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A THESIS

ON

ANALYSIS STUDY ON CAUSES OF TIME AND COST OVERRUNS THROUGHOUT ROAD CONSTRUCTION PROJECTS LIFE CYCLE IN RWANDA THE CASE OF KIGALI CITY ROADS

Submitted by

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C E R T I F I CAT E

This is to certify that the Thesis Work entitled **"ANALYSIS STUDY ON CAUSES OF TIME AND COST OVERRUNS THROUGHOUT ROAD CONSTRUCTION PROJECTS LIFE CYCLE IN RWANDA, THE CASE OF KIGALI CITY ROADS"** *is a record of the original bonafide work done by* **Clement BYIRINGIRO (Reg. No: 216358310)** in partial fulfillment of the requirement for the award of Master of Science Degree in Highway Engineering and Management at University of Rwanda-College of Science and Technology, during the Academic Year 2019-2020**.**

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Submitted for the Project Examination held at the University of Rwanda-College of Science and Technology on 29/07/2021

DECLARATION

I hereby declare that the thesis entitled "**ANALYSIS STUDY ON CAUSES OF TIME AND COST OVERRUNS THROUGHOUT ROAD CONSTRUCTION PROJECTS LIFE CYCLE IN RWANDA, THE CASE OF KIGALI CITY ROADS"** 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 City, Rwanda Signature:

Date: 29/07/2021 Name: Clement BYIRINGIRO

DEDICATION

To the Almighty God,

To my Father and Mother,

To my wife,

To my all relatives,

To all who contributed to carrying out this work,

This work is dedicated.

ACKNOWLEDGEMENT

This work is not the fruit of a single effort on our part. Many people have contributed to accomplishing it. It is difficult to know where to start acknowledging them without expressing the importance of their roles, so we will list these below:

Many thanks to my parents, relatives, and wife for providing the necessary education, advice, encouragement and mostly to satisfy my needs during my studies. My thanks and appreciations go to Dr. Daniel TWESIGE for allowing me to achieve this work under his guidance, and for providing necessary assistance regarding this thesis. I extend my sincere gratitude to all lecturers and coordinators of the Highway Engineering and Management Masters programme at the University of Rwanda for their tireless efforts to train future highway professionals. Furthermore, I would like to confer my gratitude to all of you who encouraged me when carrying out this wonderful work.

May God bless you all.

ABSTRACT

Like any other Civil Engineering project, road construction projects are complex with variability and involve various stakeholders such as owners, contractors, sub-contractors, consultants, funders, professionals, local communities. Stakeholders in Rwanda have experienced time and cost overruns in road construction projects. The key features that define road construction project success are time and cost management over the project execution period. These two items enable project stakeholders to understand the activities, resources, and time required to meet project goals, as well as the disbursements needed to complete the project to the content of the customer. The purpose of this study was to identify and analyze the factors that cause the delays and cost overruns throughout the road construction project life cycle in Rwanda; to recommend the best project delivery and management practice that can be applied in Rwanda for time and cost-effective road construction. The study used a descriptive survey by collecting data using a designed questionnaire. The research sample was purposely chosen from road construction projects and professionals working from the senior stakeholders namely contractors, consultants and owner's firms, and other highway experts involved in road construction in Rwanda, particularly in Kigali City. The professionals that were considered are mainly the Project directors, project managers, construction managers, project planners, Quantity surveyors, contract managers/administrators, Quality assurance and quality control Engineers, project/Site engineers, pavement engineers, material engineers, and design engineers. The results were analyzed, compared, regressed and recommendation on best practice to improve time and cost management over the road projects was given. The study revealed that delayed land acquisition, delayed relocation of the utilities; additional works, variation works, contractor's poor planning, and site management are on top of causes of the time and cost overruns. Employers'(owners) factors were ranked first in contributing to delays and cost overruns whereas, external factors, contractors' factors, and consultants 'factors were ranked second, third and fourth respectively. To overcome delays and cost overruns, the researcher and respondents recommended the adoption of Lean Design and Construction (LDC) in road construction in the road construction life cycle in Rwanda.

Keywords: Road construction; causes; time and cost overruns; Employers; contractors; consultants; lean construction

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LIST OF ABBREVIATIONS

AfDB: African Development Bank

BADEA: Arab Bank for Economic Development in Africa

EPC: Engineering, Procurement, Construction

FY: Fiscal Year

GoR: Government of Rwanda

LDC: Lean Design and Construction

MININFRA: Ministry of Infrastructures

NISR: National Institute of Statics of Rwanda

NST1: National Strategy for Transformation 1

OAG: Office of the Auditor General

PMBOK: Project Management Body of Knowledge Institute

RTDA: Rwanda transport Development Agency

RWF: Rwandan Franc

CHAPTER ONE: INTRODUCTION

1.1 Background

Roads in good conditions are a key portion of the national infrastructure that stimulates rapid country's economic growth by easy and safe movements of people and goods between local, national, and international economic destinations.

Transportation plays an enormous role in our everyday lives. Each of us travels somewhere almost every day, whether it be to get to work or school, to go shopping, or for entertainment purposes. In addition, almost everything we consume or use has been transported at some point [1]. A region's social and economic fabric is weaved through intricate movements of people, goods, and services. Roadways are the capillaries, veins, and arteries of life, carrying the pedestrians, bicycles, cars, buses, and cargo trucks to their intended destinations. In the conventional approach to the planning of road systems, the growth of travel demands is largely addressed by adding capacity, including widening existing roads and building new roads[2].

Rwanda is a landlocked country whose transportation is predominated by road transport catering for over 90% of freight traffic and passenger travel. The country is far from the maritime ports having the nearest port of Dar-es-Salaam approximately 1,400 km away. It lacks a connection to the regional inland water and railway transport, thus the national transport sector system is centered primarily on roads.

The Government of Rwanda, under the national development objectives contained in National Strategy for Transformation (NST1) 2017-2024, allocates fundamental importance to the development of the road infrastructures of the country as one of the economic strategies for poverty reduction and social-economic stimulation[3].

National paved roads length has been increased from 1,205.28 Km in 2011 to 1,384.5 Km in 2018; National Unpaved roads haven been upgraded to paved road hence decreased from 1,654 Km in 2011 to 1,365 Km in 2018; District and Kigali City roads and other urban areas: class 1(Paved) has increased from 0Km in 2011 to 106 Km in 2018; District and Kigali City roads and other urban areas: class 1(Unpaved) has increased from 1,838.4 Km in 2011 to 3,799.67 Km in 2018[4]. As per a 7 Years Government programme, Rwanda is targeting to have upgraded unpaved national road up to

1,745Km by FY 2023/2024 from the baseline of 1,305 Km in FY 2016/2017 and rehabilitated feeder roads up to 5,145 km from 2,060Km in 2016/2017[3].

Despite these remarkable investment efforts in road infrastructure development, most road projects in Rwanda have experienced cost and time overruns. The problem of time and cost overrun, particularly in the highway construction sector, is a worldwide phenomenon, and its effects are normally a source of friction between owners(especially government), project managers (consultant), and contractors in terms of project variation after the owners' decision-to-build [5]. Time and cost overruns are critical to any country's economy and need to be investigated to come up with recommendations of the best practices to overcome the major causal factors in future highway projects. Nabil Al-Hazim Z.[6] found that most of the critical causal factors in Jordan are: Terrain conditions, weather conditions, variation of the order, and availability of labor.

The first step to reducing time and cost overruns in highway construction projects in Rwanda is to understand the root causes associated with delay and cost increase over the past road construction projects. For this reason, this research entitled "Analysis Study on Causes of Time and Cost Overruns Throughout Road Construction Projects Life Cycle in Rwanda**"** was conducted**.**

1.2 Problem Statement

Development of the road infrastructure constitutes one of the economic development strategies for the reduction of poverty and for simulating social-economic growth by facilitating access to the domestic and international markets and ensuring favorable conditions for provision and distribution of imported products within the country[7].

Over the recent years, Rwanda has made remarkable progress in constructing, upgrading, rehabilitating and maintaining both paved and unpaved roads to cope with safe and efficient road transport infrastructures that drive the urban and regional economy allowing for quick movement of commuters and goods within the urban communities, and between countries in the region. The GoR has assigned fundamental importance to the development of the economic infrastructure of the country, and in particular to road transportation[7]. However, stakeholders involved in the industry have experienced excessive time and cost overruns that lead to the increased funding needs and act as a constraint to the country's development; therefore, a mechanism is needed to address this issue.

The audit for the year ended 30th June 2019 revealed that funds from BADEA amounting to RWF 263,682,784 meant financing feasibility study for bypass roads in five districts and construction of asphalt Rubengera- Gisiza road project was forfeited due to the failure to implement projects'

activities within a reasonable time. As such, to complete the projects' activities, the GoR will have to mobilize its resources which could have been utilized for other activities. Also, it was noted that the initial time was extended in the range of 50% to 250% on 41 road contracts, and a cost of 42,995,285,540 was added to the initial contracts on 32 projects[8].

Hence, this study was conducted to deeply investigate and analyze the causes of time and cost overruns throughout the road construction projects life cycle in Rwanda and came up with recommendations of the best project management techniques that can be adopted against the time and cost overruns in the future highway projects.

1.3 Research gap

Previous studies have previously been conducted and focused on factors leading to cost overruns in general construction projects in Rwanda such as dams, high-rise buildings but no one focused specifically on time and cost overrun associated with highway projects. Kayiranga [9] focused on monitoring, evaluation, and successful road project delivery in Rwanda: A case study of Kigali Special Economic Zone roads, and suggested further research on reasons of delay in a public building project. Later, Pascal [10] conducted a study on Factors Affecting the Time and Cost Performance of Construction Projects in Rwanda, a case study of High-Rise Building Projects in Kigali and recognized the need for future studies on various public and civil construction projects in Kigali and other areas of Rwanda to find countrywide strategies to minimize delays and cost overrun in the Rwanda Construction Industry. Also, there are many studies on factors affecting time and cost overruns in road construction projects carried out worldwide and some of their respective of their findings may not apply to Rwanda due to the different geographical locations.

Therefore, this study focused on the analysis of causes that lead to time and cost overruns throughout the road construction projects' life cycle in Rwanda.

1.3 Research questions

1. Do the road construction sector in Rwanda experience time and cost overruns?
2. What are the major causes of time overrun (delay) in road construction projects in Rwanda?
3. What are the major causes of cost overrun in road construction projects in Rwanda?
4. Is there any relationship between delays and cost overruns in road construction in Rwanda?
5. What are the best techniques that can be applied to minimize delays and cost overruns in road construction projects in Rwanda?

1.4 Objectives of the research

1. Identify and analysis of the major causes of time overrun in road construction in Rwanda.
2. Identify and analysis of the major causes of cost overrun in road construction in Rwanda.
3. Develop a relationship between delays and cost overrun as a predictive model that could help the road construction stakeholders to predict the cost overrun which is likely to occur if a project would undergo a particular delay.
4. To recommend the best project management techniques that can be applied in Rwanda to minimize delays in road construction projects.
5. To recommend the best project management techniques that can be applied in Rwanda to minimize delays in road construction projects.

1.5 Scope of the Research

Due to the limited time and financial constraints, this research will be limited to the roads under Kigali City. The upcountry roads and district roads will not be covered. On another hand, this study will not cover the rest of the highway project performance factors such as quality, safety, and benefits due to the limited time.

1.6 Research Structure

The research is composed of 5 chapters. Chapter one establishes the general introduction to the study which includes the background, problem statement, research questions, objectives of the research, scope of the research, research structure. Chapter two provides a synthesis of theoretical views from different works of literature related to causes of time and cost overruns on road projects. Chapter three entails the research design and data collection methods. Chapter Four contains findings on the collected data, their graphical representation, analysis as well as discussions on findings. Chapter five presents a conclusive summary of the research findings, conclusion, and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter provides a synthesis of theoretical views from different works of literature, which is vital to understand the root causes of time and cost overruns in road construction projects. The literature review revealed that very few studies have been conducted within the Rwandan highway construction sector despite the ample literature on projects cost and time overruns in the construction industry.

2.2 Conceptual Review

Under this section, the researcher reviewed the definitions of project, time overrun, cost overrun and project life cycle.

2.2.1 Project

A project is defined as a temporary endeavor undertaken to create a unique product, service, or result. [11]

2.2.2 Project Time Overrun (delay)

The project time overrun is defined as the difference between the estimated duration at completion ($EAC_{(t)}$) and the actual duration at completion (AD) or actual time (AT). It is often referred to as the project slippage. [12].

2.2.3 Cost Overrun

A cost overrun is defined as a cost increase or budget overrun, involves unexpected cost incurred more than the budget amount due to an underestimation of the actual cost budgeting of the road construction projects of the most important projects in Jordan. [1].
Pascal [10] defines the cost overrun refers to the difference between the construction project's final cost after the project and the agreed amount in the contract between two parties (employer and contractor).

Budget: The budget for a project is the maximum amount of money the owner is willing to spend for design and construction to economically justify the project [14].

2.2.4 Project life cycle

Project life cycle typically encompass the sequence of activities running from the time that project is initiated to the delivery of project product to the final user or owner [13]. It is composed of the following phases starting the project: starting the project, organizing and preparing, carrying out the work and closing the project [14].

2.3 Theoritical Review

This section discusses the existing theories on time overrun (delay) , cost overrun ,and senior project stakeholders.

Time and cost are among the performance goals of each stakeholder involved in any construction project. Unfortunately, in the field of project management today, significant cost and schedule overruns are the norm, rather than the exception[15].
Time goal refers to complete the project by the scheduled completion date or within the allowance for workdays whereas cost goal is to complete the project within the cost budget, including the budgeted costs of all change orders whereas cost goal refers to complete [2].

Practically every job will experience time delays, cost overruns, or quality failure during construction[16]. It is a well-Known fact that a large number of projects complete later than scheduled and exceed cost estimates. No single reason explains all of the cost overruns on projects[17].Unfortunately, industry data suggest that overruns are the norm, rather than the exception. The most significant reasons for this are low initial cost estimates, unanticipated technical difficulties, lack of or poor scope definition, specification changes, and external factors[15].

2.3.1 Types of Delays

Delays may be categorized as excusable, non-excusable, compensable, and non-compensable [18]. Delays are classified into two different types according to liability: (1) Excusable and (2) inexcusable. When the contractor fails to coordinate work, too few workers, and low productivity; he is responsible for the cause of the delay, and it is called inexcusable. The contractor is also liable for damages incurred by the employer as a result of the inexcusable delay. Excusable delays can be further broken into compensable and non-compensable delays [19] . A compensable delay is one

where a contractor is entitled to financial recovery in the form of direct and indirect time-related costs arising from an employer risk event [18]. Examples include changes in the scope of work and the employer's failure to grant site access. When neither the owner nor the contractors are responsible for the delay, it is called excusable-non-compensable delay. Examples include severe weather and acts of God[19]. When there are two or more independent delays during the same period, it is called concurrent or parallel delay[18].

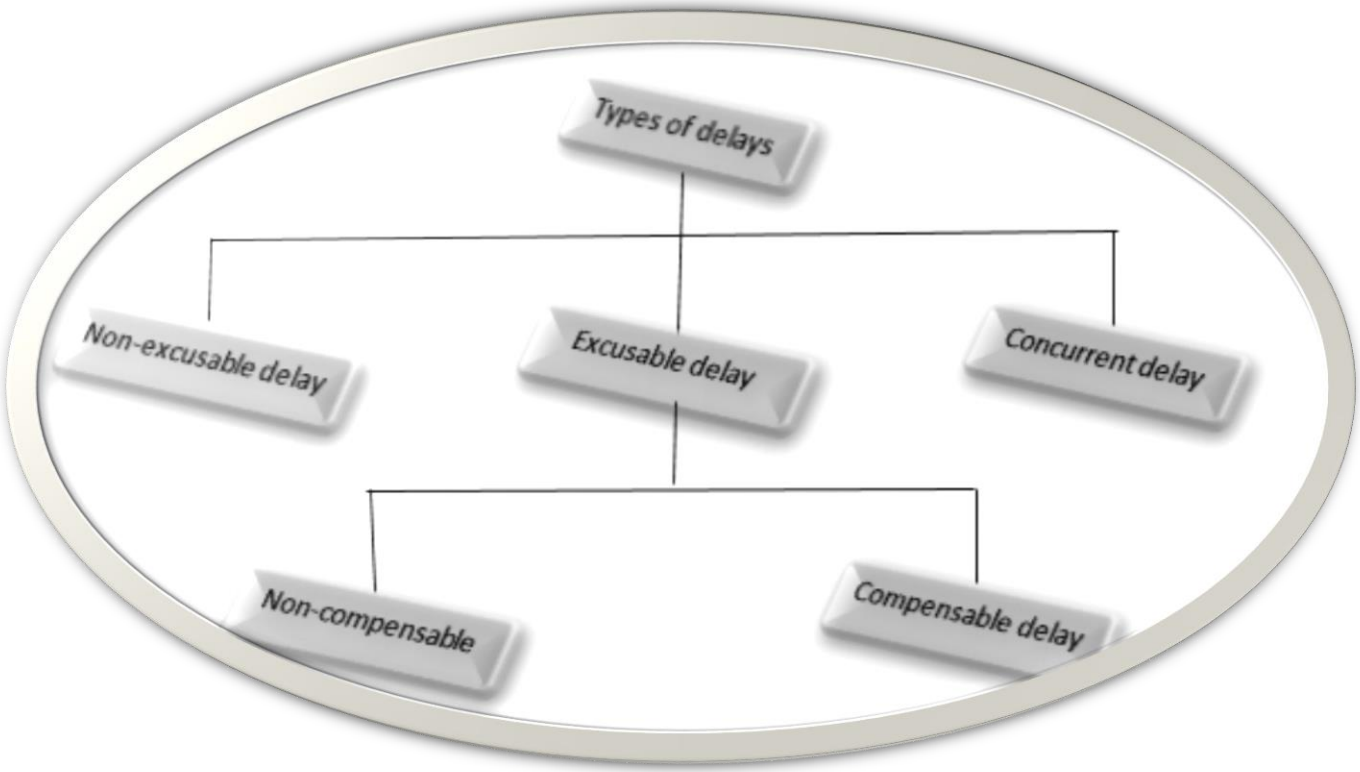

Figure 0-1 Types of delays

Source **:** [20]

2.3.2 Road project senior stakeholders

The success of any project depends on the coordination of the efforts of all parties involved, hopefully to the financial advantages of all. Road construction projects comprised a cross-section of many different participants. These participants both influence and depend on one another in addition to others involved in the construction process. As per Razzak [21], in all types of project delivery systems, there are mainly three main groups involved in road construction projects:

- **The owner (Employer/Client)**

A person or an organization that initiates and sanctions a project. He or she requests the need for a road facility and is responsible for arranging the financial resources for the creation of the facility.

