and detailed design, construction phase, before opening and after opening the roads. Consequently the road accidents for all road user increase after construction phase and the black spots are designed at some section of the road.

Some sections of Kigali-Muhanga-Huye road (NR1) have been designed as black spots after few years of operation means that many fatal accidents occur on NR1. The remedial work to reduce these accidents and correct these black spots should have been considered in the study or during construction works through road safety audit. The location of the road accidents spots/ lengths have been found through pro-Justitia dossiers analysis distributed over the 5 Districts in past 6 years. In this chapter, we present the number of fatal accidents, type of accidents, remedial road safety treatment and related cost to show the cost implication in road safety corrective measure of black spots. Note that some of the reasons for this include insufficient consideration of road safety measures in design road standards and implementation of road project.

6.2 Road Accidents Profile National Road NR-1

A total of 238 Pro-Justitia dossiers have been analyzed, distributed over the 5 Districts in past 6 years, as indicated in Table 13 (Source of data: Pro Justitia dossiers available at district police stations not all are available because they are being processed by the courts, or kept elsewhere).

Table 13: Number of fatal accidents dossiers collected along National Road NR 1

District	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**S/Total**	**Fatalities 2012-jun 2014**
Kamonyi	0	9	14	22	22	11	78	**93** (55)
Muhanga	3	0	9	10	10	6	38	**39** (26)
Ruhango	0	4	16	13	12	13	58	**50** (38)
Nyanza	8	2	7	3	2	4	26	**20** (9)
Huye	14	1	2	3	9	9	38	**51** (21)
Total "NR-1 Corridor"	**25**	**16**	**48**	**51**	**55**	**43**	**238**	**253** (149)

The right side column of table 13 shows the (**bold**) number of *Fatalities* (generally larger than the number of *fatal accidents*) as reported in the common monthly/annual Transport Police reports for

the 2.5 years from 2012 until mid-2014. Comparing these numbers with the number of *Fatal accidents (in 2012, 2013 and 2014)*, and considering that one is comparing numbers of *Fatalities* and *Fatal accidents*, it seems almost certain that Huye and Nyanza districts are under- represented in the sample.

6.3 Accident dossier analysis NR-1 by District

Most, but not all, accidents retrieved from the P-J dossiers occurred on NR-1. The distribution of the 187 fatal accidents (total sample 238) on NR-1 over the various sectors within the Districts is shown in the following tables 14:

KAMONYI DISTRICT

Table 14: Fatal accidents by sector and consequences, Kamonyi District

Sector	**Approx Kms**	**Approx ADT**	**Fatal Acc's**	**Total killed**	**Tot Ser Injuries**	**Driver Killed**	**Driver Ser**	**Pass Killed**	**Pass Ser**	**Ped Killed**	**Ped Ser.**	**Bicyc Killed**	**Bicyc Ser.**
Runda	7.9	4200	11	15	26	2	3	7	21	3	1	3	1
Rugarika	3.5	4200	14	20	40	4	3	10	35	5	2	1	0
Gacurabwenge	10.6	4224	29	28	49	7	4	9	42	11	3	1	0
Musambira	9.3	4200	18	24	55	2	2	13	50	7	2	2	1
Total Kamonyi District (31.3 km)			**72**	**87**	**170**	**15**	**12**	**39**	**148**	**26**	**8**	**7**	**2**

Gacurabwenge is the most (fatal) accident prone sector in Kamonyi District in absolute numbers (29), but Rugarika had more fatal accidents per km road length (4); the average for Kamonyi District is 2.3 fatal accident (in the sample) per kilometre of NR-1 road length (the true figure is higher)

Table 15: Fatal accidents by sector and accident type, Kamonyi District

Sector	Mv only	Mv/Pedestrian	Mv/Bicyclist	Total
Runda	4	3	4	11
Rugarika	7	6	1	14
Gacurabwenge	17	11	1	29
Musambira	8	7	3	18
Total	**36**	**27**	**9**	**72**

Table 15 shows that (fatal) accidents involving motor vehicle only (colliding motor vehicles/26/ and single 'run-off-the-road' vehicles/10/) have the highest frequency in Kamonyi District, but there are as many fatal accidents involving the most vulnerable road users (pedestrians/27/ and

bicyclists/9/). On the Sector level, the ranking between sectors will again be different for absolute numbers and numbers per unit road length. When (mini)buses are involved in such accidents, this raises the number of passenger casualties significantly, as Table 14 shows (notably for Rugarika and Musambira sectors).

According to the traffic counting program undertaken in 2013, the Average Daily Traffic (ADT) volume in Gacurabwenge Sector (around Km 25 from Kigali) was 4,224, with 483 Motorcycles, 2,268 Light motor vehicles and 1,473 Heavy motor vehicles. This was the only counting point in Kamonyi District; the next counting point (2013) on NR-1 was past Muhanga (around Km 58), with an ADT of 2,382, already significantly lower.

The motorized traffic volume and composition is believed to be fairly uniform throughout the (4) sectors in Kamonyi District, probably with higher motorcycle concentrations and certainly significant pedestrian and bicycle flows on and around/ across the "urbanized" and "settlement" passages of NR-1. But the "threats" posed by the motor vehicles (safety risk) for the vulnerable pedestrians and cyclist might be considered more or less the same for all sectors within Kamonyi District. This implies that the factor "road section length" would be a main and only "weighing criterion" in a priority ranking exercise within Kamonyi District , between various most dangerous locations in the different sectors (because the other criterion, "traffic", is considered equal for all 4 sectors in this particular situation).

A similar 'story line' and 'reasoning' can be applied for each of the following Districts, but further 'Sector' lengths data and ADT data still need to be completed in the following District tables. Therefore, the comments going with these tables are strictly based an 'absolute' numbers per Sector, not weighted by road length in that Sector and neither by ADT (where 'traffic' could be a distinctive factor between various Sectors).

However, as explained, the focus here is on developing a practical, acceptable and reproducible methodology in the first place. Weighing by road section length and traffic volume will be feasible in the future to a certain extent (depending on the density of the traffic counting locations in future traffic counting campaigns).

But the application of such weighing factors makes sense only when the basic data (Fatal accidents only or perhaps other accident categories as well) constitute a "controlled" sample covering the

road network under consideration (which could be a smaller or larger part of the total road network) and not the largely "coincidental" sample such as the P-J dossier collection that had to be used.

MUHANGA DISTRICT (starting at about km 39.9 from Kigali 0-point, following Kamonyi District

Table 16: Fatal accident by sector and consequences, Muhanga District

Sector	Approx Kms	Approx ADT	Fatal Acc's	Total killed	Tot Ser Injuries	Driver Killed	Driver Ser	Pass Killed	Pass Ser	Ped Killed	Ped Ser.	Bicyc Killed	Bicyc Ser.
Cyeza	5.8		2	2	1	2	1	1	0	1	0	0	0
Shyogwe	2.8		8	8	0	4	0	2	0	5	0	1	0
Nyamabuye	6.5		16	18	4	7	2	3	1	11	1	1	0
Total Muhanga District (15.1 km)			**26**	**28**	**5**	**3**	**3**	**6**	**1**	**26**	**1**	**2**	**0**

Table 17*: *Fatal accidents by sector and accident type, Muhanga District

Sector	Mv only	Mv/Pedestrian	Mv/Bicyclist	Total
Cyeza	1	1	0	2
Shyogwe	2	5	1	8
Nyamabuye	4	10	2	16
Total	**7**	**16**	**3**	**26**

Nyamabuye sector has the poorest road safety in Muhanga District in absolute numbers (16), and it is the pedestrians who are at greatest risk (10). This is the case in most "urbanized" and "settlement" passages where the speeds are too high considering the large number of pedestrians who are also road users. Shyogwe sector also has a high share of fatal pedestrian accidents.