- **Designer (Consultant)**

  This consists of architects or engineers or consultants. They are the owner's appointed group accountable to convert the owner's conception and needs into the specific facility with detailed directions through drawings and specifications within the economic objectives. They are responsible for the design of the project and in certain cases supervision of the construction process.

- **Contractor**

A construction firm engaged by the owner to complete the specific facility by providing the necessary staff, workforce, materials, equipment, tools, and other accessories to the satisfaction of the owner/end-user in compliance with the contract documents. The contractor is responsible for implementing the project activities and achieving the owner's objectives.

2.4 Empirical Review

In this section, the researcher explored the past studies on time and cost overruns in road construction. A wide variety of factors influence construction time and the cost of road projects. Barbara [16] listed some of these factors below and explained how they can influence project performance: weather conditions, quality of the workforce, quality of the supervision, incorrect sequencing of work, change orders, overcrowded job site, inadequate tools, and equipment and late deliveries. Weather is probably the most common and most obvious reason for work slowdown resulting in cost overruns. Work proceeds much more slowly under adverse weather conditions, and such conditions can impact the quality of work as well.

Garold D. [22], mentioned that the lack of scope definition has been identified as the root cause of the cost overruns, late completion dates, excessive rework, unnecessary disputes, poor team alignment, and other problems associated with engineering construction projects.

AfDB [23], conducted studies and observed that cost overruns in road infrastructure projects had become increasingly common. The average cost overrun was 35 percent, but in a third of the cases, it could be as high as 50 to 100 percent. The assumption has been made that the increases are due to a variety of factors, including lack of competition in the bidding process, increases in fuel and

bituminous product prices locally and internationally, the technology used in road works, contract management practices, and the availability and quality of road construction materials.

Chitkara [24] noted that the factors contributing to cost and time overruns are:

i. **Inadequate project formulation**: Poor field investigation, inadequate project information, bad cost estimates, lack of experience, inadequate project analysis, and poor investment decision.
ii. **Poor planning for implementation:** Inadequate time plan, inadequate resource plan, inadequate equipment supply plan, inter-linking not anticipated, poor organization, poor cost planning.
iii. **Lack of proper contract planning and management**: Improper pre-contract actions, poor post-award contract management.
iv. **Lack of project management during execution:** Inefficient and ineffective working, delays, change in the scope of work and location, law.

Failure can also be due to unforeseen natural calamities like earthquakes, floods, and natural disasters. Failure can also result from deliberate attempts made by manipulators during the feasibility stage by incorporating inaccurate time and cost estimates to secure a business or to start a project.

Russ J. et Al. [25] presented the following common reasons for project cost overruns:

i. Insufficient fund;
ii. Inaccurate cost estimates;
iii. Scope increases;
iv. Extended project schedules;
v. Lack of risk management contingency;
vi. Poor cost management.

Pinto et Al. [15] revealed that inaccurate forecasts, late deliveries, equipment breakdowns, substandard raw material quality, scope creep, resources constraints, and so on can contribute to significant schedule and cost overruns for a project organization. Nabil Al-Hazim [6] while carrying out a study on delay and cost overrun in road construction projects in Jordan, revealed a very big discrepancy between estimated and final cost ranging from 101% to 600% with an average of 214% and the delay ranging from 124% to 455% with an average of 226%. Their study proved that most

road construction projects in Jordan are characterized by delay and overrun in cost and most of the critical factors are:

i. Terrain conditions, weather conditions;
ii. Variation of orders, and
iii. Availability of labor.

The analysis of Garry D. et Al. [5] have produced important findings concerning the reason highway projects have overrun and provided evidence of the most important risks on which highways agencies need to focus their efforts of particular concern are Changes in project designs and scope changes during project development. Pinto et Al. [15]emphasized that, projects that suffer from cash flow ultimately incur additional costs and, possibly, significant delays as well. Barbar J.[16] mentioned that poorly managed subcontractor coordination, low productivity, or delayed material deliveries can result in cost overruns and scheduling fiascoes.

Yosef et Al.[26] conducted a study to assess the causes of excessive delays in the completion of road projects during the construction phase due to the failures of Employer, Consultant, and Contractor in Addis Ababa City Road Authority and found that, the contractors have the highest percentage of responsibility areas that causes the delay of about 40%, while the second was on the part of the Employer, which comprised of 26.15%, the consultant which placed third of 23.08%, and shared responsibility area which causes project delay of about 10.77%.

Massimo[27] listed the reasons for project overruns and overcoats :

i. Clients who don’t know what they want,
ii. commercially naïve clients;
iii. Inappropriate contractual arrangements,
iv. Underfunding,
v. Tendering based solely on price without capacity checks or quality checks on the bidders,
vi. Fragmented execution organization with no continuity of management through the life of the project,
vii. Little or no incentive for pride in workmanship, therefore little or no pride/ownership of the end product-no owner focus,
viii. Site execution controlled on cost with no regard for quality and its effect on the end product,
ix. Little or no quality assurance or quality control,
x. Little or no understanding of handover and commissioning processes; and
xi. Many disputes often involving lawyers to clear snag lists and settle a final invoice.

2.5 Conceptual Framework

Under this section, the researcher constructed a concept framework to show exactly which variables will be measured in this research and how they are related each other.

Alan Griffith et Al [28] highlighted two aspects of performance for which construction has been much criticized as time and cost overruns in contract completion and the innovative performance of the industry. They argue that the cost and time overruns are numerous but are in part concerned with the level of site efficiency in getting men and materials on-site on time and completing work on schedule. Figure (2-2) shows the relationship between time overrun and cost overrun. It indicates that cost overrun (dependent variable) is a function of time overrun (independent variable).

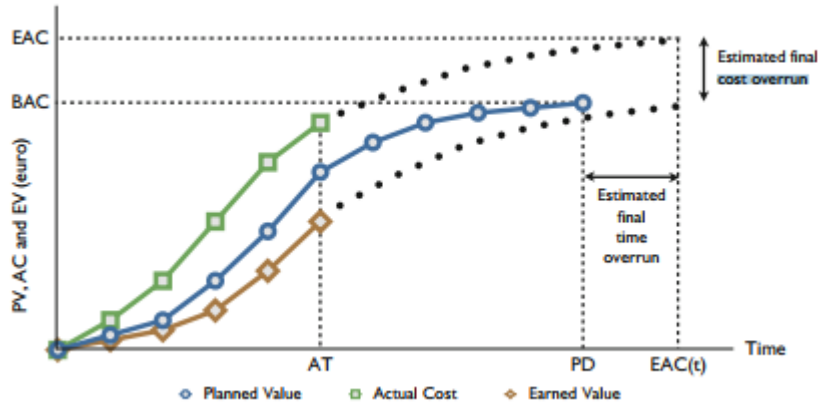

Figure 0-2 Expected cost and time performance

(Source :[12])

2.6 Research gap

Previous studies have previously been conducted and focused on factors leading to cost overruns in general constructions projects in Rwanda such as dams, high rise buildings but no one focused specifically on time and cost overrun associated with highway projects. Kayiranga [9] focused on monitoring, evaluation and successful road project delivery in Rwanda: A case study of Kigali Special Economic Zone roads, and suggested further research on reasons of delay in public building project. Later, Pascal [10] conducted a study on Factors Affecting time and Cost Performance of Construction Projects in Rwanda. A case Study of High-Rise Building Projects in Kigali and recognized the need of future studies on various public and civil construction project in Kigali and

other areas of Rwanda in order to find countrywide strategies to minimize delays and cost overrun in the Rwanda Construction Industry. Also, there are many studies on factors affecting time and cost overruns in road construction projects carried out worldwide and some of their respective of their findings may not be applicable to Rwanda due to the different geographical locations. Indeed, none of them recommended lean design and construction as remedy to delays and cost overruns.

2.6.1 Lean Design and Construction

a. Definition of Lean Construction

Ballard (2001) views lean construction as a new way to manage construction. The Construction Industry Insititute (CII) has defined lean construction as the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream, and pursuing perfection in the execution of the constructed project.

Lean design and construction involve the application of lean methods/techniques to the design and construction processes, to derive the benefits that have been established in manufacturing operations. Benefits include:

- Lower costs
- Fewer delays
- Less uncertainty
- Less waste
- More efficient facilities
- Higher user satisfaction

b. Deficiencies in Traditional Construction methods

Conventional construction methods are based on craft production methods, hence it is slow and expensive in comparison to mass and lean production methods. These craft production methods are carried out by many different specialists (contractors, subcontractors, Civil contractors, MEPs, etc.) having separate contracts with a central entity (General contractors). These contracts place the parties to construction projects in adversarial roles as each party is trying to maximize its profit and complete the work within its timeline. Consequently, the parties tend to have little intercommunication and

often proceed quickly as possible, frequently resulting in work that interrupts the sequence of upstream tasks. Typically, projects are subdivided into activities; in turn, the resource requirements and time frames for each activity are placed on a CPM chart, guided by a master schedule. Once the work starts, the CM attempts to control it by comparing progress with preplanned schedules [29].

Unfortunately, these efforts to improve productivity have a limited impact on the overall project. As schedules could quickly go off track, CMs are often in reactive mode, adjusting staffing or sequencing to maintain the schedule. Errors often result from poor communication and unplanned events. Attempts to get back on schedule may lead to cost overruns, quality deficiencies, or lapses in safety practices.

Traditional project management is very limited in its ability to reduce project variability. It uses the critical path methods (CPM) to establish overall project schedules and keeps track of whether projects are on time or not. The master schedule defines construction milestones and tasks but does not give workers incentives to work together or define the best methods. Lean construction does not replace CPM or other tools that define the overall work schedule, but it works within them to improve the delivery of the short-term assignment.

Earned value analysis helps project managers to evaluate performance. However, these tools do not control project variability. Even though these tools are available to project managers, projects are still delayed and have cost overruns.

Traditional project management also involves a culture of "pushing" work assignments to subcontractors to meet schedule, whether or not these producers have all needed resources to complete those assignments in a given time.

c. Lean Principles

Lean construction 5 principles are:

A. **Value:** Identify the value desired by customers
B. **Value stream**: Represents the actions needed to create a product or service from its inception as raw material until it reaches a customer in its completed form. Value stream includes both value-added and non-value added activities.
C. **Value Stream Mapping:** VSM shows material and information flows required to produce output. VSM identifies sources of waste by distinguishing between NVA and VA activities.

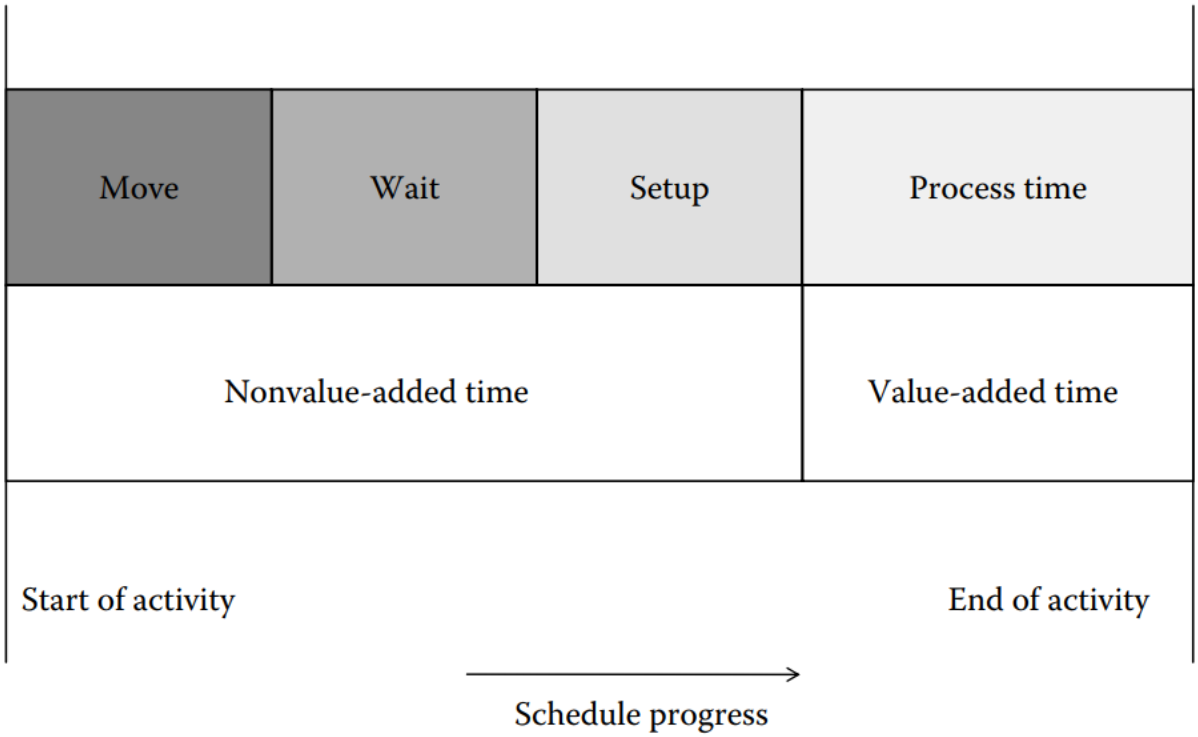

Figure 2-3 Impact of value-added vs. non-value-added time in a typical construction process

Source: [17]

D. **Flow:** The goal of lean thinking is to have a continuous flow of a product from one activity to the next in a process without delays, stoppages, or storage as work in process. This concept is called one-piece flow or single-piece flow.

E. **Pull:** Pull a schedule are a tool where a project is planned from end to the start to understand which work tasks are impacted by particular construction activity. The project is planned in reverse starting with the completed project or some series of milestones as a goal. The schedule is then pulled back to include the steps needed to achieve those goals[30].

F. **Perfection:** Strive for perfection, although it may never be achieved. Develop work instructions and procedures and establish quality controls.

d. Structure of the Lean Project Delivery System

The LPDS comprises many phases that capture the intent of the traditional project phases but juxtaposes them in such a manner as to apply production system design principles to enhance the delivery of the entire project from predesign to completion and use.

The phases are:

1. Project definition
2. Lean design
3. Lean Supply
4. Lean assembly
5. Use/completion

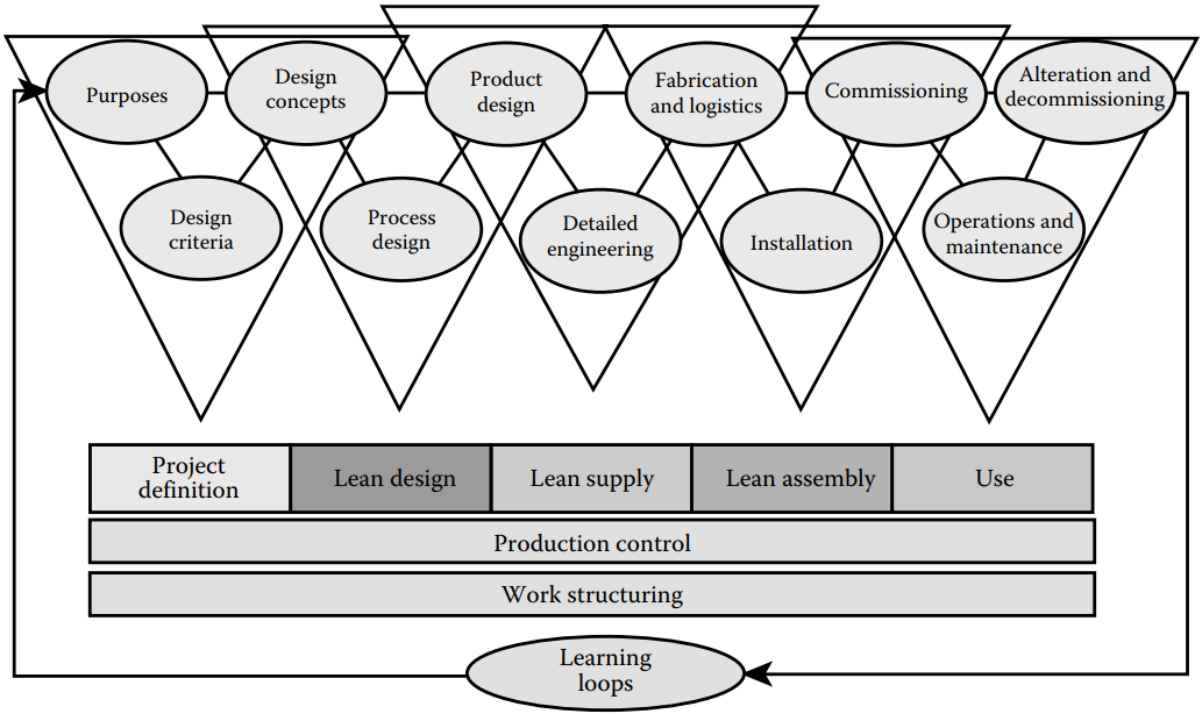

Figure 2-4 LPDS

Source : [29]

e. Lean techniques for use on Infrastructure Projects

The theory of Lean is very much about creating a collaborative, continuous learning culture. Many tools have been developed to aid in the creation of the lean culture. Wodalski [30] indicates that Lean techniques can be implemented in two ways, incrementally and transformatively. Incremental techniques draw off current practices and add a lean twist to current work habits to gain buy-in. A transformative technique requires a completely new outlook on a project and relies very little on the current practices.