RUHANGO DISTRICT (Starting at about km 55 from Kigali 0-point, following Muhanga District)

Table 18: Fatal accidents by sector and consequences, Ruhango District

Sector	Approx Kms	Approx ADT	Fatal Acc's	Total killed	Tot Ser Injuries	Driver Killed	Driver Ser	Pass Killed	Pass Ser	Ped Killed	Ped Ser.	Bicyc Killed	Bicyc Ser.
Byimana	8.8		18	18	2	3	1	1	1	12	0	2	0
Ruhango	15.5		27	28	14	5	0	0	8	17	2	6	4
Total Ruhango District (24.3 km)			**45**	**46**	**16**	**8**	**1**	**1**	**9**	**29**	**2**	**8**	**4**

Table 19: Fatal accidents by sector and accident type, Ruhango District

Sector	Mv only	Mv/Pedestrian	Mv/Bicyclist	Total
Byimana	4	12	2	18
Ruhango	5	17	5	27
Total	**9**	**29**	**7**	**45**

Also in Ruhango District, pedestrians are by far the road user category at highest risk (29 of the 45 fatal accidents), both in Ruhango and Byimana Sectors. Over the years considered, the number of fatal bicycle accidents almost equals the fatal motor vehicle accidents.

NYANZA DISTRICT (Starting at about Km 74.3 from Kigali 0-point, following Ruhango District)

Table 20: Fatal accidents by sector and consequences, Nyanza District

Sector	Approx Kms	Approx ADT	Fatal Acc's	Total killed	Tot Ser Injuries	Driver Killed	Driver Ser	Pass Killed	Pass Ser	Ped Killed	Ped Ser.	Bicyc Killed	Bicyc Ser.
Kigoma	3.5		8	8	2	0	0	0	0	4	2	4	0
Mukingo	5.5		2	2	0	0	0	0	0	1	0	1	0
Busasamana	6.4		5	5	1	0	1	1	0	3	0	1	0
Total Nyanza District (15.4 km)			**15**	**15**	**3**	**0**	**1**	**1**	**0**	**8**	**2**	**6**	**0**

Table 21: Fatal accidents by sector and accident type, Nyanza District

Sector	Mv only	Mv/Pedestrian	Mv/Bicyclist	Total
Kigoma	0	4	4	8
Mukingo	0	1	1	2
Busasamana	1	3	1	5
Total	**1**	**8**	**6**	**15**

Compared to the neighbouring Districts, fatal accidents in Nyanza District are relatively few (15) with Kigoma and Busasamana sectors as the more accident prone, particularly for the vulnerable road users pedestrians and bicyclists (altogether 14 out of 15 fatal accidents).

HUYE DISTRICT (Starting at about km 89.7 from Kigali 0-point, following Nyanza District)

Table 22: Fatal accidents by sector and consequences, Huye District

Sector	Approx Kms	Approx ADT	Fatal Acc's	Total killed	Tot Ser Injuries	Driver Killed	Driver Ser	Pass Killed	Pass Ser	Ped Killed	Ped Ser.	Bicyc Killed	Bicyc Ser.
Kinazi	7.5		3	3	9	1	0	0	6	1	3	1	0
Rusatira	6.4		8	13	16	0	0	6	15	4	0	3	1
Ruhashya	9.0		3	4	1	0	0	1	0	3	0	0	1
Mbazi	5.5		5	5	0	1	0	0	0	3	0	1	0
Ngoma			5	4	4	1	0	1	0	2	4	0	0
Tumba			4	4	1	0	0	2	1	2	0	0	0
Mukura			1	2	0	1	0	1	0	0	0	0	0
Total Huye District (… km)			**29**	**37**	**31**	**6**	**0**	**11**	**22**	**15**	**7**	**5**	**2**

Table 23: Fatal accidents by sector and accident type, Huye District

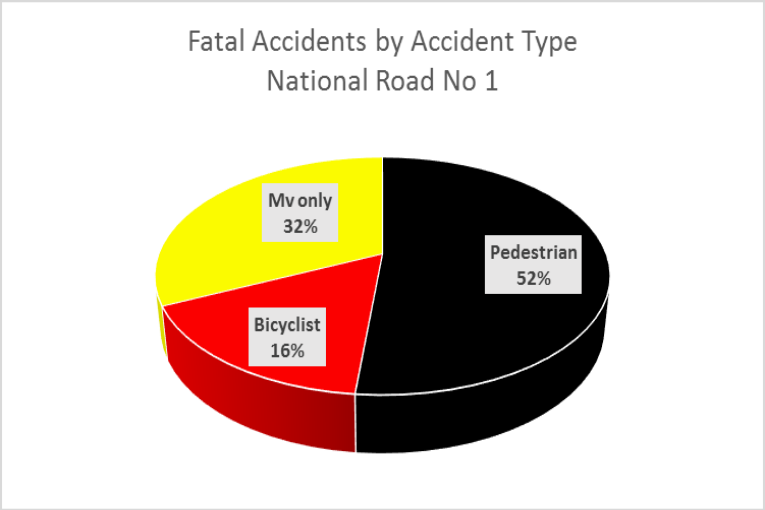
Sector	Mv only	Mv/Pedestrian	Mv/Bicyclist	Total
Kinazi	1	1	1	3
Rusatira	1	4	3	8
Ruhashya	0	2	1	3
Mbazi	0	4	1	5
Ngoma	3	2	0	5
Tumba	2	2	0	4
Mukura	1	0	0	1
Total	**8**	**15**	**6**	**29**

As in the other Districts on National Road no 1, it is the pedestrian accidents that are most frequent in Huye District (15 out of 29 fatal accidents), spread over practically all sectors. In May 2013 there was a single head on collision in Rusatira sector between a mini bus and a truck with 6 deaths and 15 seriously injured.

6.3 Types of accidents

Overall, considering about 120 km of length of NR-1 (from Nyabarongo Bridge to Huye), the distribution of the 187 fatal accidents in terms of conflicts between various road user categories was as follows in figure 9:

Figure 9: Fatal Accidents by Accident Type on National Road 1



The most common fatal accident type on NR -1 is pedestrian accidents which constitutes 52 % of all accidents in the sample. Adding the bicyclist fatal accidents with 16 % it means that 2 out of every 3 fatal accidents involve the vulnerable road users.

Fatal accidents involving motor vehicles only (no pedestrians or cyclist) constituted 32% of the total (60 in absolute numbers); among these head on collision and single vehicle accidents (run-off) accidents were the most frequent (share of 42% and 27% respectively).

The various conflicts between the road users and consequences thereof are shown in more detail in table 24.