Incremental Lean Techniques

To implement incrementally learn techniques, the following tools are required:

I. Value Stream mapping;
II. Last planner /Collaborative Scheduling
III. Just-in-Time Delivery (JIT) and Supply chain Management
IV. Six Sigma (6σ): Six Sigma is a business management strategy, originally developed by Motolala, focusing on quality control. 6σ improves quality by identifying and removing the causes of defects and variability in the production process. It is a business improvement methodology and must be applied throughout the road construction process. It defines a defect as anything outside of consumer specifications.

2.6.2 Building Information Modeling (BIM)

The new approach to construction management: Lean design and construction are based on a foundation of team integration and open sharing of project-related information. ICT and BIM are an effective mechanism for providing some effective mechanisms for providing construction stakeholders with the informational and analytical tools for better management of construction delivery processes.

The simulation and Modeling technique covers many ways to virtually plan and constructs a project before breaking ground. It is a very key part of resolving any logistical issues before arriving onsite. BIM relates closely to the concept of integrated project delivery Development (IPD), which is based on bringing all project participants together early in the process to create a team approach to the building project. Simulation and modelling allow the project team to identify and solve problems early in the design and construction process, and to resolve issues during design before they become problems during construction.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

This chapter describes methodology used in the study. It covers research design, study population, sample design, data collection, data analysis, reliability and validity and ethical consideration of the research.

3.1 Research Design

There are two categories of research that are widely used by researchers: Qualitative research and Quantitative research. Qualitative research involves studies that do not attempt to quantify their results through statistical summary or analysis. They typically involve interviews and observations without formal measurement. Qualitative research is often used as a source of hypotheses for later testing in quantitative research whereas quantitative research involves studies that make use of statistical analyses to obtain their findings[31]

In this study, the researcher selected the quantitative method because he used statistics to analyze the data.

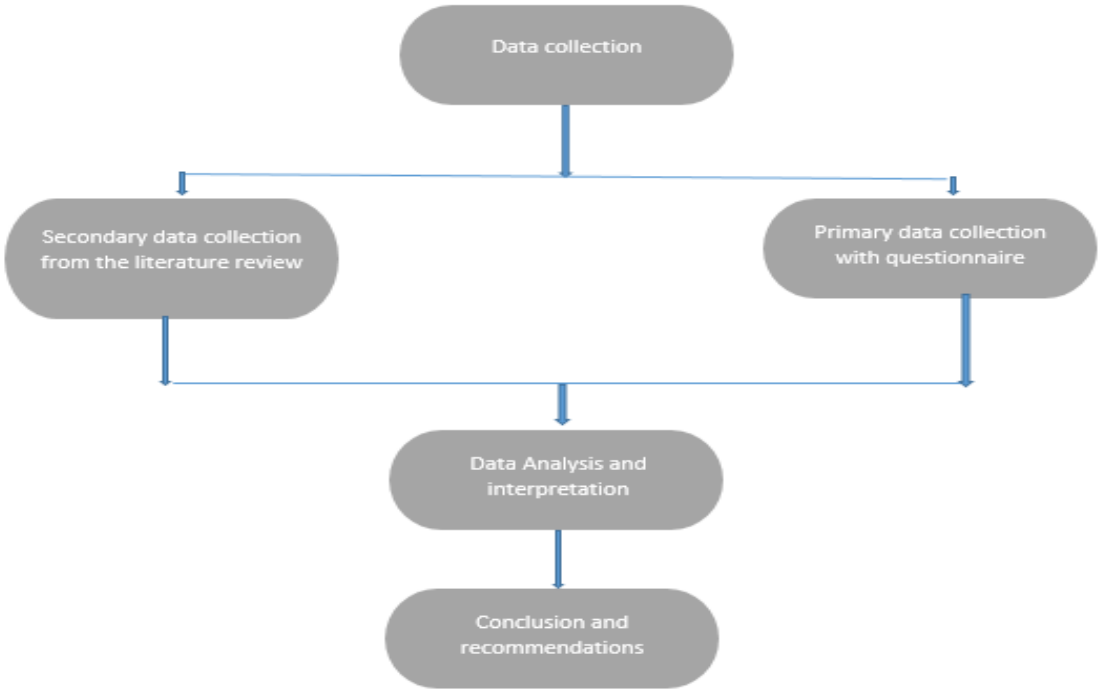

Figure 3-1 Research methodology flowchart

3.2 Study Population

In this study, the researcher targeted roads in Kigali City as the study population because Kigali is the capital city of Rwanda and has been undergoing a series of major road network upgrade projects.

3.3 Sample Design

For obvious reasons, researchers are typically unable to study the entire population. Therefore, researchers typically study a subset of the population, and that subset is called a sample[31]. A sample is the number of individual cases that a researcher ultimately draws and from which/whom he or she generates data.

The researcher must decide the way of selecting a sample of what is popularly known as the sample design. In other words, a sample design is a definite plan determined before any data are collected for obtaining a sample from a given population[32]. However, the sample must be representative of the population.

3.4 Sampling Method

Sampling is the process by which research selects a number of individuals cases from a large population. The first thing a researcher needs to do is to determine the elements in his/ her study. An element is a kind of person, group, or nonliving item in which the researcher is interested.

There are two types of sampling methods: Probability sampling and Non-Probability Sampling also known as Purposeful or Convenience Sampling or judgmental sampling.

a. Probability Sampling

Probability Sampling relies on probability theory and involves the use of any strategy in which samples are selected in a way that every element in the population has a known and nonzero chance of being selected [33].This means that the chance that each element in the population will be included in the sample can be statistically determined, and the chance of inclusion, no matter how small, will be a number above zero. Probability sampling is typically used in quantitative research.

b. Purposeful Sampling

Purposeful Sampling (also called Judgement or convenience sampling) is based on the premise that seeking out the best cases for the study produces the best data, and research results are direct of the cases sampled. Sampling is a central feature of research design when purposeful strategies are used

because the better the participants are positioned in relation to the topic, the richer the data will be[33].

Though the researcher used the quantitative method in this study, it is important to note that although, generally speaking, probability sampling methods are preferred in quantitative research, there are instances when purposeful sampling is used. Convenience sampling involves identifying research subjects based on their accessibility to the researcher. Leavy [33] indicated that this approach is often used when the researcher has access to subjects within a particular institution, organization, business, group, and so forth.

Six (6) road construction projects in Kigali City that mostly have experienced time and cost overruns over the past years were selected. These projects include earth roads, stone-paved roads, concrete roads, and asphalt concrete roads, hence they represent all roads. As seen in Table 3.1 The researcher categorized the respondents in three categories: Employer/Client's professionals, Consultant's professionals, Contractor's professionals who were either directly or indirectly involved in seven selected projects in the study.

Table 3.1. Sample size

Projects	**Employer 's Professionals**	**Consultant's Professionals**	**Contractors' professionals**	**Total professionals per project**	**Frequency(%)**
A	2	2	2	6	17%
B	2	2	2	6	17%
C	2	2	2	6	17%
D	2	2	2	6	17%
E	2	2	2	6	17%
F	2	2	2	6	17%
	12	**12**	**12**	**36**	**100%**

(Source, Author 2021)

3.5 Data collection

For the researcher to answer the research questions, a mixture of secondary and primary data was adopted. Primary data can be collected either through the experiment or through a survey. If the researcher experiments, he observes some quantitative measurements, or the data, with the help of which he examines the truth contained in his hypothesis[32].

3.5.1 Secondary data collection

The researcher tack together the secondary data from previous various literature reviews related to the current research questions and data of the seven road projects provided by the City of Kigali Office. Contracts, addenda, progress reports, handover reports, for seven projects that have mostly experienced delays and cost overruns were analyzed to identify the eventual causes of both delays and cost overruns. The causes of time and cost overruns identified from these seven projects were merged with causes of time and cost overruns gathered from the literature review then, the researcher got a list of the eventual causes of time and cost overruns in road construction life cycles in Rwanda. The secondary data collected are presented in Table 3.2

Table 3.2 Causes of time overruns in road construction

#	Factors Identified causes of time overrun from 7 road projects in Kigali City and literature review	Variable
		Time overrun
A	**Employer's time overrun causes**	
1	Additional works not envisaged in the original scope	
2	Variation works	
3	Employer's orders to change the design	
4	Delay in relocating the existing utilities (water, electrical, telecommunication)	
5	Delay in land acquisition for right-of-way (Expropriation)	
6	Delay in service order provision/commencement letter by employer/client	
7	Client budget constraints/Delays in payment by the client that leads to the Contractor’s cash flow fluctuations	
8	Suspension of works due to the shortage of funds by Employer	
9	Underestimation of the initial duration	
10	Delay in decision making	
B	**Consultant time overrun causes**	
11	Changes in the designs	
12	Delay in issuing the IPC by Consultant	

13	Underestimation of the initial duration and lack of time contingency while estimating the project duration	
14	Delayed approvals of the submittals by consultant	
15	Consultant not cooperative with the contractor	
16	Consultant's instruction to delay works	
17	Consultant personnel not experienced	
18	Suspension of work by Employer/consultant	
19	Consultant's lack of expertise in road design and supervision	
20	Design complexity/lack of design detail/delay in issuing details to the contractor	
21	Consultant's Poor communications	
C	**The contractor's time overrun causes**	
22	Lack of contractor's Capacity /Lowest bidder	
23	Poor planning by contractor	
24	Poor site management by the contractor	
25	Shortage/Lack of the equipment by the contractor	
26	Delay/procurement issues	
27	Contractor's lack of enough expertise in road construction	
28	Delayed submittals by a contractor	
29	Suspension of works by the contractor	
30	Contractor delays to submit payment invoice	
31	Equipment breakdown and delay in attending their repairs	
32	Contractor's Poor communication	
33	Subcontractors coordination problems/incompetent subcontractors	
34	The contractor's failure to comply with HSE guidelines force the consultant to instruct to hold the works	
D	**Third Party's/External time overrun causes**	
35	Unforeseen Ground Conditions	
36	Force Majeure	
37	Adverse Weather conditions	
38	Traffic Management issues during construction	

Table 3.3 Causes of cost overruns in road construction

	Independent Variables	Dependent Variables
#	**Identified causes of cost overrun from 7 road projects in Kigali City and literature review**	Cost Overrun
A	**Funder/Employer's Cost overrun causes**	
1	Additional works not envisaged in the original scope	
2	Variation works	
3	Employer's orders to change the design	
4	Delay in relocating the existing utilities (water, electrical, telecommunication)	
5	Delay in land acquisition for right-of-way (Expropriation)	
6	Lack of risk management plan by project client prior to award a tender to the contractor	
7	Delays payment by the client that leads to project delays and Price adjustments	
8	Lack of Cost contingency while estimating the project cost	
9	Suspension of works due to the shortage of funds by Employer	
10	Client's Instruction to change the designs	
11	Work omissions by client	
12	Awarding a contract to the lowest bidder with no capacity	
B	**Consultant's cost overrun causes**	
13	Poor design/Changes in the designs	
14	Delayed approvals by consultants lead to poor designs/contractor supervision	
15	Consultant personnel not experienced	
16	Suspension of work by consultant	
17	Consultant's lack of expertise in road design and supervision	

18	Design complexity/lack of design detail/delay in issuing details to the contractor	
19	Poor contract Management by Consultant	
20	Vagueness and poor interpretation of the technical specifications	
C	**Contractor's cost overrun causes**	
21	Poor planning by contractor	
22	Poor site management by the contractor	
23	Currency fluctuation issues	
24	Delay/procurement issues	
25	Contractor's lack of enough expertise in road construction	
26	Delayed submittals by a contractor	
27	Suspension of works by the contractor	
28	Extension of time	
29	Equipment breakdown and delay in attending their repairs	
30	Heavy Bank loan interest rate and charges	
31	Contractor's delay penalties	
32	Poor pricing during the bidding period	
33	Lack of risk management plan by a contractor	
34	Poor quality of work that leads to demolition and redoing works	
35	Contractor's low productivity	
D	**Third Party's/External cost overrun causes**	
36	Unforeseen Ground Conditions	
37	Force Majeure	
38	Adverse Weather conditions	
39	Traffic Management issues during construction	

3.5.2 Primary Data Collection

To get primary data, the researcher used a pre-structured questionnaire that was sent to the road professionals from clients, consultants, and contractors. Respondents were selected using purposeful sampling and were requested to answer the pre-set questions by filling in a Google survey form that the researcher shared with them on email.

The questionnaire distributed among the road construction professionals from employers/clients, consultants, and contractors to name but a few: Project Directors, Project Managers, Construction Managers, Site Engineers, Business Development Managers, Cost controllers/Quantity Surveyor, Material Engineers, Pavement Engineers, Design Engineers, Contract Managers/Claim Managers.

3.6 Data analysis

For the researcher to analyze the data, descriptive and inferential statistics were used. As their names imply, descriptive statistics are used to describe the data collected in research studies and to accurately characterize the variables under observations within specific samples. Descriptive analyses are frequently used to summarize a study sample before analyzing a study's primary hypotheses. This provides information about the overall representativeness of the sample, as well as the information necessary for other researchers to replicate the study if they so desire [31].

3.6.1 Relative importance index technique

The researcher used the Relative Importance Index (RII) to determine the relative importance of the different and rank causes of time and cost overruns. The method was adopted in this study within various groups (i.e. Employer/Client/Funder's causes, Consultant's causes, Contractor's causes, and External causes). The five-point scale ranged from 1 (not significant) to 5 (Very significant) was used and relative importance indices (RII) for each factor was calculated as following.

$$\boldsymbol{RII = \Sigma W/(A * N)} \quad (3.1)$$

Where W is the weighting given to each factor by respondents (ranging from 1 to 5), A is the highest weight (i.e. 5 in this case), and N is the total number of respondents. Higher the value of RII, more important is the cause of time and cost overrun.

3.6.2 Statistical modeling

Linear regression analysis was used to estimate the relationship between delays and cost overruns.

Delays were considered as an independent variable that might influence the cost overruns which were considered as a dependent variable.

Mathematically, linear regression is defined by this equation:

$$\boldsymbol{y = bx + a + \epsilon} \qquad (3.2)$$

Where: x is the time overruns (independent variable), y is cost overruns (dependent variable), a is the Y-intercept, which is the expected mean value of y when all x variables are equal to 0. On a regression graph, it is the point where the line crosses the Y-axis, b is the slope of the regression line, which is the rate of change for y as x changes. $\boldsymbol{\epsilon}$ is the random error term, which is the difference between the actual value of dependent variables and its predicted value.

3.7Reliability and validity

To understand the degree to which the questionnaire survey scale yields consistent results to the same sample over a period of time, a reliability analysis using the internal consistency was conducted. Internal consistency refers to how well a questionnaire survey measures what is intended to be measured. The higher the internal consistency, the more confident that survey is reliable. In this study, a statistic Cronbach's Alpha was calculated to test the internal consistency of our survey. The value for Cronbach's Alpha normally range between 0 and 1, with higher values indicating that the survey is more reliable. To understand the reliability of the correlation between time (independent variable) and cost overrun (dependent variable), Analysis of Variance (ANOVA) test was conducted. the Multiple R which is the correlation that measure the strength of a linear relationship between two variables (time and cost overruns) was calculated. This correlation can be any value between -1 and 1, and its absolute values indicates the relationship strength. The larger the absolute value, the stronger the relationship. **R square** which is the coefficient of determination, was used as an indicator of goodness of fit of the regression model between cost and time overruns. It shows how many points fall on the regression line. The R^2 value is calculated from the total sum of squares, more precisely, it is the sum of the squared deviations of the original data from the mean. The standard error is another goodness of fit measure that was used in this study to show the precision of the regression analysis. The smaller, the more certain you can be about your regression equation.

Validity refers to the degree to which an instrument accurately measures what intends to measure. The findings of this study on causes of time and cost overruns were validated based on five important levels (evidences) of the Relative Importance Index Values: High (H) ($0.8 \leq RII \leq 1$), High-Medium (H-M) ($0.6 \leq RII \leq 0.8$), Medium (M) ($0.4 \leq RII \leq 0.6$), Medium-Low (M-L) ($0.2 \leq RII \leq 0.4$), and

Low (L) (0 ≤RII≤0.2) [34]. For regression model, F-test for null hypothesis was used to test overall significance of the regression model between time and cost overrun., and Significance F: P-values was calculated. The model is significant if significance F is less than 5%.

3.8 Ethical consideration

In this study, the researcher carefully considered ethic while carrying out the research design. A google form survey was designed in such way the participants are clearly informed on: who is the researcher, what is the intent of this research, what data will be collected from respondents, what level of commitment is required from participants, how data will be analyzed and reported. In addition, the researcher gave a phone call to all participants prior to sending the survey form to their respective emails. Each participant reserved the right to decline his/her participation and/or to withdraw the data at any time without reason. Participants were given a right to access their data even after submitting their answers and, right to ask for more information. After receiving the responses from participants, the researcher kept confidential all identities of the participants by avoiding mentioning any name, email, phone contacts of any participant. Indeed, the names of the road projects considered while sampling were renamed in this study, to eliminate any risk associating with relating the participants with those projects.

CHAPTER FOUR: FINDINGS, DISCUSSIONS, AND ANALYSIS

4.1 Introduction

This chapter contains findings on the collected data, their graphical representation, analysis as well as discussions on findings. Results were presented in diagrams, tables and analyzed as well as interpreted.

4.2 Rate of response

The research aimed at collecting data from a sample of 6 road projects in Kigali City each with 6 professionals (2 professionals from Employer/Client/Funder, 2 from consultant, and 2 from contractor) which in total would be 36 professionals. However, as it is seen in Fig. 4.1, only 26 (72%) professionals responded over 36 professional anticipated. Among 26 returned, 35% are from employers/Clients/Funders, 38% from consultants and 27% from contractors.

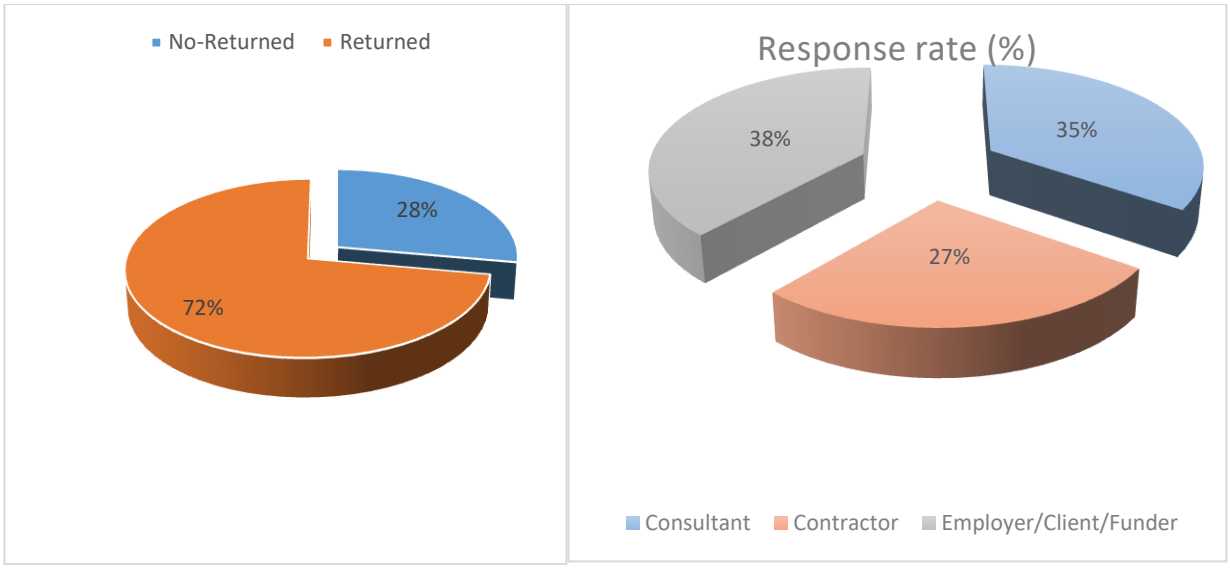

Figure 4-1 Returned vs Non-returned questionnaire and professionals responded from each category

4.2.1 Education level of the respondents

Figure 4.2 indicates that among the respondents, none with a diploma responded, 46% of the respondents hold Bachelor's degree in Civil Engineering, 4% has a Post-Graduate Diploma, 46% of the respondents hold Master's degree in different specialties of Civil Engineering and 4% hold a Ph.D. In other words, all the respondents hold at least Bachelor's Degree which assured the researcher that their responses to his questionnaire are reliable.

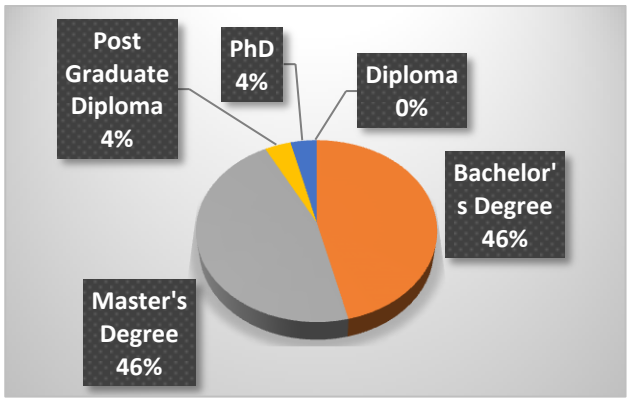

Figure 4-2 Education Level of the respondents

4.2.2. Positions of the respondents

Figure 4.3 indicates that the number of respondents was dominated by project managers (project managers /contract managers/claim managers on questionnaire) in road construction industry up to 46%, both material and design engineers responded are 12%, site engineers 8%, all the rest are 4% each. The dominance of project managers /contract managers/claim managers gives the researcher the highest quality of the results as Project Managers/Contract Managers/Claim Managers are the most managing projects time/schedules and costs.

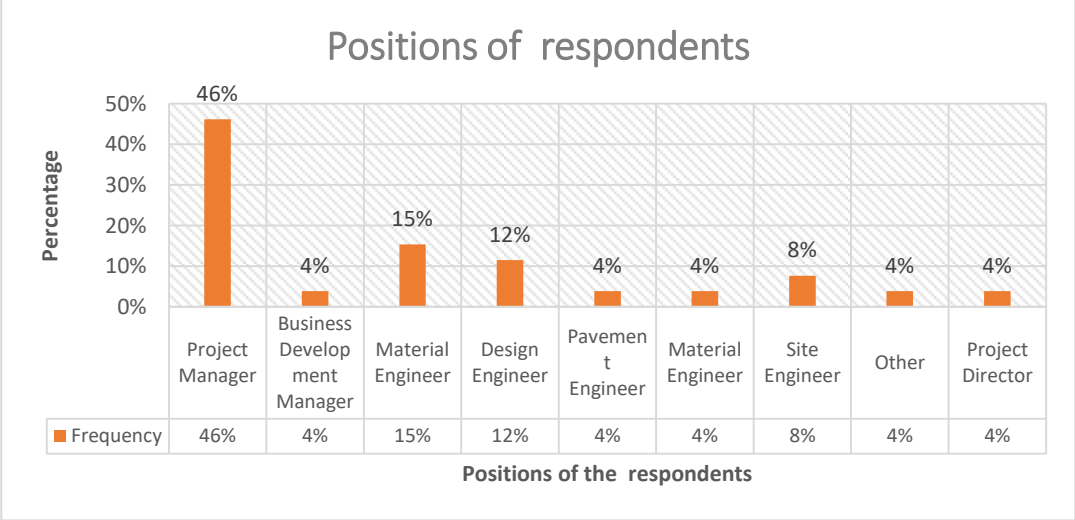

Figure 4-3 Positions of respondents

4.2.3 Experience of the respondents in road construction

As indicated in Figure 4.4, among 26 respondents, 4 have experienced between 0-5 years in Rwandan road construction,20 have 5-10 years of experience and only 1 road professional has acquired more than 15 years' experience in Rwandan road construction. On the other hand, As the researcher was

investigating the causes of time and cost overrun in Rwanda road construction, the case of Kigali City Road, he was interested in understanding the experience of respondents in Kigali City road construction. Among 26 road construction who responded, 15 have experience of 0-5 years in Kigali City road construction, 10 with 5-10 years, and only 1 with more than 15 years. The survey results prove that the respondents have extensive experience in road construction in Rwanda, hence they can provide informed answers while responding to the researcher's questionnaire.

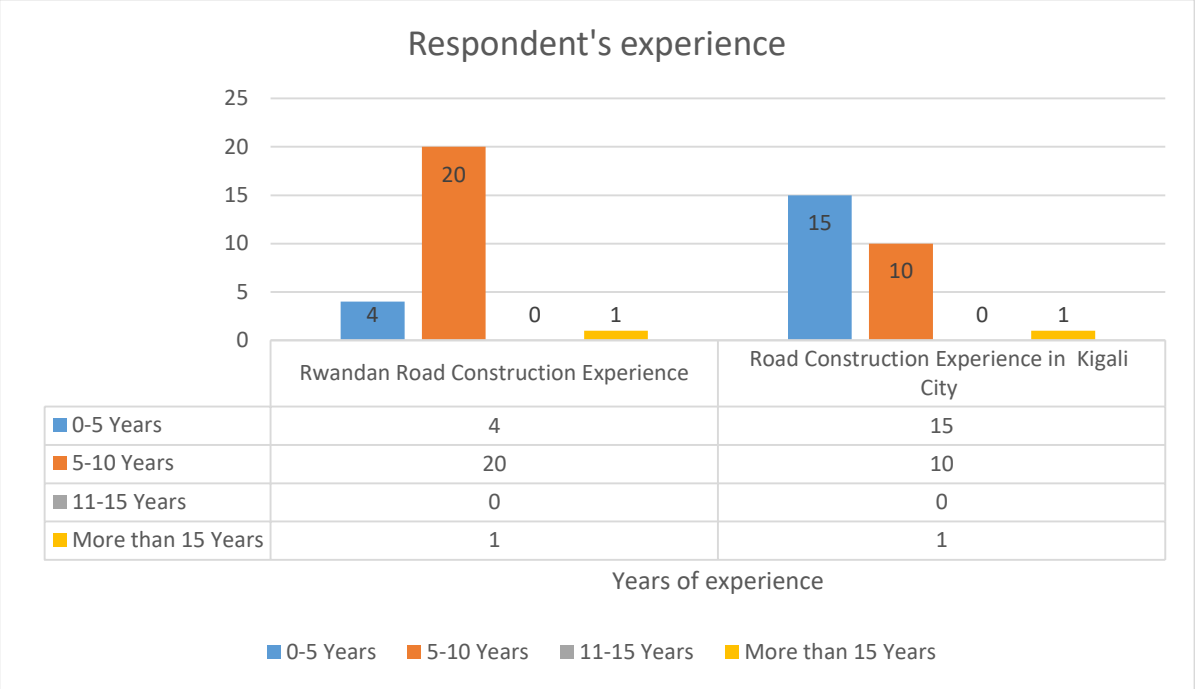

Figure 4-4 Respondent's experience

4.2.4 Level of time and cost overrun in the road construction industry

The researcher was interested to confirm if the road construction industry has experienced the issues of excessive delays and cost. As it is noted in figure 4.5, the researcher noted that the respondents who were involved in 0-5 road construction projects revealed that:

None of the road projects was completed ahead of planned time, neither below the planned budget, only one respondent indicated that the project he/she was involved was completed on time and five respondents who indicated the road projects were completed on budget. Six respondents indicated that the road projects they were involved incurred 1-20% delay (time overrun), whereas 1-20% cost overrun occurred for 7 respondents. Eight respondents indicated that the projects they were involved incurred 21-40% time overrun, whereas 21-40% cost overrun occurred for 4 respondents. In the same category, the projects incurred 41-60% time overrun once, whereas no occurrence of 41-60%

cost overrun. Again, 61-80% time overrun occurred once and there was no cost overrun at 61-80%; In this group, no 81-100% time overrun occurred but there was one occurrence of 81-100% cost overrun. Finally, there was one occurrence of time overrun beyond 100% of the planned budget, but no cost overrun was incurred at 100% of the planned budget.

In the category of respondents who were involved in the road projects ranging from 5-10 projects, the survey results indicated: no project was completed ahead of time, neither below the planned budget; one occurrence of on time and 5 times on-budget completion;1-20% time overrun occurred 5 times while 1-20% cost overrun occurred 5 times as well; in this category, no occurrence of any time and cost overrun beyond 20% observed.

In the last but not the least category of respondents who were involved in road projects above ten (10), the researchers noted the following: only 1-20 % time overrun occurred while cost overrun was still 1-20%; there was no other occurrence of time and cost overruns recorded in the rest of the cases.

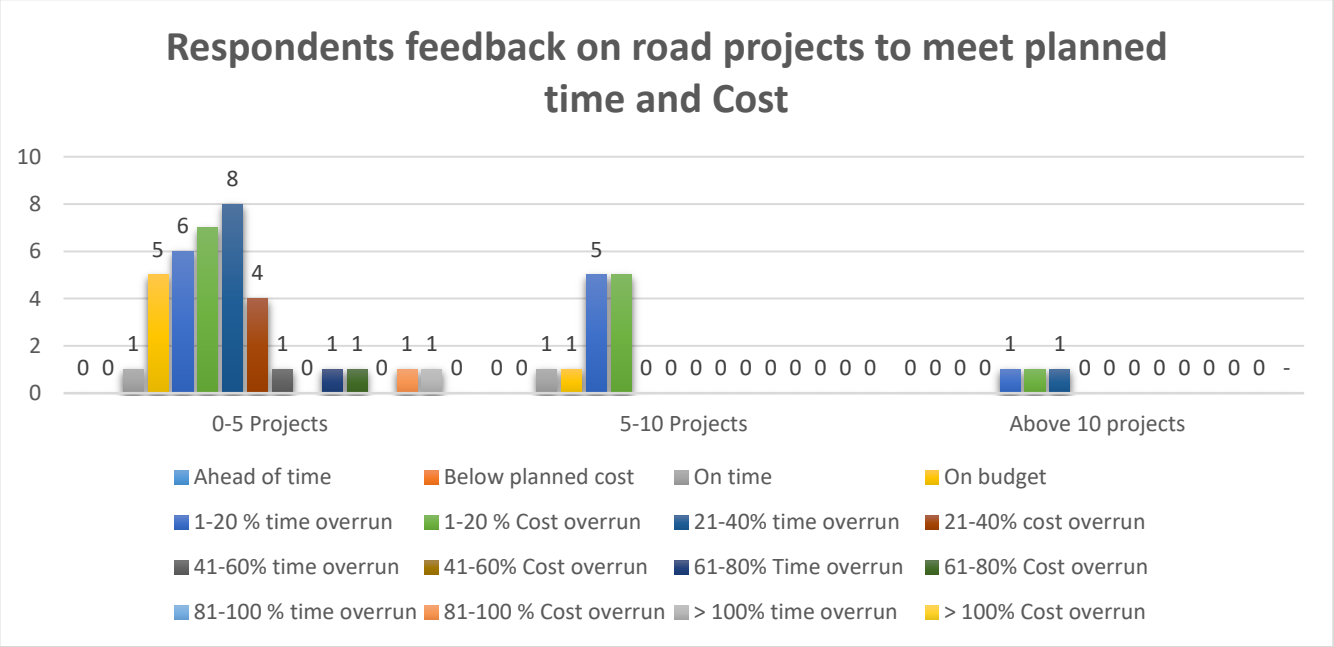

Figure 4-5 Level of time and cost overruns in the road construction industry

4.3 Analysis of road project delays (time overruns) in road construction in Rwanda

To attain his objectives, through the desk study and secondary data collection, the researcher identified the eventual causes of time and cost overruns from the literature review and project documents of the six projects from Kigali City. Then, the eventual causes were included in the researcher's questionnaire and respondents were requested to give their opinion on the significance of

the time overrun (delay) client/funder/Employer's factors, consultant factors, contractors' factors as well as external factors in road construction projects in Rwanda. Factors rank: 1=Not significant, 2 =Low significant ,3 =Uncertain, 4+ significant and 5=Very significant.

4.3.1 Client/funder/employer's factors for time overrun in road construction projects

The researcher sought to identify and analyze the Employer/client/Funder's causes for time overrun (Delays) in road construction in Rwanda. Ten client-related factors were analyzed and ranked by the RII method and the findings are presented in table 4.1 and figure. The relative importance index, RII, was determined for each cause to identify the most significant causes. Higher the value of RII, more important is the cause of time overrun (delay). The findings revealed that delay in land acquisition for right-of-way (Expropriation) with RII=0.854 (important level: High) is the most factor of time overrun in road construction in Rwanda. Delays in relocating the existing utilities (water, electrical, telecommunication) were ranked as the second factor with RII=0.800 (important level: High), The third factor is the additional works not envisaged in the original scope with RII=0.735 (important level High-Medium), the fourth factor with RII= 0.708 (Level: H-M), is the Client budget constraints/Delays in payment by the client that leads to the contractor's cash flow fluctuations. On firth rank, we have two factors with the same RII=0.692 which are variation works and delay in decision making by client. The seventh factor with RII= 0.653 is the underestimation of the initial duration. The 8^{th} factor with RII=0.646 is the employer's order to change the design. Suspension of works due to shortage of funds by an employer was ranked as the 9^{th} factor with RII=0.523. The last but not the least cause is the delay in service order provision/commencement letter by the employer.