Table 24: Overview of main fatal accident types and categories of Victims (Killed and Seriously injury)

National Road 1	No of Fatal Accidents		Driver Killed	Driver Ser	Pass Killed	Pass Ser	Ped Killed	Ped Ser.	Bicyc Killed	Bicyc Ser.
Single mv	16	8.5%	3	5	13	33				
Mv/mv Head on	25	13.3%	12	4	33	124				
Mv/mv Overtake	10	5.3%	6	3	7	19				
Mv/mv rear end	5	2.7%	3	1	1	4				
Mv/mv Intersect	4	2.1%	3	1	1	0				
Total MV's Conflict	60	31.9%	27	14	55	180				
Mv/Pedestrian	97	51.6%					96	20	1	2
Mv/Bicyclist	31	16.5%					1	1	28	6

Total Mv/Ped+BC	**128**	68.1%					97	21	29	8
GRAND TOTAL	**187**	**Fatal Acc's**	**27**	**14**	**55**	**180**	**97**	**21**	**29**	**8**
Total Deaths	208	1.11/Acc	13%		26%		47%		14%	
Total serious Injuries	223	1.19/Acc		6%		81%		9%		4%

It is not known how many of the seriously injured might have died on the way to or in hospital; it could be 20-40%. The nationwide indication for year 2013 is 34% (556 fatalities registered on the spot by Traffic Police, with a further 190 dying in hospitals). Adding this % implies an additional number of more than 90 deaths to this sample of NR-1.

6.4 Priority sections NR-1 for remedial road safety treatment

The Sectors with more than 15 fatal accidents (in the sample[9]) are:

- 29 Gacurabwenge (Kamonyi D.) – length 10.6 km (incl. "Gihinga")
- 27 Ruhango (Ruhango D.) – length 15.5 km
- 18 Byimana (Ruhango D.) – length 8.8 Km (ref. Km 64.5)
- 18 Musambira (Kamonyi D.) – length 9.3 Km (ref. Km 36.2)
- 16 Nyamabuye (Muhanga D.) – length 6.5 Km (incl. "Gahogo")

The two most dangerous "locations" in terms of fatal accidents (data sample collected) are "Gahogo" in Muhanga District (with 40% [10/26] of the fatal accidents in Muhunga D) and "Gihinga" in Kamonyi District (with 10% [7/72] of the fatal accidents in Kamonyi D).

Table 25 below lists five (5) priority sections suggested for remedial road safety treatment on NR-1. Three of those will represent typical RS designs in detail, suitable for 'adjusted replication' in many other similar situations.

Table 25: List of identified "dangerous sections" for remedial road safety engineering measures (NR-1)

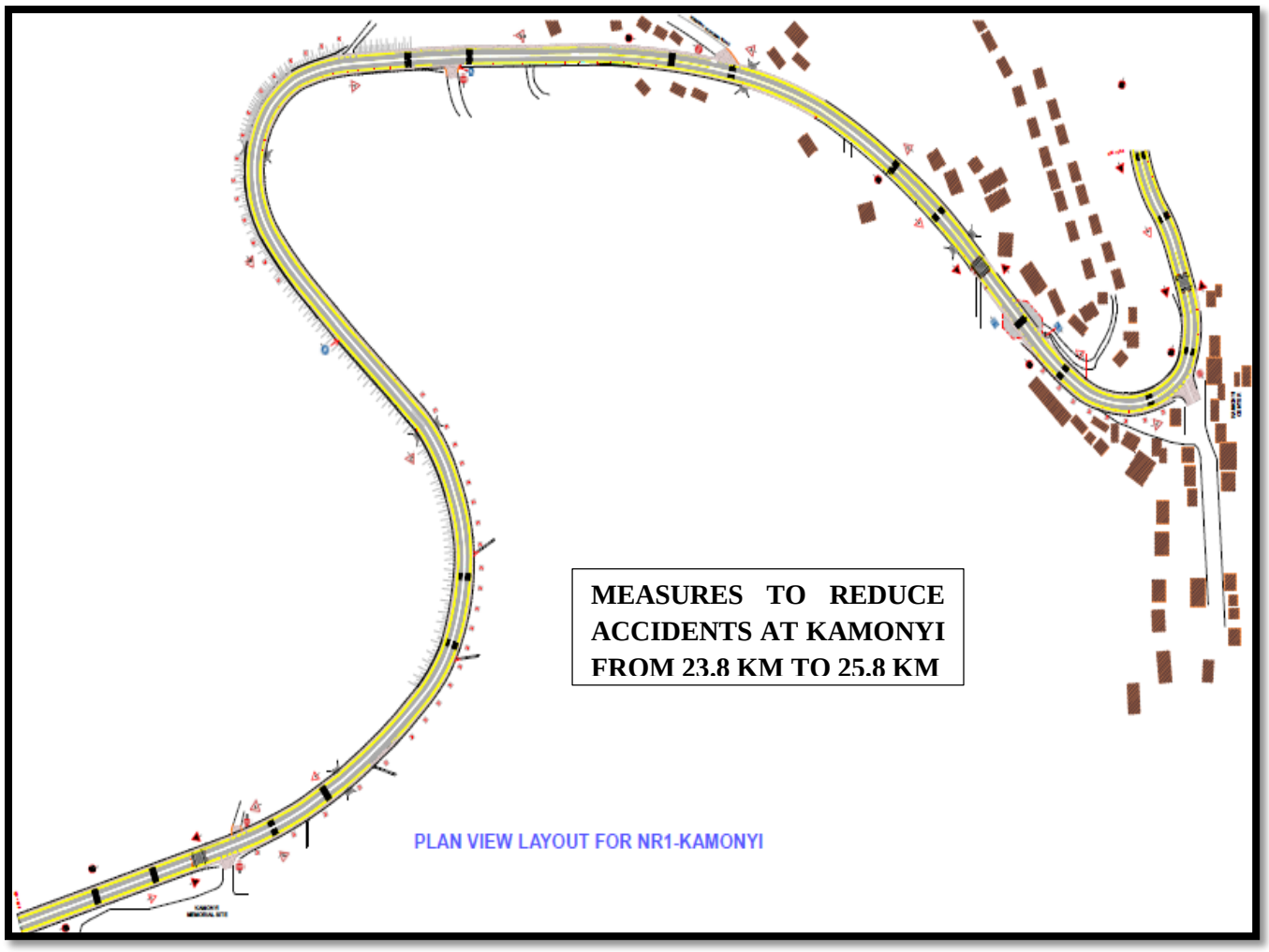
Location (kilometer-age)	Type of Environment	Type of Accidents	Recommended Corrective Measures
21.4 to 22.4 Gihinga	**Hilly Terrain-Sharp Curves**	**Run Off Crashes**	**Road markings-Warning signs-Speed reduction-Delineation-Guardrail**
24.4 to 25.4 Gihinga	Hilly Terrain-Sharp Curves	Run Off Crashes	Road markings-Warning signs-Speed reduction-Delineation-Guardrail-Road Widening
36.2 Musambira	Hilly Terrain-Sharp Curves	Run Off Crashes	Road markings-Warning signs-Speed reduction-Delineation-Guardrail
51.7 Gahogo	**Urban-Intersection**	**Pedestrian Accidents**	**Access Control-Road markings-Warning signs-Speed reduction-Delineation**