Table 4.4 Respondents' views on Employers' causes for time overrun in road construction in Rwanda

#	Employer/Client/ Funder causes	Respondents	1=Not significant	2 =Low significant	3=Uncertain	4=Significant	5=Very significant	N	RII	Rank	Level
		Factor Rank	**1**	**2**	**3**	**4**	**5**				
1	Additional works not envisaged in the original scope	n	1	5	5	5	10	26	0.738	**3**	**H-M**
	Frequency (%)	%	4%	19%	19%	19%	38%	100%			
2	Variation works	n	1	5	6	9	5	26	0.692	**5**	**H-M**
	Frequency (%)	%	4%	19%	23%	35%	19%	100%			
3	Employer's orders to change the design	n	0	10	5	6	5	26	0.646	**8**	**H-M**
	Frequency (%)	%	0%	38%	19%	23%	19%	100%			
4	Delay in relocating the existing utilities (water, electrical, telecommunication)	n	1	4	2	6	13	26	0.800	**2**	**H**
	Frequency (%)	%	4%	15%	8%	23%	50%	100%			
5	Delay in land acquisition for right-of-way (Expropriation)	n	0	2	2	9	13	26	0.854	**1**	**H**
	Frequency (%)	%	0%	8%	8%	35%	50%	100%			
6	Delay in service order provision/commencement letter by employer/client	n	7	12	4	2	1	26	0.431	**10**	**M**

	Frequency (%)	%	27%	46%	15%	8%	4%	100%			
7	Client budget constraints/Delays in payment by the client that leads to the contractor's cash flow fluctuations	n	1	7	1	11	6	26	0.708	**4**	**H-M**
	Frequency (%)	%	4%	27%	4%	42%	23%	100%			
8	Suspension of works due to the shortage of funds by Employer	n	7	5	8	3	3	26	0.523	**9**	**M**
	Frequency (%)	%	27%	19%	31%	12%	12%	100%			
9	Underestimation of the initial duration	n	1	7	5	10	3	26	0.654	**7**	**H-M**
	Frequency (%)	%	4%	27%	19%	38%	12%	100%			
10	Delay in decision making	n	2	3	7	9	5	26	0.692	5	**H-M**
	Frequency (%)	%	8%	12%	27%	35%	19%	100%			

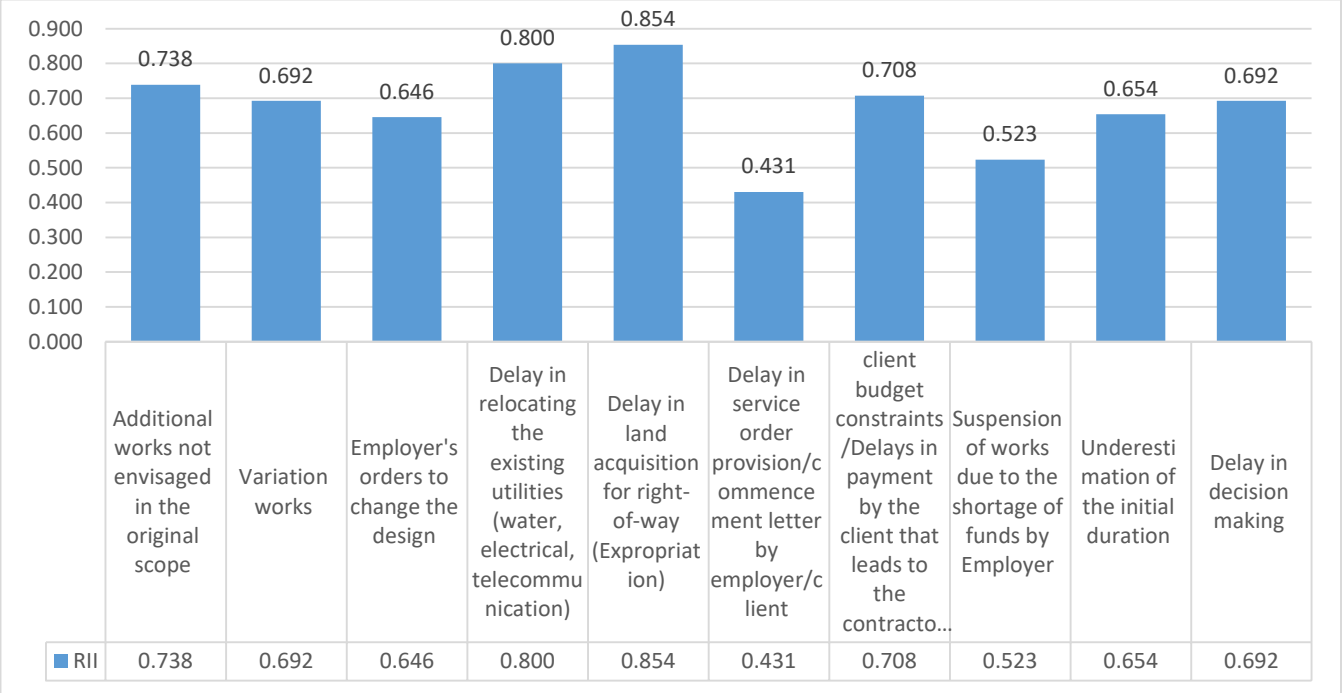

Figure 4-6 Employer/Client /Funder's causes ranking

4.3.2 Consultants' factors for time overrun in Road construction projects

Eleven causes of time overrun associated with consultant were analyzed and ranked by the RII method and results are presented in Table 4.2. As it is seen in Figure 4.2, the most consultant's factor causing time overrun on road construction in Rwanda is the underestimation of the initial duration and lack of time contingency while estimating the project duration with RII=0.654 at high-medium importance level, the second factor is the changes in designs with RII=0.646 (Level: H-M), the third factor is the design complexity/lack of design detail/delay in issuing details to the contractor with RII=0.569 (Medium), the 4th factor is the delayed approvals of the submittals by a consultant with RII=0.546 (Medium level), the 5th cause is the lack of experience if the consultant personnel with RII=0.531(Medium), the 6th is the consultant's lack of expertise in road design and supervision and delay in issuing interim payment certificate, the 8th cause is the consultant's poor communication,9th is the consultant's instruction to delay works,10th is the consultant not cooperative to the contractor and last but not the least is the suspension of work by a consultant.

Table 4. 5 Respondents' views on Consultants' causes for time overrun in road construction in Rwanda

#	CONSULTANT'S CAUSES	RESPONDENTS	1=NOT SIGNIFICANT	2 =LOW SIGNIFICANT	3 =UNCERTAIN	4=SIGNIFICANT	5=VERY SIGNIFICANT	N	RII	RANK	Level
		Scale	1	2	3	4	5				
1	Changes in the designs	n	1	6	8	8	3	26	0.646	2	**H-M**
	Frequency (%)	%	4%	23%	31%	31%	12%	100%			
2	Delay in issuing the IPC by Consultant	n	3	13	5	5	0	26	0.492	6	**M**
		%	12%	50%	19%	19%	0%	100%			
3	Underestimation of the initial duration and Lack of time contingency while estimating the project duration	n	2	7	3	10	4	26	0.654	1	**H-M**
		%	8%	27%	12%	38%	15%	100%			
4	Delayed approvals of the submittals by consultant	n	2	12	6	3	3	26	0.546	4	**M**
		%	8%	46%	23%	12%	12%	100%			
5	Consultant not cooperative to the contractor	n	5	11	7	3	0	26	0.462	10	**M**
		%	19%	42%	27%	12%	0%	100%			
6	Consultant's instruction to delay works	n	9	7	4	4	2	26	0.469	9	**M**
		%	35%	27%	15%	15%	8%	100%			
7	Consultant personnel not experienced	n	5	7	8	4	2	26	0.531	5	**M**
		%	19%	27%	31%	15%	8%	100%			

8	Suspension of work by Employer/consultant	n	10	8	7	1	0	26	0.392	11	**M-L**
		%	38%	31%	27%	4%	0%	100%			
9	Consultant's lack of expertise in road design and supervision	n	6	9	5	5	1	26	0.492	6	**M**
		%	23%	35%	19%	19%	4%	100%			
10	Design complexity/lack of design detail/delay in issuing details to the contractor	n	3	9	5	7	2	26	0.569	3	**M**
		%	12%	35%	19%	27%	8%	100%			
11	Consultant's Poor communications	n	5	9	9	2	1	26	0.485	8	**M**
		%	19%	35%	35%	8%	4%	100%			

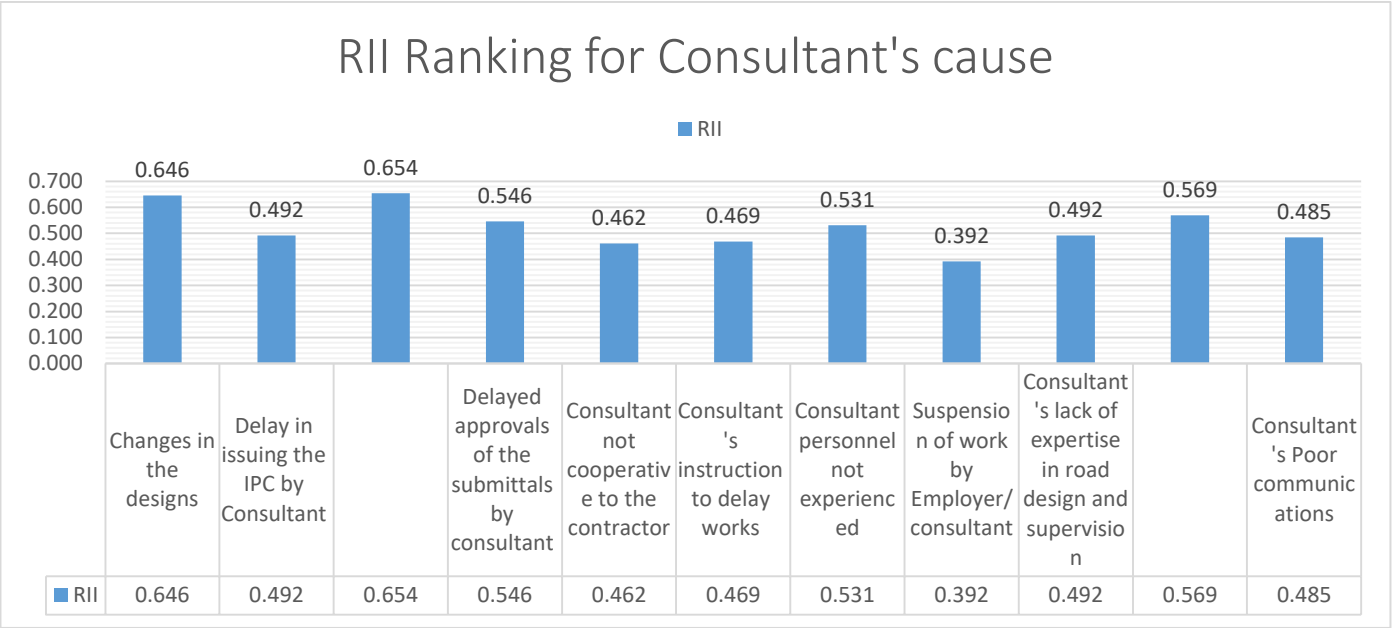

Figure 4-7 Ranking for consultants causes for time overrun

4.3.3 Contractor's factor for time overrun in Road construction projects

Fourteen causes of time overrun in road construction associated with the Contractors' group were analyzed based on the respondents' views. The researcher ranked them in table 4.3 and on figure 4.3 by RII method and the most factor was found to be poor planning by contractor having RII=0738(Level: H-M), the second is the delays/procurement issues by a contractor with RII=0.685 (Level: H-M). The third factor is poor site management by a contractor with RII=0.677 (Level: H-M), the 4th factor is the lack of contractor's capacity due to the procurement method of selecting the lowest bidder which is the most used while selecting contractors. The 5th factor was found to be both contractor's equipment breakdown with delays in attending their repairs and subcontractor's coordination and incompetent problems with RII=0.646. the 7th factor is the delayed submittals by the contractor that lead to delays in approving materials, samples, tests, method statements, and finally delays in procurement and construction. The shortage/lack of equipment by a contractor was ranked number 8. The rest factors from contractor's lack of enough expertise in road construction, poor communication, failure to comply with HSE guidelines which force consultant to instruct to hold the works, suspension of works by contractor, poor quality that leads to demolition and redoing works, and contractor's delay to submit payment invoice were ranked from 9th to 14th.

Table 4. 6: Respondents' views on contractors' causes for time overrun in road construction in Rwanda

#	Contractor's factors	respondents	1=Not significant	2 =Low significant	3 =Uncertain	4=Significant	5=Very significant	N	RII	Rank	Level
		Scale	1	2	3	4	5				
1	Lack of contractor's Capacity /Lowest bidder	n	2	5	7	6	6	26	0.669	4	**H-M**
	Frequency (%)	%	8%	19%	27%	23%	23%	100%			
2	Poor planning by contractor	n	0	3	8	9	6	26	0.738	1	**H-M**
	Frequency (%)	%	0%	12%	31%	35%	23%	100%			
3	Poor site management by contractor	n	0	6	7	10	3	26	0.677	3	**H-M**
	Frequency (%)	%	0%	23%	27%	38%	12%	100%			
4	Shortage/Lack of the equipment by contractor	n	2	7	5	9	3	26	0.631	8	**H-M**
	Frequency (%)	%	8%	27%	19%	35%	12%	100%			
5	Delay/procurement issues	n	0	7	6	8	5	26	0.685	2	**H-M**
	Frequency (%)	%	0%	27%	23%	31%	19%	100%			
6	Contractor's lack of	n	2	8	9	5	2	26	0.577	9	**M**

	enough expertise in road construction										
	Frequency (%)	%	8%	31%	35%	19%	8%	100%			
7	Delayed submittals by contractor	n	1	6	8	9	2	26	0.638	7	**H-M**
	Frequency (%)	%	4%	23%	31%	35%	8%	100%			
8	Suspension of works by contractor	n	3	9	10	3	1	26	0.523	12	**M**
	Frequency (%)	%	12%	35%	38%	12%	4%	100%			
9	Contractor delays to submit payment invoice	n	10	8	8	0	0	26	0.385	14	**M-L**
	Frequency (%)	%	38%	31%	31%	0%	0%	100%			
10	Equipment breakdown and delay in attending their repairs	n	2	6	5	10	3	26	0.646	5	**H-M**
	Frequency (%)	%	8%	23%	19%	38%	12%	100%			
11	Contractor's Poor communication	n	4	8	8	5	1	26	0.531	10	**M**
	Frequency (%)	%	15%	31%	31%	19%	4%	100%			
12	Subcontractors coordination	n	3	6	3	10	4	26	0.646	5	**H-M**

	problems/incompetent subcontractors										
	Frequency (%)	%	12%	23%	12%	38%	15%	100%			
13	Contractor's failure to comply with HSE guidelines force consultant to instruct to hold the works	n	3	9	8	6	0	26	0.531	10	**M**
	Frequency (%)	%	12%	35%	31%	23%	0%	100%			
14	Poor quality that leads to demolition and redoing works	n	5	8	8	3	2	26	0.515	13	**M**
		%	19%	31%	31%	12%	8%	100%			

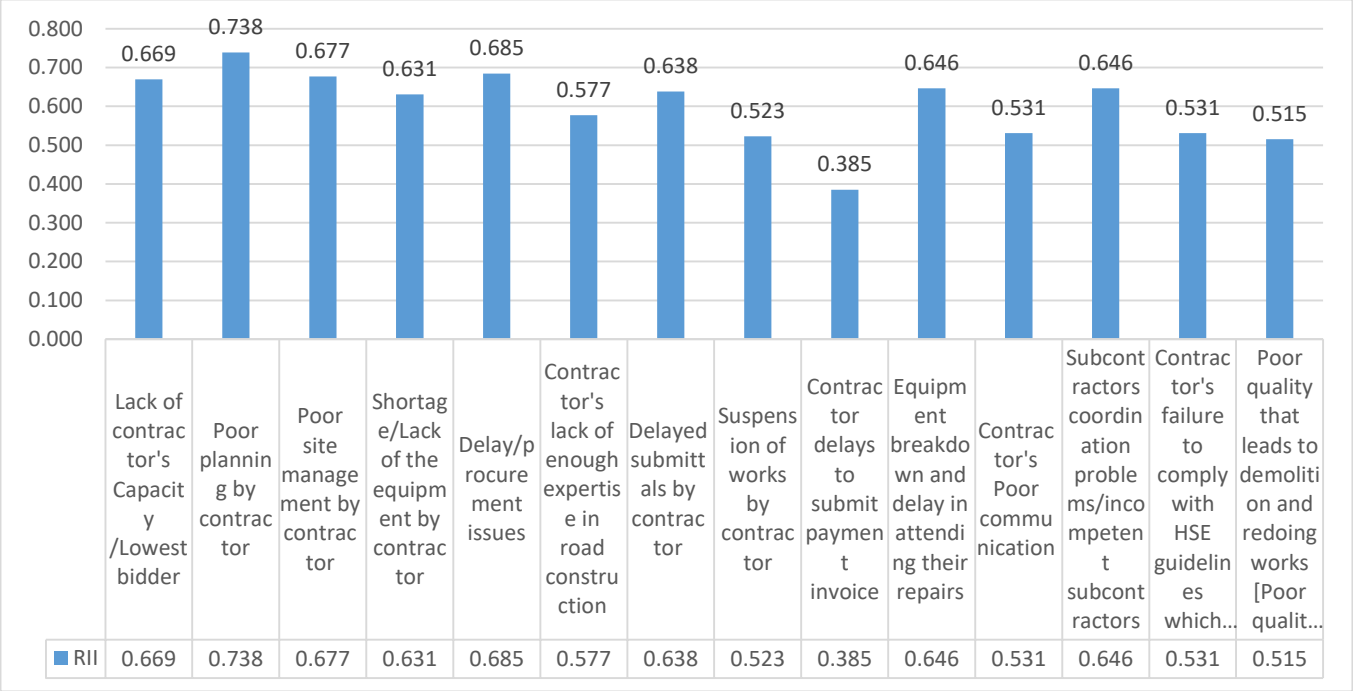

Figure 4-8 Contractors' causes ranking

4.3.4 External factors for time overrun in road construction in Rwanda

The research has revealed that there are other four factors not associated with road project senior stakeholder's groups that negatively affect the road project performance as far as time is concerned. Those external factors were ranked based on respondents' views by using RII Method. Unground seen ground conditions factor was ranked the most critical factors with RII=0754 (Level of importance: H-M), Adverse weather conditions on 2nd rank with RII=0.631 (level: H-M), whereas Force Majeure is ranked on 3rd and traffic management issues during construction the 4th.