6.5. Remedial road safety treatment and related indicative cost estimate

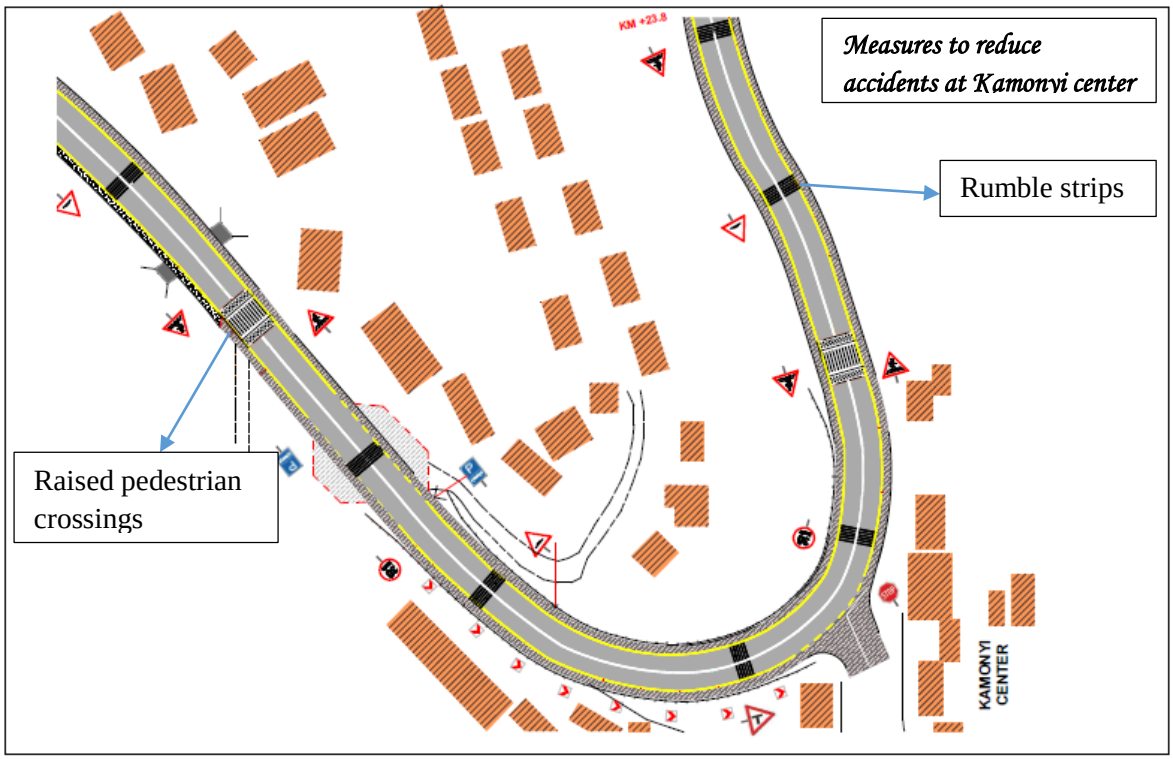
Following the identification and confirmation of the dangerous (Black) spots/sections through the Paved National Road 1, the representative typical designs of the remedial measures and safety improvements covering all the typical problems identified at NR1 should be developed. Considering the mentioned factors, 2 sections covering most of the safety issues were selected for design. These sections are as follow:

NR1 Km + 23.8 to Km + 25.8 (Kamonyi): At this section we have the combination of a Residential Area with Sharp Curves and Hilly terrain and the accidents mainly consist of pedestrian and run off the road crashes. The safety measures considered for the design include Traffic Calming (Raised pedestrian Crossings and Rumble Strips), Guardrails, Delineation, Road Marking, Improved signing, closing the unnecessary accesses and prohibiting overtaking by using double center line (See Design drawings for details).

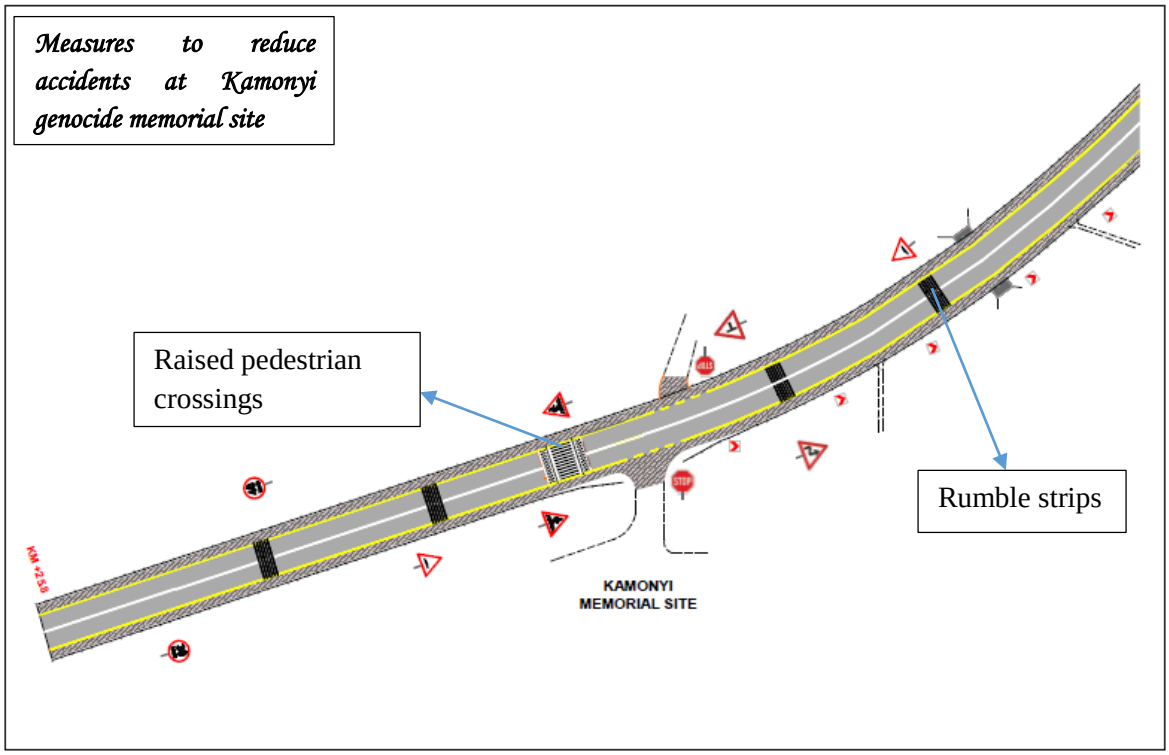
Drawing 1 for corrective measures to reduce accidents at Kamonyi (NR1 from Km 23.8 to Km 25.8)



Drawing 2 for corrective measures to reduce accidents at Kamonyi center

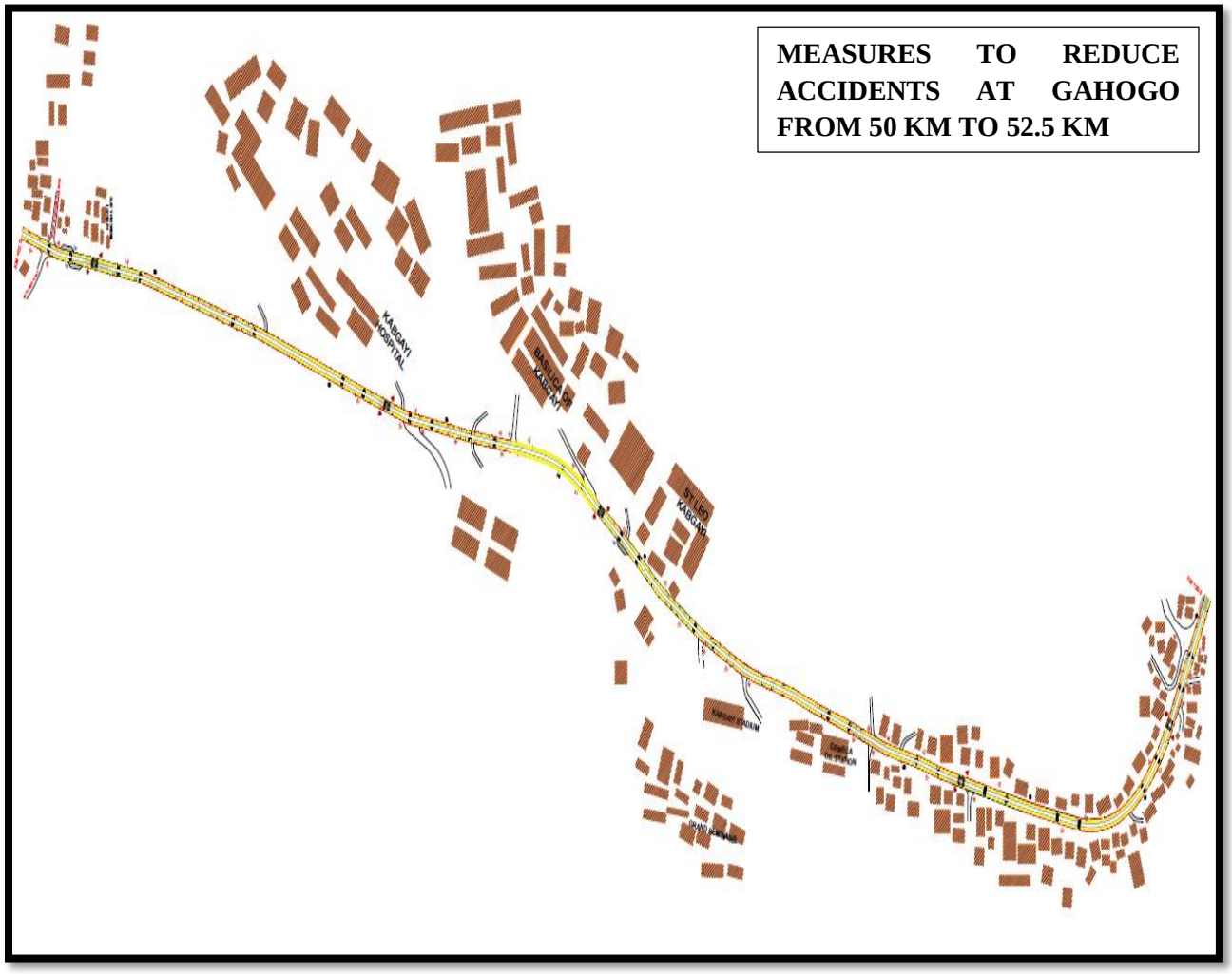


Drawing 3 for corrective measures to reduce accidents at Kamonyi genocide memorial site

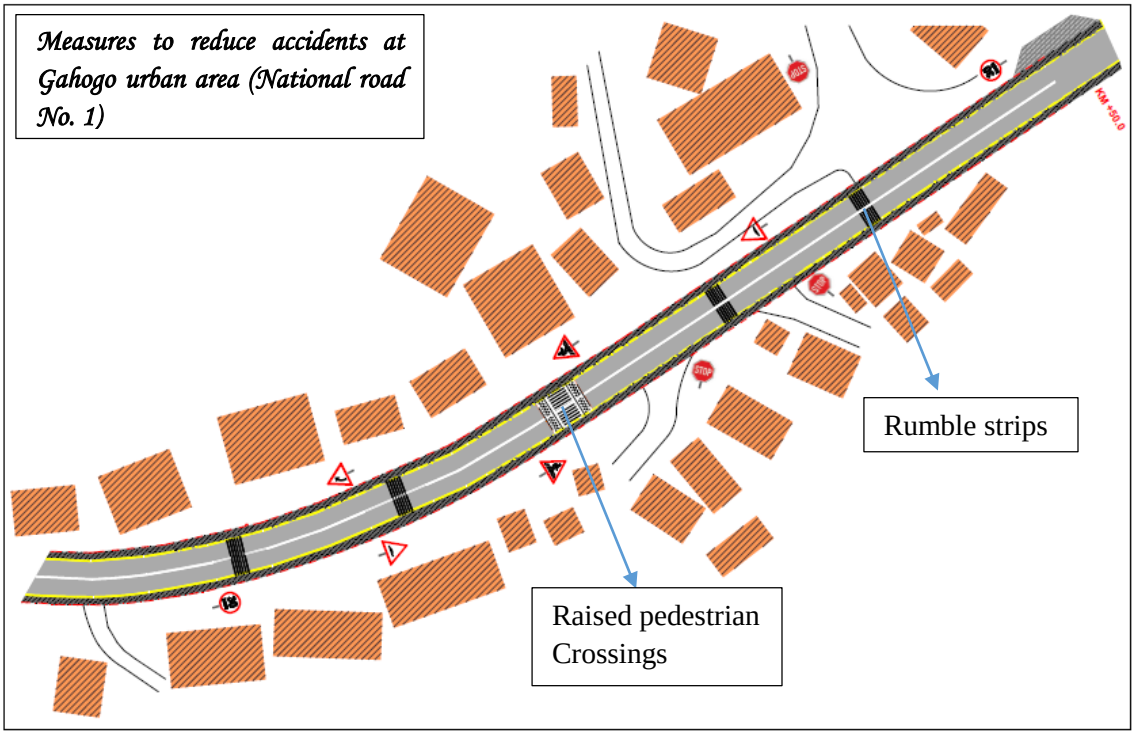


NR1 Km + 50.0 to Km + 52.5 (Gahogo): This section sees the transition from urban road to rural road with accesses to many facilities such as church, stadium, hospital and school and the accidents mainly include pedestrian crashes. The safety measures considered for the design include Traffic Calming (Raised pedestrian Crossings and Rumble Strips), Delineation, Road Marking, Improved signing, controlling the accesses and prohibiting overtaking by using double center line (See Designs for details).

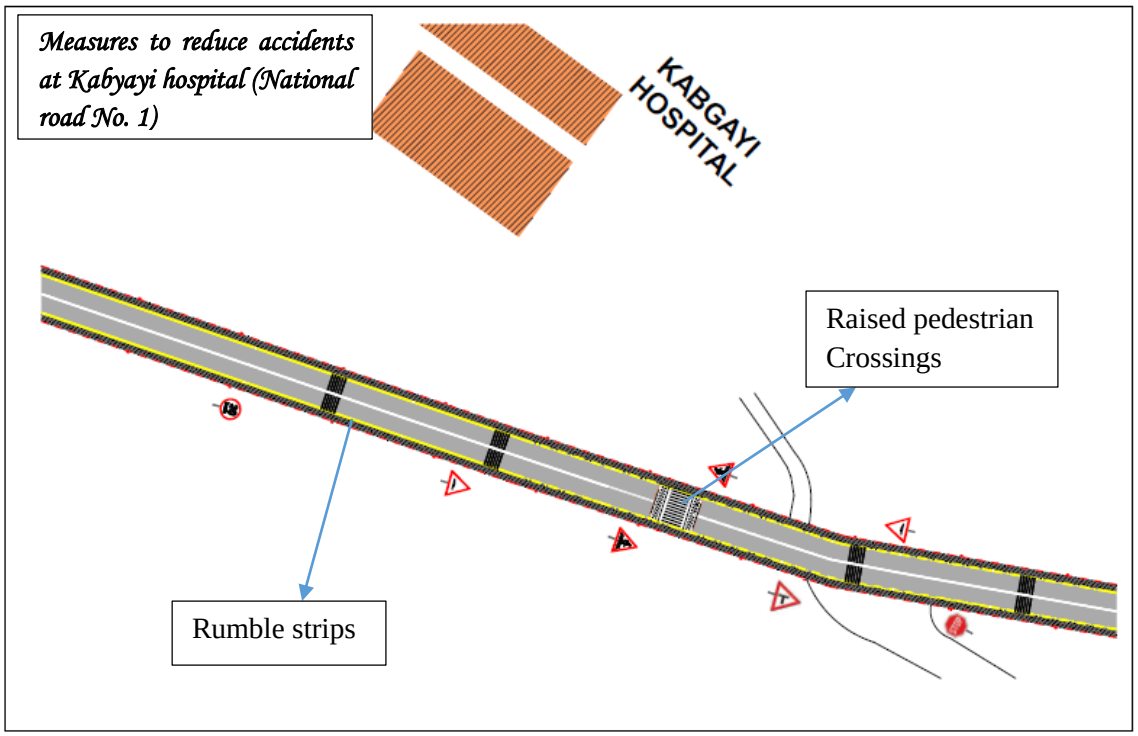
Drawing 4 for corrective measures to reduce accidents at Gahogo (NR1 from Km 50 to Km 52.5)