Table 4.7 Respondents' views on external causes for time overrun in road construction in Rwanda

#	**External factors for time overrun**	Respondents	**1=Not significant**	**2 =Low significant**	**3 =Uncertain**	**4=Significant**	**5=Very significant**	**N**	**RII**	**Rank**	**Level**
		Scale	**1**	**2**	**3**	**4**	**5**				
1	Unforeseen Ground Conditions	n	0	4	5	10	7	26	0.754	1	**H-M**
	Frequency	%	0%	15%	19%	38%	27%	100 %			
2	Force Majeure	**n**	4	11	2	5	4	26	0.554	3	**M**
	Frequency	%	15%	42%	8%	19%	15%	100 %			
3	Adverse Weather conditions	n	2	6	7	8	3	26	0.631	2	**H-M**
	Frequency	%	8%	23%	27%	31%	12%	100 %			
4	Traffic Management issues during construction	n	3	10	9	2	2	26	0.523	4	**M**
	Frequency	%	12%	38%	35%	8%	8%	100			

	%

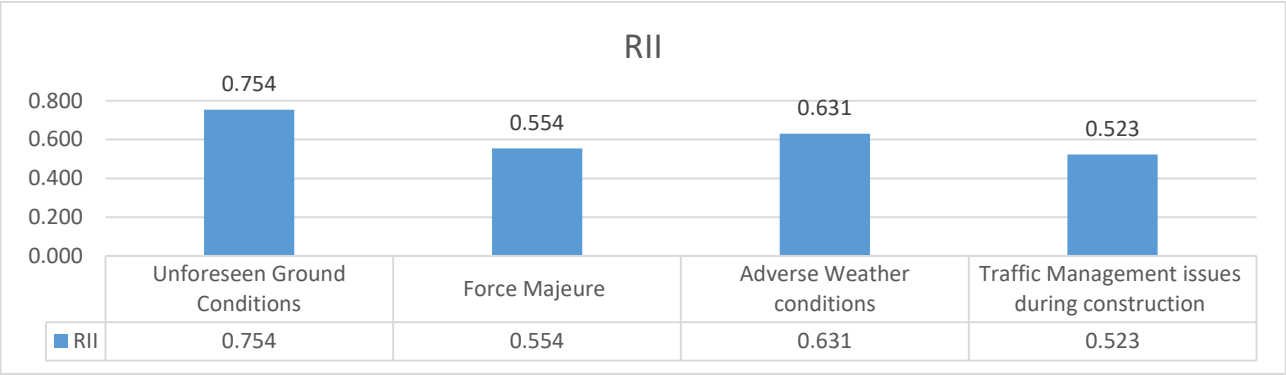

Figure 4-9 External causes ranking

4.3.5 Overall Comparison of group causes of time overrun in road construction

To understand the magnitude at which each causal group (Employers, consultants, contractors, external factors) causes time overruns in road construction in Rwanda, the mean RII of each causal group was calculated and results were presented in table 4.5. The findings revealed that the highest mean RII is 0.674 (with High-medium level of importance) of the employers (Owners, clients) group which implies that employers are on top of causing delays in road construction projects in Rwanda. The external factors with mean RII=0.615 are on the second rank in causing the time overruns whereas contractors and consultants groups are on 3rd and 4th rank respectively.

Table 4.8 Time overrun causal groups comparison

Group factor	*Mean RII*	*Ranking*	*Importance Level*
Employers' causes	0.674	1	High-medium
Consultants' causes	0.522	4	Medium
Contractors' causes	0.599	3	Medium
External causes	0.615	2	High-medium

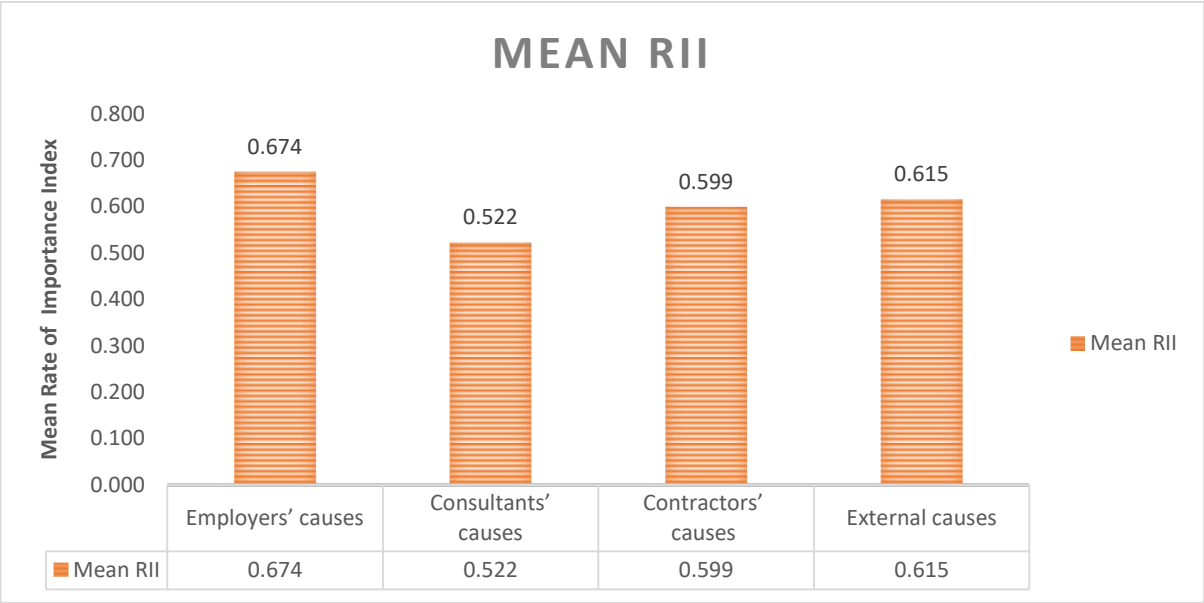

Figure 4-10 Comparison of time overrun causal groups

4.4 Analysis of road project cost overruns in Road construction in Rwanda

4.4.1 Employer's causes of cost overruns in road construction

The findings of this study as presented in table 4.6 and figure 4.11 indicate that delays in land acquisition for right-of-way known as expropriation with RII=0.815 (Level: High) are the most factor that causes cost overruns in road construction. This is because most of the time land acquisition is delayed, the contractors incur excessive delays on projects and are forced to suspend the works until the right-of-way is granted by employers. However, in most cases contractor claims for extension of time and financial cost incurred due to the delays and extension of time which finally lead. The second factor with RII==0.762 (H-M Level) is the additional works not envisaged in the original scope, the 3rd factor is the delayed relocation of the existing utilities with RII=0.738. Variation works are on 4th rank with RII=0.715 (H-M Level) whereas awarding the contract to the lowest bidder with no capacity is ranked 5th with RII=0.685. The other factors such as lack of risk management plan by the client before awarding a tender to the contractor, delays in payment by the client that lead to project delays and price adjustments, lack of cost contingency while estimating the project cost, employers' orders to change the design, suspension of work due to the shortage of funds by the employer, and work omission by a client are ranked from 6th to 11th respectively.

Table 4. 9 Ranks of Employers causes for cost overruns in road construction in Rwanda

#	*Employer/Client's cost Overrun causes*	*Respondents*	*1=Not significant*	*2 =Low significant*	*3 =Uncertain*	*4=Significant*	*5=Very significant*	*N*	*RII*	*Rank*	*Level*
		Scale	**1**	**2**	**3**	**4**	**5**				
1	Additional works not envisaged in the original scope	n	0	4	3	13	6	26	0.762	2	**H-M**
	Frequency	%	0%	15%	12%	50%	23%	100%			
2	Variation works	n	1	4	4	13	4	26	0.715	4	**H-M**
	Frequency	%	4%	15%	15%	50%	15%	100%			
3	Employer's orders to change the design	n	1	9	6	7	3	26	0.615	9	**H-M**
	Frequency	%	4%	35%	23%	27%	12%	100%			
4	Delay in relocating the existing utilities (water, electrical, telecommunication)	n	1	5	5	5	10	26	0.738	3	**H-M**
	Frequency	%	4%	19%	19%	19%	38%	100%			
5	Delay in land acquisition for right-of-way (Expropriation)	n	0	4	2	8	12	26	0.815	1	**H**
	Frequency	%	0%	15%	8%	31%	46%	100%			
6	Lack of risk management plan by project client prior to award a tender to the contractor	n	0	6	6	13	1	26	0.669	6	**H-M**
	Frequency	%	0%	23%	23%	50%	4%	100%			

7	Delays payment by the client that leads to project delays and Price adjustments	n	1	7	5	9	4	26	0.662	7	**H-M**
	Frequency	%	4%	27%	19%	35%	15%	100%			
8	Lack of Cost contingency while estimating the project cost	n	1	5	12	6	2	26	0.623	8	**H-M**
	Frequency	%	4%	19%	46%	23%	8%	100%			
9	Suspension of works due to the shortage of funds by Employer	n	4	9	6	6	1	26	0.531	11	**M**
	Frequency	%	15%	35%	23%	23%	4%	100%			
10	Work omissions by client	n	4	11	7	3	1	26	0.492	11	**M**
	Frequency	%	15%	42%	27%	12%	4%	100%			
11	Awarding contract to the lowest bidder with no capacity	n	1	5	9	4	7	26	0.685	5	**H-M**
	Frequency	%	4%	19%	35%	15%	27%	100%			

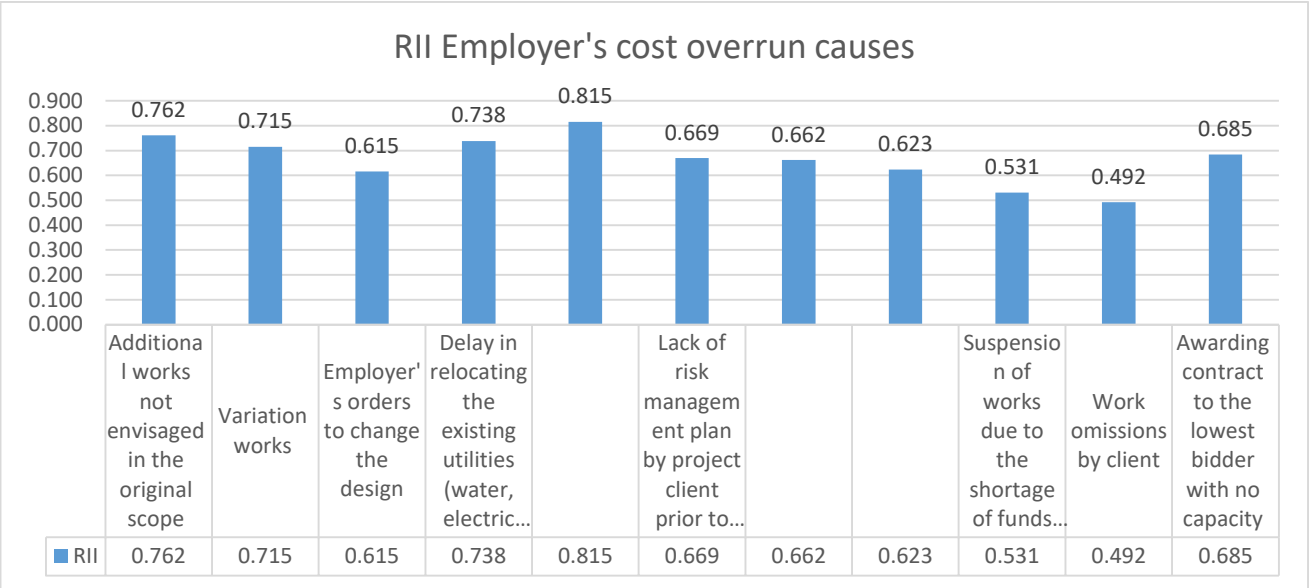

Figure 0-11. Ranks of the Employers' causes for cost overruns in road construction in Rwanda

4.4.2 Consultant's causes of cost overruns in road construction

The findings of the study on consultants' factors causing cost and time overruns were presented in table 4.7 and figure 4.12. With the same Relative Importance Index (RII), the causes were ranked as per their RII values. Poor design/changes in the design done by road design consultants are leading to the cost overruns caused by consultants with RII=0.685 (High Medium level), vagueness, and poor interpretation of the technical specifications during the road construction period was found to be the second factor from the site of consultants with RII=0.631 (High-Medium level). Delayed approvals by consultants, personnel who are not experienced, design complexity and lack of details, poor contract management, lack of expertise in road construction, suspension of work by the consultant were ranked from 3rd to 8th respectively.

Table 4. 10 Ranks of consultants causes for cost overruns in road construction in Rwanda

	Consultants' causes of cost overruns	Respondents	1=not significant	2 =low significant	3 =uncertain	4=significant	5=very significant	N	RII	Rank	Level
#		Scale	1	2	3	4	5				
1	Poor design/Changes in the designs	n	1	6	5	9	5	26	0.685	1	H-M
	Frequency	%	4%	23%	19%	35%	19%	100%			
2	Delayed approvals by consultants	n	0	10	6	7	3	26	0.623	3	H-M
	Frequency	%	0%	38%	23%	27%	12%	100%			
3	Consultant personnel not experienced	n	2	8	5	8	3	26	0.615	4	H-M
	Frequency	%	8%	31%	19%	31%	12%	100%			
4	Suspension of work by consultant	n	4	14	4	3	1	26	0.469	8	H-M
	Frequency	%	15%	54%	15%	12%	4%	100%			
5	Consultant's lack of expertise in road design and supervision	n	2	13	3	5	3	26	0.554	7	M
	Frequency	%	8%	50%	12%	19%	12%	100%			
6	Design complexity/lack of design detail/delay in issuing details to the contractor	n	0	12	4	6	4	26	0.615	4	H-M
	Frequency	%	0%	46%	15%	23%	15%	100%			

7	Poor contract Management by Consultant	n	1	11	5	5	4	26	0.600	6	**H-M**
	Frequency	%	4%	42%	19%	19%	15%	100%			
8	Vagueness and poor interpretation of the technical specifications	n	2	7	6	7	4	26	0.631	2	**H-M**
	Frequency	%	8%	27%	23%	27%	15%	100%			

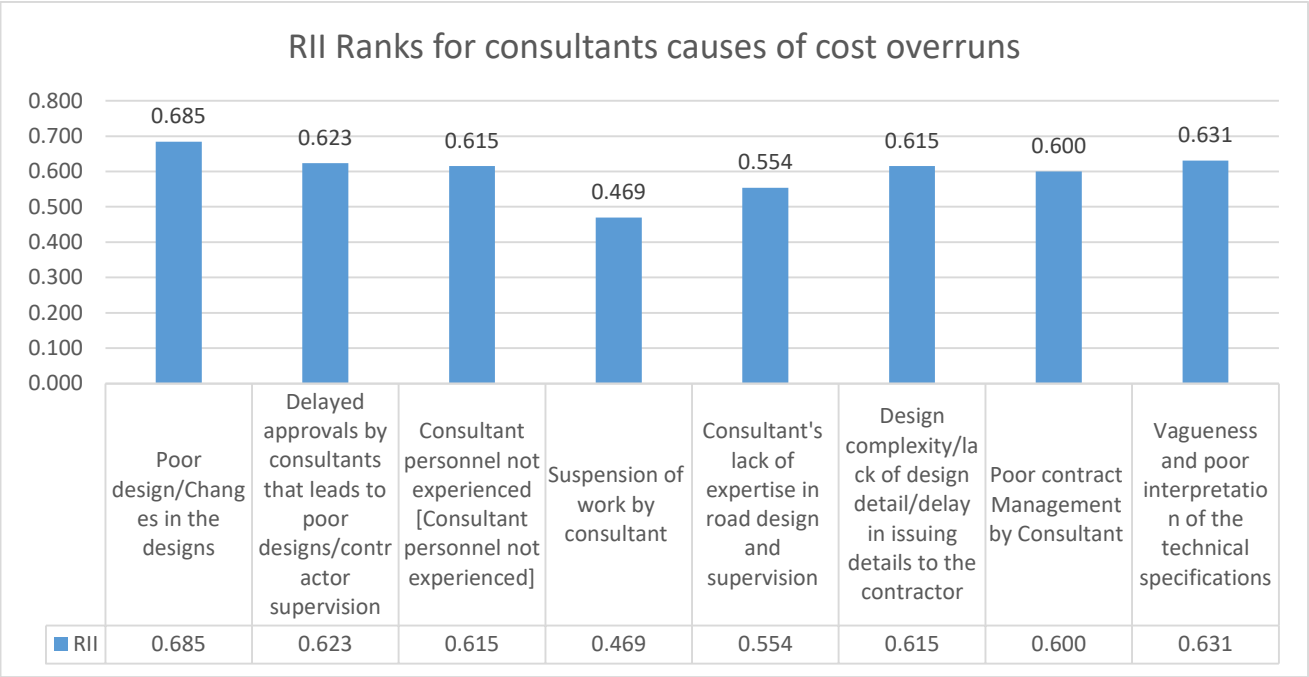

Figure 4-11 Ranks of consultants' causes of cost overrun in road construction

4.4.3 Contractors' causes of cost overruns in road construction

The researcher analyzed respondents' views on contractors' factors that contribute to the cost overruns in the Rwandan road construction sector and the results were presented in table 4.8 and graphical illustration in figure 4.13. With the same method of Relative Importance Index (RII), contractors' factors for cost overruns were ranked. The study findings indicated that contractors' poor planning is ranked first with RII=0.762 (Level: H-M), the second factor is contractors' low productivity with RII=0.754, 3rd factor is the poor pricing during bidding period with RII=0.746 (H-M), 4th factor is poor site management by the contractor with RII=0.715 (H-M level), whereas an increase in cost associated with extension times is ranked number five. The rest factors such as equipment breakdown and delays in attending their repairs, lack of risk management plan, delay/procurement issues, lack of enough expertise in road construction, heavy bank loan interest rates, and charges, delayed submittals, poor quality of work that leads to demolition and redoing works, currency fluctuation issues, suspension of works, delay penalties are ranked from 6th to 15th respectively.