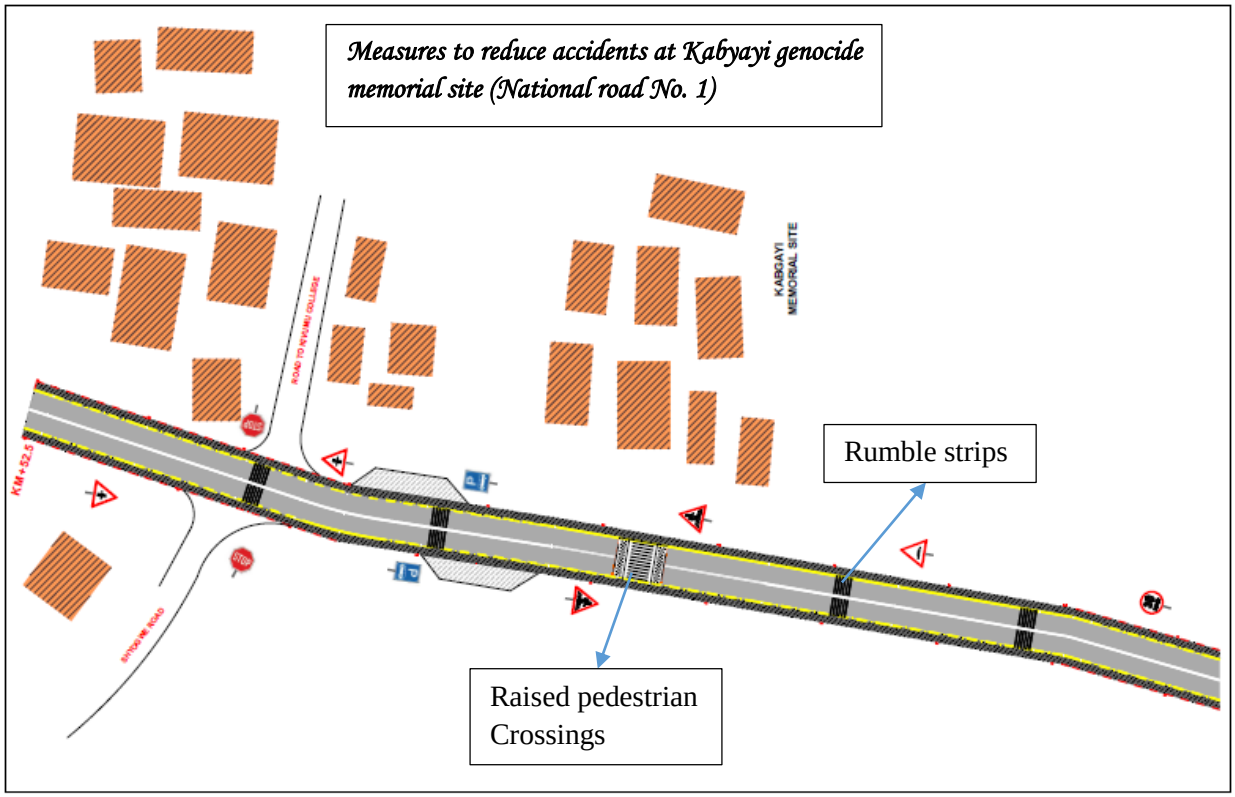
Drawing 5 for corrective measures to reduce accidents at Gahogo urban area



Drawing 6 for corrective measures to reduce accidents at Kabyayi hospital



Drawing 7 for corrective measures to reduce accidents at Kabyayi genocide memorial site



Drawing 8 raised pedestrian crossing

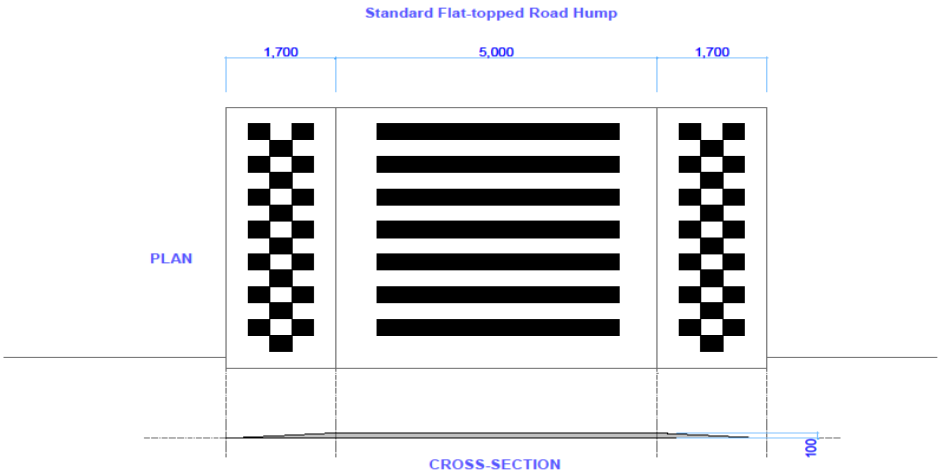


Table 26: GPS coordinate for section selected for corrective measures (NR-1)

BM NAME	SECTION NAME	ESTIMATED DISTANCE OF A SECTION	GPS COORDINATE			
			X	Y	Z	
RS 1	NR 1-Kamonyi	ST23+800-ST25+800=2000 m	489463	4778645	1779	Start point
RS 2			488544	4778159	1650	End Point
RS 3	NR 1-Gahogo	ST50+00-ST52+500= 2500 m	472805	4769080	1894	Start point
RS 4			472381	4766928	1808	End Point

6.6 Indicative Cost Estimates

Based on the BOQs, and using recent cost data from the NR-3 (Kigali-Gatuna road) road safety works, carried out recently (November 2014, Strabag), cost estimates have been prepared to implement the proposed corrective measures to reduce accidents identified on NR1 section (Kamonyi and Gahogo road sections), which are shown after below:

LOCATION OF THE SECTION: NR1 KAMONYI

LENGTH OF SECTION: 2KM

INDICATIVE COST ESTIMATE (BoQ)

						Unit price/Km	
						$131,513	
				US$=	650		
Item No.	**Description**	**Unit**	**Rate RWF**	**Rate US $**	**Quantity**	**Cost RWF**	**Cost US $**
	Division 1: General Provisions						
101	Mobilization and Demobilization	LS	RWF 12,000,000	$18,461.54	1	RWF 12,000,000	$18,462
102	Setting-Out	linear m	RWF 300,000	$461.54	2	RWF 600,000	$923
	Sub-Total Division 1					RWF 12,600,000	$19,384.62
	Division 2: ROADS WORKS						
201	Center line (Double)	M	RWF 1,200	$1.85	4,000.00	RWF 4,800,000	$7,385
202	Edge Line	M	RWF 1,200	$1.85	4,000.00	RWF 4,800,000	$7,385
203	Guardrail	M	RWF 50,000	$76.92	900.3	RWF 45,015,000	$69,254
204	Double guardrail	M	RWF 90,000	$138.46	610.2	RWF 54,918,000	$84,489
205	Raised zebra crossing including Painting	M3	RWF 500,000	$769.23	58.8	RWF 29,400,000	$45,231
206	Cross section Transverse rumble strips	M	RWF 15,000	$23.08	756	RWF 11,340,000	$17,446
207	Studs	NO	RWF 4,000	$6.15	60	RWF 240,000	$369
208	Intersection line marking	M	RWF 800	$1.23	80	RWF 64,000	$98
209	Traffic sign of reflective aluminum quality	NO	RWF 170,000	$261.54	32	RWF 5,440,000	$8,369
210	Chevron Sign	NO	RWF 50,000	$76.92	47	RWF 2,350,000	$3,615
	Sub-Total Division 2					**RWF 158,367,000**	**$243,641.54**
	General Total					**RWF 170,967,000**	**$263,026**

LOCATION OF THE SECTION: NR1 GAHOGO

LENGTH OF SECTION: 2.5 KM

INDICATIVE COST ESTIMATE (BoQ)

						Unit price/Km	
						$67,567	
				US$=	650		
Item No.	**Description**	**Unit**	**Rate RWF**	**Rate US $**	**Quantity**	**Cost RWF**	**Cost US $**
	Division 1: General Provisions						
101	Mobilization and Demobilization	LS	RWF 12,000,000	$18,461.54	1	RWF 12,000,000	$18,462
102	Setting-Out	linear m	RWF 300,000	$461.54	2.5	RWF 750,000	$1,154
	Sub-Total Division 1					RWF 12750000	$19,615.38
	Division 2:ROADS WORKS						
201	Center line(Double)	M	RWF 1,200	$1.85	5,000.00	RWF 6,000,000	$9,231
202	Edge Line	M	RWF 1,200	$1.85	5,000.00	RWF 6,000,000	$9,231
203	Guardrail	M	RWF 50,000	$76.92	0	RWF 0	$0
211	Road edge guide posts	NO	RWF 40,000	$61.54	156	RWF 6,240,000	$9,600
205	Raised zebra crossing including Painting	M3	RWF 500,000	$769.23	98	RWF 49,000,000	$75,385
206	Cross section Transverse rumble strips	M	RWF 15,000	$23.08	1,260.00	RWF 18,900,000	$29,077
207	Studs	NO	RWF 4,000	$6.15	100	RWF 400,000	$615
208	Intersection line marking	M	RWF 800	$1.23	170	RWF 136,000	$209
209	Traffic sign of reflective aluminum quality	NO	RWF 170,000	$261.54	61	RWF 10,370,000	$15,954
210	Chevron Sign	NO	RWF 50,000	$76.92	0	RWF 0	$0
	Sub-Total Division 2					**RWF 97,046,000**	**149,302**
	General Total					**RWF 109,796,000**	**$168,917**

6.7 Conclusion

There are typically four opportunities within the design and development process for a road project when a road safety audit can be conducted, regardless of the size or nature of the project:

- At the feasibility stage
- Once the preliminary design stage has been developed
- Once the detailed design stage is complete
- At the pre-opening stage (or soon after the project is complete).

There is no road safety audit conducted at any stage of the study for the project of rehabilitation of National road 1 (NR1). Therefore, many people are losing their lives at some section of this road because some black spots have been designed and implanted and there is a cost implication to implement the corrective measures in order to reduce road accidents.

The road safety audit is highly recommended at four stages of the road design because it is cheaper and easier to correct projects on the drawing board than it is after they have been implemented.

CHAPTER 7 DEVELOPMENT OF A SIMPLE ROAD SAFETY AUDIT PROCEDURE FOR RWANDA

Based on the accidents report it is found that the more road networks are developed, the more the accidents increase due to insufficient road safety measures in design road standards. Rwanda already has many road safety issues, such as substandard cross sections, mixing of different road users and roadside obstacles.

It is in this regards, that the development of road safety audit procedure for Rwanda has to be initiated. The road safety audit have to be conducted at different stages in the course of a road project from initiation to pre-opening of the road project. This road safety audit has the greatest potential to improve safety by preventing people from being killed or injured on the roads and is most cost-effective when it is applied to a road or traffic design before the project is built.

The guidelines on how to apply these procedures is in form of Checklists which will be applied at each stage of a road project. The checklists is used as a "memory prompt" and a form of guidance to ensure that all safety issues are considered.

The road safety audits in Rwanda shall be performed at the following stages:

- Preliminary Stage
- Draft design Stage
- Detailed design Stage
- Construction Stage
- Pre-opening Stage

7.1 The Stage 1 Road Safety Audit: Preliminary Design Stage of a Project

The road safety audit shall be performed at preliminary design stage of a project. The following are objectives:

- To identify the potential safety problems that can influence the:
  - Project scope
  - Choice of route, layout and/or treatment
  - Design standard selection

- Impact on the adjacent road network
- Access Control: Provision of accesses/ intersections/ interchanges
- Continuity of routes

- To consider the design and operating speeds
- To assess the relative safety performance of various alternatives for the road project

7.2 Reasons for Conducting a Stage One

The following are the reasons for conducting a Stage one Road Safety Audit at Feasibility Stage:

- It offers the greatest scope to improve the safety of a road project
- It ensures that safety is considered as criterion for the selection of elements of a road project
- It eliminates safety-related problems that cannot be altered after land acquisition or approval of rezoning applications
- It assists the project team to grasp which road users are affected and should be provided for
- It tests the compatibility of the concept and design of the road project with the functional classification of the road and the expectations of the affected road users
- It considers the adjacent road network to ensure that the road project is compatible with the adjacent road sections/ road network, and that it will be consistent with the rest of the network

The guidelines on how to apply these procedures is in form of Checklists Appendix A. The checklists focus on general topics, design issues, intersections, land-use and road users, environmental constraints and other matters.

7.3 The Stage 2 Road Safety Audit: Draft Design

The Draft Design Road Safety Audit is done after completion of a preliminary or draft design.
A Stage two: Draft Design Stage Road Safety Audit has the following objectives:

- To address issues regarding layout of intersections/ interchanges
- To address the design standards utilized for the draft design.
- To consider, among others, the following:
  - Alignment (horizontal, vertical)
  - Sight distances

- Layout of intersections
- Widths: Lanes and shoulders
- Cross-section and super elevation of pavement
- Provision for road users: Pedestrians, Cyclists, Heavy vehicles, etc
- Any deviation from guidelines and design standards

- To consider the issues listed in the Stage one Road Safety Audit if the Stage two Road Safety Audit is the first audit of the road project.