Table 4.11 Ranks of Contractors' causes for cost overruns in road construction in Rwanda

#	***Contractor's causes for cost overruns***	***Respondents***	***1=Not significant***	***2 =Low significant***	***3 =Uncertain***	***4=Significant***	***5=Very significant***	***N***	***RII***	***Rank***	***Level***
		Scale	**1**	**2**	**3**	**4**	**5**				
1	Poor planning by contractor	n	0	2	6	13	5	26	0.762	1	**H-M**
	Frequency	%	0%	8%	23%	50%	19%	100%			
2	Poor site management by contractor	n	0	5	6	10	5	26	0.715	4	**H-M**
	Frequency	%	0%	19%	23%	38%	19%	100%			
3	Currency fluctuation issues	n	0	11	10	4	1	26	0.562	13	**M**
	Frequency	%	0%	42%	38%	15%	4%	100%			
4	Delay/procurement issues	n	1	9	6	6	4	26	0.623	8	**H-M**
	Frequency	%	4%	35%	23%	23%	15%	100%			

5	Contractor's lack of enough expertise in road construction	n	0	9	8	7	2	26	0.615	9	**H-M**
	Frequency	%	0%	35%	31%	27%	8%	100%			
6	Delayed submittals by contractor	n	1	10	6	6	3	26	0.600	11	**HM**
	Frequency	%	4%	38%	23%	23%	12%	100%			
7	Suspension of works by contractor	n	4	8	9	3	2	26	0.531	14	**M**
	Frequency	%	15%	31%	35%	12%	8%	100%			
8	Extension of time	n	0	6	5	10	5	26	0.708	5	**H-M**
	Frequency	%	0%	23%	19%	38%	19%	100%			
9	Equipment breakdown and delay in	n	0	8	5	11	2	26	0.654	6	**H-M**

	attending their repairs										
	Frequency	%	0%	31%	19%	42%	8%	100%			
10	Heavy Bank loan interest rate and charges	n	3	7	7	4	5	26	0.608	10	**H-M**
	Frequency	%	12%	27%	27%	15%	19%	100%			
11	Contractor's delay penalties	n	5	8	7	6	0	26	0.508	15	**M**
	Frequency	%	19%	31%	27%	23%	0%	100%			
12	Poor pricing during bidding period	n	2	2	7	5	10	26	0.746	3	**H-M**
	Frequency	%	8%	8%	27%	19%	38%	100%			
13	Lack of risk managemen t plan by contractor	n	0	7	7	10	2	26	0.654	6	**H-M**

	Frequency	%	0%	27%	27%	38%	8%	100%			
14	Poor quality of work that lead to demolition and redoing works	n	0	10	9	5	2	26	0.592	12	**M**
	Frequency	%	0%	38%	35%	19%	8%	100%			
15	Contractor's low productivity	n	0	3	6	11	6	26	0.754	2	**H-M**
	Frequency	%	0%	12%	23%	42%	23%	100%			

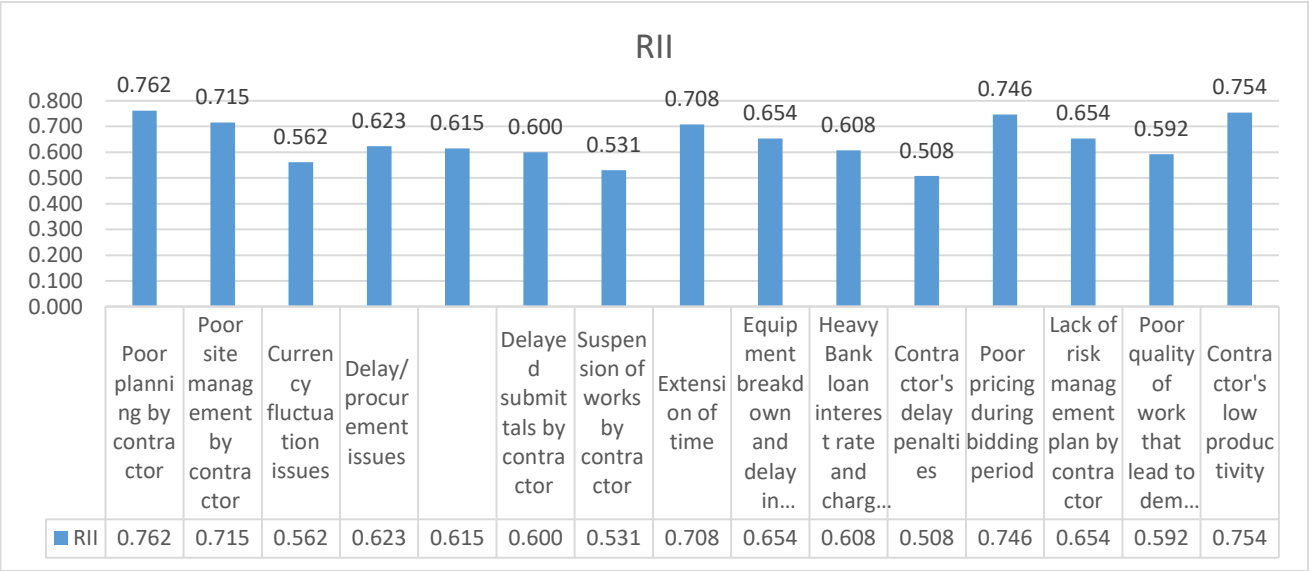

Figure 0-13 Ranks of contractors' causes of cost overrun in road construction

4.4.4 External factors for cost overrun in road construction in Rwanda

The respondents' views on the external causes for cost overruns in the road construction project are presented in table 4.9. As illustrated in figure 4.14, the leading factor in this group is the unforeseen ground conditions with RII=0.685 (Level: H-M), followed by adverse weather conditions on 2nd rank with RII=0.608 (H-M level). Force majeure and traffic management issues during construction are ranked 3rd and 4th respectively.

Table 4.12 Respondents' views on external causes for time overrun in road construction in Rwanda

#	*External factors for cost overrun*	*Respondents*	*1=Not significant*	*2 =Low significant*	*3 =Uncertain*	*4=Significant*	*5=Very significant*	*N*	*RII*	*Rank*	*Level*
		Scale	**1**	**2**	**3**	**4**	**5**				
1	Unforeseen Ground Conditions	n	3	3	5	10	5	26	0.685	1	**H-M**
	Frequency	%	12%	12%	19%	38%	19%	100%			
2	Force Majeure	n	2	11	6	4	3	26	0.562	3	**M**
	Frequency	%	8%	42%	23%	15%	12%	100%			
3	Adverse Weather conditions	n	2	9	3	10	2	26	0.608	2	**H-M**
	Frequency	%	8%	35%	12%	38%	8%	100%			
4	Traffic Management issues during construction	n	3	10	9	4	0	26	0.508	4	**M**
	Frequency	%	12%	38%	35%	15%	0%	100%			

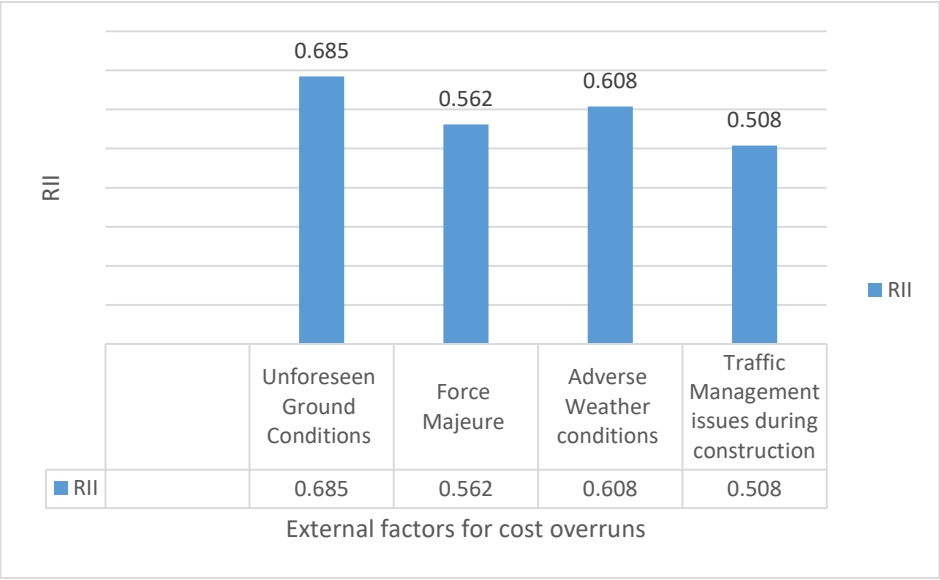

Figure 0-14 Ranking external factors for cost overrun in road construction

4.4.5 Overall comparison of group causes of cost overrun in road construction

To understand the magnitude at which each causal group (Employers, consultants, contractors, external factors) causes cost overruns in road construction in Rwanda, the mean RII of each causal group was calculated and results were presented in table 4.10. The findings revealed that the highest mean RII is 0.664 of the employers (Owners, clients) group which implies that employers are on top of causing cost overruns in road construction projects in Rwanda. Contractors' factors with mean RII=0.642 are on the second rank in causing the cost overruns whereas consultants and external factors groups are on 3rd and 4th rank respectively.

Table 4.13 Comparison of causal groups for cost overrun in road construction in Rwanda

Group factors	*Mean RII*	*Ranking*	*Level of Importance*
Employers' causes	0.664	1	High-Medium
Consultants' causes	0.599	3	Medium
Contractors' causes	0.642	2	High-Medium
External causes	0.590	4	Medium

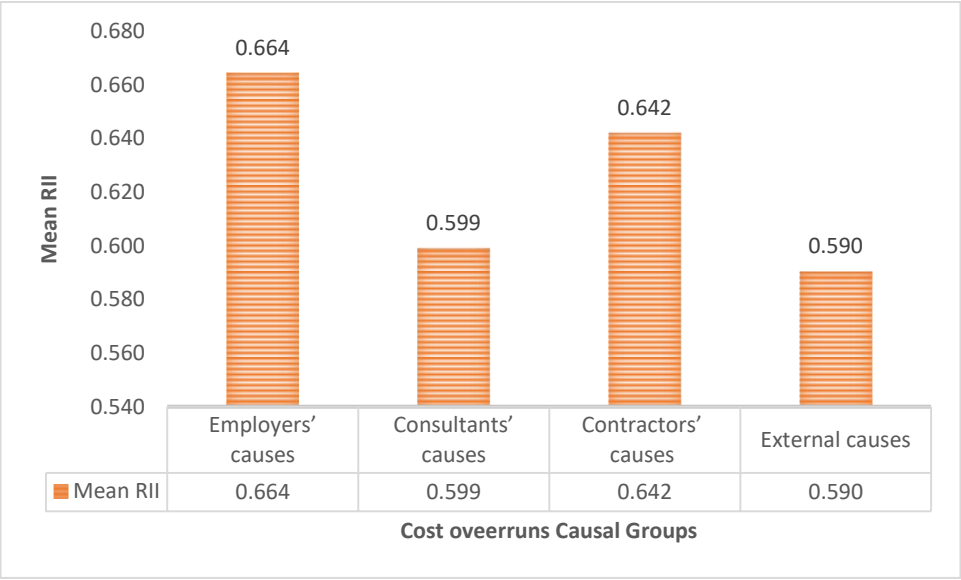

Figure 4.12 Overall cost overruns causal group ranking

4.5 Findings on time and cost overruns in road construction industry

Survey results on the level of time and cost overruns in the Road construction industry substantiates the existence of the critical issues of delays (time overrun) and cost overruns in road construction projects in Rwanda. Thus, the researcher was able to answer the first question of his research that was asking ***"Does the road construction sector in Rwanda experience time and cost overruns?".*** The answer is yes**,** the road construction sector faces time and costs overrun. Indeed, this justifies the researcher's problem statement and need for this study.

4.6 Reliability Analysis

To analyze the reliability of the survey, Cronbach's Alpha values were calculated. The values obtained for the Employers', Consultants, and Contractors factors of time overruns in road construction are 0.701,0.915, and 0.910 respectively. All values are greater than 0.70 hence all reliable coefficients are acceptable and the internal consistency is excellent.

Cronbach's Alpha values for Employers, consultants, contractors and external factors for cost overrun were calculated as well and 0.837,0.945,0.834, and 0.767 are the values obtained respectively. All values are greater than 0.70 which implies the acceptable reliability and excellent internal consistency of the survey results.

4.7 Relationship between road construction Time (Delays) and Cost Overrun in Rwanda

To assess the relationship between delays and cost overruns in road construction projects in Rwanda, a regression analysis was carried out the researcher. A data set of time and cost overruns of the 15 projects was used. As it is seen in Figure 4.16, a linear relationship exists between time and cost overruns in road construction.

Table 4.14 Road data for time and cost overruns set of 15 projects

	ROAD PROJECT NAME	TIME OVERRUN (%)	COST OVERRUN (%)
1	A	125%	25%
2	B	59%	63%
3	C	497%	57%
4	D	56%	19%
5	E	163%	40%
6	F	77%	5%
7	G	25%	18%
8	H	100%	33%
9	I	37%	17%
10	J	50%	15%
11	K	75%	20%
12	L	7%	0%
13	M	17%	0%
14	N	167%	17%
15	O	120%	20%

Source (RTDA, CoK)

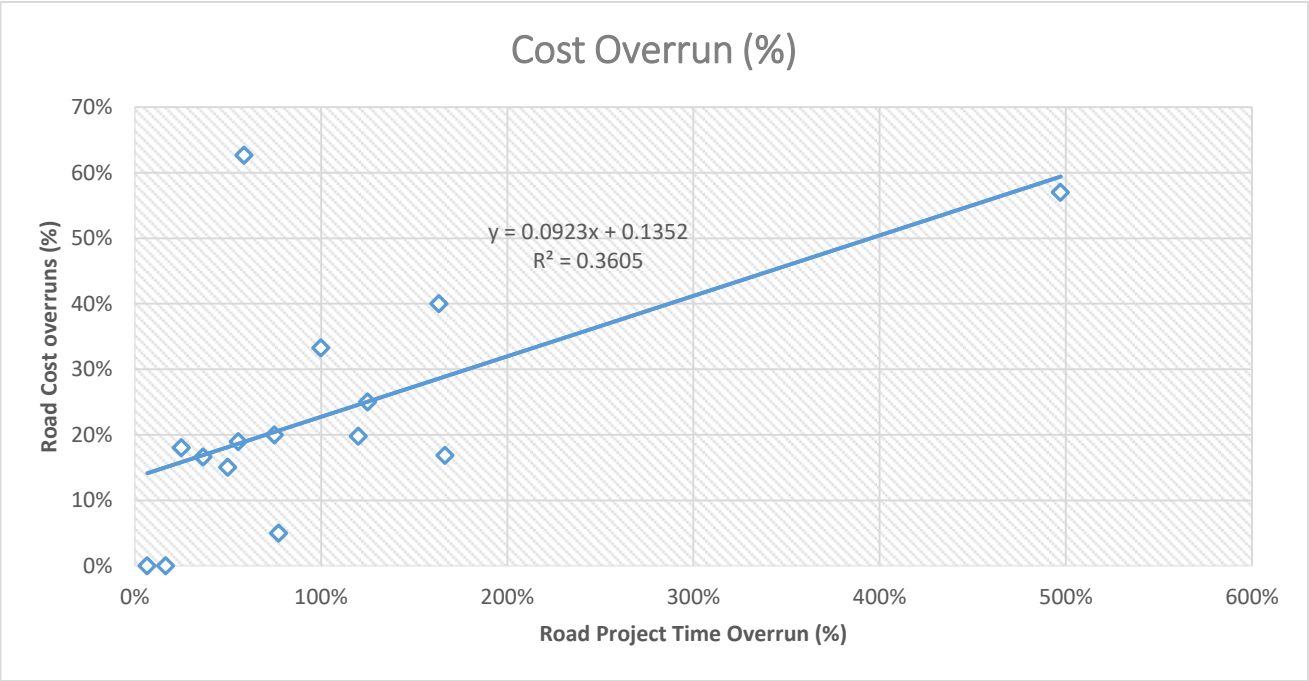

Figure 4-16. Linear regression equation of time and cost overruns in road construction in Rwanda

The linear regression obtained is:

$$y = 0.0923x + 0.1352 \qquad (4.1)$$

Where y is a cost overrun (%) as the dependent variable, x is time overrun (%) as an independent variable.

4.7.1 Interpretation of the linear regression equation

As it is indicated in Table 4.12, the Multiple R is the correlation that measures the strength of a linear relationship between two variables (time and cost overruns). This correlation can be any value between -1 and 1, and its absolute values indicate the relationship strength. The larger the absolute value, the stronger the relationship. For our equation (1), the Multiple R is 0.600, which indicates that there a fair relationship between delays and cost overruns in road construction projects in Rwanda.