The Stage two Road Safety Audit: Draft Design should be performed before any land acquisition takes place.

7.4 Reasons for Conducting a Stage two

The following reasons for conducting a Stage two Road Safety Audit: Draft Design audit:

- It may be the first Road Safety Audit of the project
- It will identify any issue omitted in Stage one; these issues may have been omitted due to a lack of available information at the feasibility stage or as a result of certain design decisions not yet taken during the feasibility stage

The guidelines on how to apply these procedures is in form of Checklists Appendix B. The checklists focus on, general topics, design standards, alignment, intersections, special road users, road traffic signs, markings and lighting, construction, operation and other.

7.5 The Stage 3 Road Safety Audit: Detailed Design

The Detailed Design Road Safety Audit shall be performed after completion of the detailed design but before the contract documents are prepared.

A Stage three: Detailed Design Road Safety Audit has the following objectives:

- To consider, among others, the following:
- Any changes since Stage
- Road traffic signs and markings
- Road lighting

- Delineation
- Intersection detail
- Roadside hazard management issues (clear zones, traffic barriers, fixed objects etc.)
- Needs and requirements for Special Road Users (pedestrians, cyclists, individuals with disabilities, heavy vehicles, buses etc.)
- Traffic management and control drawings for accommodation of traffic during construction
- Drainage
- Landscaping
- Cross-section and side-slopes, etc.

- To consider the issues listed in the Stage one and Stage two Road Safety Audit if the Stage three Road Safety Audit is the first audit of the road project.

7.6 Reasons for Conducting a Stage three

The following reasons for conducting a Stage 3 Road Safety Audit at Detailed Design Stage:

- It offers the opportunity to audit the changes made after previous audits
- It identifies any previously omitted issues during previous audits, these issues may have been omitted due to a lack of available information at the previous stages or as a result of certain design decisions not yet been taken during the previous stages
- In the case of no previous audits, it allows for the auditing of the road safety project
- It offers the opportunity to audit any deviations from standards or guidelines
- The audit will enable the Road Safety Audit Team to review the:
  - Road signs and markings drawings
  - Landscaping drawings
  - Details of operations; this typically will include checking whether:
    - Vehicles would be able to turn safely
    - The different road users would be able to see each other
    - The different road users are able to see and react upon the traffic control devices to be installed
    - The alignment and cross-section details would be appropriate and consistent

- No roadside hazards are present and, if present, that they are protected in a way that conforms to Roadside Hazard Management.

- Interaction between the various elements of the road project

- Detail at the transition areas between the new road project and the existing adjacent road network

- Findings of the Stage three Road Safety Audit save the cost and time associated with changes at the Pre-Opening stage of a project.

The guidelines on how to apply these procedures is in form of Checklists Appendix C. The checklists focus on, general topics, design issues, alignment, intersections, pedestrians, special road users, road traffic signs, markings and lighting, roadside hazards, construction, operation and other.

7.7 The Stage 4 Road Safety Audit: Construction

The Stage four Road Safety Audit shall take place during construction. The traffic management and control drawings are audited during the Stage three Detailed Design Road Safety Audit.
The objectives of the Stage 4 Construction Stage Road Safety Audit are:

- To ensure that the traffic accommodation drawings and on-site conditions correspond
- To ensure that the construction site is safe by identifying any issues that may have a safety hazard potential or that may influence the road safety on the construction site negatively.

7.8 Reasons for Conducting a Stage four

The reason for conducting a stage four are as follow:

- To prevent accidents from occurring at the roadworks.
- To ensure that workers, through traffic, and all road users are provided with a safe road environment
- To allow for the road safety auditing of the plans for the accommodation of traffic if a Stage three audit was not performed

The Construction Stage Road Safety Audit also include specific recommendations to rectify any safety problems at the site. These should be discussed as soon as possible with the Client as all safety issues at the roadworks should be classified as requiring “IMMEDIATE ACTION

7.9 The Stage 5 Road Safety Audit: Pre-opening

The Pre-opening Road Safety Audit shall be conducted before the opening of a road scheme to traffic. The Road Safety Audit Team will need to walk, drive and possibly cycle the project to check whether:

- Sufficient provision was made for the different road users of the road project;
- Roadside hazards are adequately protected;
- What was presented on the detailed drawings was actually constructed as far as safety issues are concerned and, where variations took place, to assess the influence on the safety of the facility;
- Road signs and markings, lighting and other night-time related issues are adequately addressed; and
- To consider the issues listed in the Stages one, two and three Road Safety Audits if the Stage five Road Safety Audit is the first audit of the road project.

7.10 Reasons for Conducting a Stage 5:

Following are the reasons for conducting a Stage five Pre-Opening Road Safety Audit:

- It identifies any issues omitted during previous audits – these issues may have been omitted due to a lack of available information at the previous stages or it may be the first Road Safety Audit of the road project
- To check the interaction between the vertical and horizontal alignment as well as the 3D dimension of the project, the project might have seemed safe on 2D drawings but some visual effects may only have been revealed after actual construction.
- To check that the details as presented on the drawings correspond with what was built
- To audit the safety of details that were altered during construction – this may have been the result of services being in the way, etc.
- To audit the effect of the actual landscaping
- To check the night-time conditions at the road project
- To audit the placement of roadside hazards that were not on the detailed design drawings and the protection thereof
- To check whether all road signs and markings are as visible as they should be.

The guidelines on how to apply these procedures is in form of Checklists Appendix D. The checklists focus on general topics, alignment, intersections, pedestrians, special road users, road traffic signs, markings and lighting, roadside hazards, construction, operation and other.

CHAPTER 8 CONCLUSION AND RECOMMENDATION

8.1 Conclusion

It was found that the international best practice in road safety audit is not applied in Rwanda. No road safety auditor is hired at any stage; only the road design and topographer carry out the detailed road design of the road project from feasibility, preliminary design and detailed design, before opening and after opening stages. There are gaps between international best practice in road safety audit and current local practice in Rwanda.

Infrastructure development and improving road transport services are the main strategic policy of the Government of Rwanda in terms of economic development and poverty reduction. To achieve these objectives the safer roads for sustainable development are needed. The safer road shall be constructed by respect of road safety audits procedure at each stage of the road project from feasibility study to pre-opening the road. Also, the road safety audit procedure in Rwanda will lead to many benefits, such as safer new roads through accident prevention and crash severity reduction, safer road networks, reduced whole life costs of road schemes, a reduced need to modify new schemes after they are built, a better understanding and documentation of road safety engineering, eventual safety improvements to standards and procedures, more explicit consideration of the safety needs of vulnerable road users. Note that Safe design practices and the safety needs of all road users are important considerations in attracting donor funding.

8.2 Recommendation for future work

With regards to future works, the following are recommended**:**

- Development of Road safety audit manual for Rwanda
- Road design and bridge manual comprising safe design practices
- Other similar works are recommended for Kigali urban roads and urban roads of major towns of Rwanda;
- Deep analysis to know the real cause of a high number of accidents and propose the mitigation measures;
- Deep analysis of a cause of accidents on different black spots and find out the mitigation measures to reduce accidents;

- Improvement of motorcyclists safety as mode of public transport;
- Improvement of safety of pedestrians crossing the road in urban areas of Rwanda;

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