R square: is the coefficient of determination, which is used as an indicator of goodness of fit. It shows how many points fall on the regression line. The R2 value is calculated from the total sum of squares, more precisely, it is the sum of the squared deviations of the original data from the mean. For our equation (1), R2 is 0.360, which is means that 36% of our values fit the regression analysis model. In other words, 36% of the dependent variable (cost overruns) are explained by the independent variable (delays). However, this R squared is not good since it is generally considered a good fit when it is 95%. This is because of the limited data (only 15 project data) were used). However, another factor

behind this, is that employers in the Rwandan road construction sector are always government institutions (mainly RTDA, City of Kigali, and Districts) always try to make sure that cost overrun does not exceed 20% of the contract amount (as per national procurement policy) even when the delays have been accumulated beyond 20%. In this case, it is the contractors who suffer from cost overruns since they do not have any option rather than completing the projects at any cost to protect their companies' reputations otherwise they might be blacklisted if they fail to complete the project. The standard error is another goodness of fit measure that shows the precision of the regression analysis. The smaller, the more certain you can be about your regression equation. For our regression equation of time and cost overruns relationship, the standard error is 0.159 which is small, hence the researcher is certain about the regression equation (4.1).

Table 4.15 Regression statistics

Regression Statistics	
Multiple R	0.600
R Square	0.360
Adjusted R Square	0.307
Standard Error	0.159
Observations	14

4.7.2 Analysis of Variance (ANOVA)

The findings from Table 4.13 of the analysis of variance of our regression model between time (delays) and cost overruns in road projects in Rwanda indicate that the significant value in testing the reliability of the relationship model between time (independent variable) and cost overruns (dependent variables) in road construction in Rwanda was **F (1,13) = 6.75, *p*=0.023 (2.3%). As p is less than 5%, the regression model (4.1) is OK.**

Table 4.16 ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.169602	0.169602	6.750	0.023
Residual	12	0.301487	0.025124		
Total	13	0.471089			

Where ***df***: degree of freedom, ***SS***: Sum of squares, ***MS***: mean square, ***F***: F-test for null hypothesis used to test overall significance of the model, and ***significance F***: P-values of F which is OK if less than 0.05 (5%).

4.8 Respondents opinions on adopting Lean Construction in Road construction in Rwanda

As indicated in the table 4.17, among 26 respondents, 58% recommended the adoption of LPD in the road construction industry in Rwanda. 54% of respondents indicated that with LPD, time and cost overrun can be reduced from 1-20%, 26% of respondent believe that LPD can overcome delays and cost overrun from 20-40%, whereas, 15%,4%, and 4% believe that LPD can reduce delays and cost overruns from 20-40%, 60-80%, and 80-100% respectively.

Table 4.17 Respondents' opinions on the recommendation to adopt *LPD* in road construction in Rwanda

Questions	*Respondents*						*N*
Have you ever heard about Lean Construction?	n	18	8				26
Frequency	%	69%	31%				1
If yes, would you recommend road construction industry in Rwanda adopt the Lean Construction Method to mitigate time and cost overruns?		15	11				26
Frequency	%	58%	42%				
If yes, at which % do you think Lean Construction can reduce time and cost overruns in the road construction project in Rwanda?		1-20%	20-40%	40-60%	60-80%	80-100%	
		14	6	4	1	1	26
Frequency	%	54%	23%	15%	4%	4%	100%

CHAPTER FIVE: RESEARCH SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.0 Introduction

This chapter summarizes major findings of this study. It provides answers to the five research questions and recommendation on best road project delivery technique that can be adopted in Rwanda road construction industry to overcome the factors that cause the delays and cost overruns throughout the road construction projects life cycle.

5.1 Summary of the key findings

It is of great importance that road construction senior stakeholders (employer, consultants, and contractors) in Rwanda understand the factors contributing to cost and time overruns in road constructions and their magnitude as well so that they can cope with them towards improving their respective performances while executing their responsibilities in road construction projects. This study revealed the existence of the excessive delays and cost overruns in road construction projects in Rwanda.

Employers' factors were found to be the most contributing to both time and cost overruns in road construction. This is the result of the higher magnitude of employers' responsibilities to name but a few, of delays in land acquisition, relocation of the utilities, additional works, variation works, employers' orders to change the designs, budget constraints that lead to delays in payment which finally cause contractors to incur cash flow fluctuation issues which most of the cases force to suspend works until they are paid. The study revealed that external factors are ranked second in causing delays in road projects due to the higher magnitude of the unforeseen adverse ground conditions that mostly require additional time to carry out additional soil investigations and come up with cost-effective design and construction solutions to cope with these ground conditions. The contribution of the adverse weather conditions also was found to be significant to delays due to their governance in road earthworks and compaction works that form the bigger part of road construction. The contractors are forced to wait for the favorable weather conditions hence the delays are incurred as a result of the adverse weather conditions. Contractors' poor planning, procurement issues, poor site management, low capacity (lowest bidders), incompetent subcontractors and coordination issues, equipment breakdowns were found to be the most contractors' factors that cause delays hence making contractors ranked 3rd in causing the time overruns. Consultants factors were ranked 4th due to the

underestimation and lack of time contingency while estimating the road project duration, changes in the designs, design complexity, and lack of design details that lead to the project delays.

On another hand, contractors' factors were found on 2nd rank in causing cost overruns as a result of top causes regarding poor planning, low productivity, poor pricing during the bidding period, poor site management, an extension of time, and lack of risk management. Consultants' factor was ranked 3rd in causing cost overruns and external factors on 4th.

5.2 Conclusion

In conclusion, this analysis study substantiates the existence of the extreme delays and cost overruns in a road construction project in Rwanda. The findings expressed a linear regression relationship between time and cost overruns in which cost overruns are a function of delays. This implies that, once delays are minimized on road projects, cost overruns do so.

5.3 Recommendations

5.3.1 Moving from traditional project delivery Methods to Lean Design and Construction.

For the road construction industry to mitigate time and cost overruns in the road project, there is an urgent need to move from traditional project contracting and management techniques to relational contracting and management principles. Traditional construction contracts such as Design-bid build, Design-build, EPC, Design-Construction Management, Design-agency CM contracts, Fast track contracts are adversarial as they typically include penalties for the underperformance of non-performance by each party in the project. There are many limitations in traditional contracting structure and relational contracting seeks to address them. These limitations to name but a few: design ideas often lack field input, cooperation and innovation are inhibited, planning systems are not coordinated, self-preservation.

Lean Project Delivery with Integrated Agreement (LPD/IA) is one of the relational project delivery methods that can be adopted in the road construction industry in Rwanda to solve the issues of delays and cost overruns in road construction projects. As the researcher described in detail the lean and construction techniques, the LPD method aims at minimizing /eliminating waste (time, resources, information, cost, etc.) while improving quality and safety throughout the construction process. The traditional project delivery methods anticipate adverse events and focus on transferring risk to other

parties but lean reduce risk by empowering project team stakeholders to use lean thinking and collaborative approaches to problem-solving to enable them to overcome unexpected challenges. The road industry needs to adopt the lean design, lean supply, lean construction by applying lean principles and tools such as BIM to bring together and enhance collaboration among the project team members. Lean construction involves better short-term planning and control that improves the timely completion of job tasks and reduces the variability of work output that tends to happen with traditional project management methods. It emphasizes having a workflow between crews without interruption. With LPD, owners benefit from reduced time and costs as well as improved quality; Consultants and contractors increased profits, owner satisfaction, as well as greater employees' satisfaction.

5.3.2 Recommendations for Future researchers

Due to the limited time, and financial capacity of the researcher, this study did not explore the integration process of LPD in Rwanda, hence the researcher recommends further research on how LPD can be integrated.

REFERENCES

[1] W. F. CHEN and J. Y. RICHARD LIEW, *H A N D B O O K CIVIL ENGINEERING*. 2003.

[2] T. F. Fwa, *The handbook of highway engineering*. Taylor & Francis, 2006.

[3] "7 Years Government Programme: National Strategy for Transformation (NST1)."

[4] NISR, *NATIONAL INSTITUTE OF STATISTICS OF RWANDA REPUBLIC OF RWANDA*. .

[5] G. D. Creedy, M. Skitmore, and J. K. W. Wong, "Evaluation of Risk Factors Leading to Cost Overrun in Delivery of Highway Construction Projects," *J. Constr. Eng. Manag.*, vol. 136, no. 5, pp. 528–537, May 2010, doi: 10.1061/(asce)co.1943-7862.0000160.

[6] N. Al-Hazim and Z. Abusalem, "Delay and cost overrun in road construction projects in Jordan," *Int. J. Eng. Technol.*, vol. 4, no. 2, p. 288, Apr. 2015, doi: 10.14419/ijet.v4i2.4409.

[7] "The World Bank FOR OFFICIAL USE ONLY," 2017.

[8] OAG, "REPORT OF THE AUDITOR GENERAL OF STATE FINANCES FOR THE YEAR ENDED 30 JUNE 2019."

[9] "MONITORING, EVALUATION (M&E) AND THE SUCCESSFUL ROAD PROJECT DELIVERY IN RWANDA A CASE STUDY OF KIGALI SPECIAL ECONOMIC ZONE ROADS BUILT BY NPD-CONTRACO LTD FELICIEN KAYIRANGA MBA/0480/13 A Research Project Submitted in Partial Fulfillment of the Requirement for the Award of Degree of Master of Business Administration (Project Management Option) of Mount Kenya University," 2015.

[10] P. Tuyishime, "UNIVERSITY OF NAIROBI SCHOOL OF THE BUILT ENVIRONMENT FACTORS AFFECTING TIME AND COST PERFORMANCE OF CONSTRUCTION PROJECTS IN RWANDA. A Case Study of High-Rise Building Projects in Kigali."

[11] A. Lester and A. Lester, *Project management, planning and control : managing engineering, construction and manufacturing projects to PMI, APM and BSI standards*. Elsevier/Butterworth-Heinemann, 2007.

[12] M. Vanhoucke, "Project Management with Dynamic Scheduling."

[13] "Project Life Cycle Economics_ Cost Estimation, Management and Effectiveness in

Construction Projects (PDFDrive).”

[14] Project Management Institute and Project Management Institute, *A guide to the project management body of knowledge (PMBOK guide)*. .

[15] R. R. Venkataraman and J. K. Pinto, “COST AND VALUE MANAGEMENT IN PROJECTS.”

[16] S. Francisco, L. JumpStart, and B. J. Jackson, “Construction Management.”

[17] P. P. Shrestha, L. A. Burns, and D. R. Shields, “Magnitude of Construction Cost and Schedule Overruns in Public Work Projects,” *J. Constr. Eng.*, vol. 2013, pp. 1–9, Dec. 2013, doi: 10.1155/2013/935978.

[18] P J. Keane & A.F. Caletka, *Delay Analysis in Construction Contracts*. .

[19] W. Menesi, “Construction Delay Analysis under Multiple Baseline Updates,” 2007.

[20] N. Hamzah, M. A. Khoiry, I. Arshad, N. M. Tawil, and A. I. Che Ani, “Cause of construction delay - Theoretical framework,” in *Procedia Engineering*, 2011, vol. 20, pp. 490–495, doi: 10.1016/j.proeng.2011.11.192.

[21] A. Razzak Rumane, “HANDBOOK OF CONSTRUCTION MANAGEMENT Scope, Schedule, and Cost Control.”

[22] G. D. Oberlender, *Project management for engineering and construction*. McGraw-Hill, 2000.

[23] “Study on Road Infrastructure Costs- Analysis of Unit Costs and Cost Overruns of Road Infrastructure Projects in Africa.” [Online]. Available: www.afdb.org.

[24] “CONSTRUCTION PROJECT MANAGEMENT K K CHITKARA.”

[25] R. J. Martinelli and D. Z. Milosevic, “PROJECT MANAGEMENT TOOLBOX Second Edition.”

[26] Y. Amare, E. T. Quezon, and M. Busier, “Causes of Delays During Construction Phase of Road Projects due to The Failures of Contractor, Consultant, And Employer in Addis Ababa City Road Authority,” *Int. J. Sci. Eng. Res.*, vol. 8, no. 3, 2017, [Online]. Available: http://www.ijser.org.

[27] P. Massimo, *Project Life Cycle Economics_ Cost Estimation, Management and Effectiveness in Construction Projects (PDFDrive)*. Gower Publishing Limited.

[28] A. Griffith and P. Watson, “Construction Management Principles and Practice.”

[29] L. H. Forbes and S. M. (Syed M. Ahmed, *Modern construction : lean project delivery and integrated practices*. CRC Press, 2011.

[30] M. J. Wodalski, B. P. Thompson, G. Whited, and A. S. Hanna, “Applying Lean Techniques in the Delivery of Transportation Infrastructure Construction Projects CFIRE Principal Investigator,” 2011.

[31] “Essentials of Research Design and Methodology TEAM LinG-Live, Informative, Non-cost and Genuine !”

[32] C. R. Kothari, *Research methodology : methods & techniques*. New Age International (P) Ltd, 2004.

[33] Leavy and Patricia, “Research Design: Quantitative, Qualitative, Mixed Methods, Arts-Based, and Community-Based Participatory Research Approaches.”

[34] O. P. Akadiri, “Development of a multi-criteria approach for the selection of sustainable materials for building projects,” *PhD Thesis - Univ. Wolverhampt.*, pp. 1–437, 2011, [Online]. Available: http://wlv.openrepository.com/wlv/bitstream/2436/129918/1/Akadiri_PhD thesis.pdf.

LIST OF APPENDICES

QUESTIONNAIRE

SECTION 1: GENERAL INFORMATION ABOUT RESPONDENT:

a. Names (optional): ……

b. Mobile/WhatsApp contact number: (optional) ……

c. Email Address: (optional) …….

d. Organization: **(optional)**…….

SECTION 2: EDUCATION AND POSITION OF RESPONDENT

e. What is your education level

☐ Diploma

☐Bachelor's Degree

☐Post Graduate Diploma

☐ Masters Degree

☐PhD

f. What is your position

☐ Project Director

☐Project Manager/Contract Manager/Claim Manager

☐Construction Manager

☐ Site Engineer

☐Business Development Manager

☐Cost controller/ Quantity Surveyor/Senior QS/Chief QS

☐Material Engineer

☐ Pavement Engineer

☐Design Engineer

☐Post Graduate Diploma

☐Other (Kindly specify) ……

SECTION 3: RESPONDENT EXPERIENCE IN RWANDAN ROAD CONSTRUCTION INDUSTRY

g. How long have you been working in Rwandan Road Construction?

☐0-5 years

☐6-10 years

☐ 11-15 years

☐More than 15 years

h. How long have you been working in Rwandan road construction industry specifically in the City of Kigali?

☐0-5 years

☐5-10 years

☐ 10-15 years

☐15-20 years

☐Above 20 years

i. How many road projects have you been involved in the City of Kigali?

☐0-5 projects

☐5-10 projects

☐ above 10 projects

j. How many (in percentage) projects you were involved were completed on time? (What was time overrun in %?)

☐ Ahead of time

☐on time

☐1-20 % time overrun

☐ 21-40%-time overrun

☐41-60%-time overrun

☐61-80%-time overrun

☐81-100%-time overrun

☐ >100%-time overrun

k. At which % the projects you were involved were completed within the planned budget?

☐ Below the planned budget

☐on budget

☐1-20 % cost overrun

☐ 21-40% cost overrun

☐41-60%-cost overrun

☐61-80%-cost overrun

☐81-100%-cost overrun

☐ >100%-cost overrun

SECTION 4: FUNDER/EMPLOYER'S TIME OVERRUN CAUSES

Please give your opinion on the significance of the following time overrun (delay) client/funder/Employer's factors in road construction projects in Rwanda. Factors rank: 1=Not significant, 2 =Low significant ,3 =Uncertain, 4+ significant and 5=Very significant

1. Additional works not envisaged in the original scope

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

2. Variation works
   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

3. Employer’s orders to change the designs
   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

4. Delay in relocating the existing utilities (Water, electrical, telecommunication service lines)
   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

5. Delay in land acquisition for right-of-way (Expropriation)
   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

6. Delay in service order provision/commencement letter by employer/client

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

7. Client budget constraints /delays in payment by client that lead to the contractors' cash flow fluctuations
   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

8. Suspension of works due to the shortage of funds by Employer
   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

9. Underestimation of the initial duration
   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

10. Delay in decision making
    ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

SECTION 5: CONSULTANT TIME OVERRUN CAUSES

Please give your opinion on the significance of the following time overrun (delay) Consultant's factors in road construction projects in Rwanda. Factors rank: 1=Not significant, 2 =Low significant ,3 =Uncertain, 4+ significant and 5=Very significant

1. Change in the designs

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

2. Delay in issuing the IPC by Consultant

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

3. Underestimation of the initial duration and lack of time contingency while estimating the project duration

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

4. Delayed approvals of the submittals by consultant

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

5. Consultants not cooperative to the contractors

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

6. Consultants' instruction to delay works

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

7. Consultant personnel not experienced

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

8. Suspension of work by employer/consultant

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

9. Consultants' lack of expertise in road design and supervision

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

10. Design complexity/lack of design details/delays in issuing details to the contractor

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

11. Consultants poor communication

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

SECTION 6: CONTRACTORS' TIME OVERRUN CAUSES

Please give your opinion on the significance of the following time overrun (delay) Consultant's factors in road construction projects in Rwanda. Factors rank: 1=Not significant, 2 =Low significant ,3 =Uncertain, 4+ significant and 5=Very significant

1. Lack of contractors' capacity/lowest bidder

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

2. Poor planning by contractor

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

3. Poor site management by contractor

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

4. Shortage/lack of the equipment by contractor

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

5. Delay/procurement issues

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

6. Contractors' lack of enough expertise in road construction

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

7. Delayed submittals by contractor

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

8. Suspension of works by contractor

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

9. Contractors delays to submit payment invoice

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

10. Equipment breakdown and delays in attending their repairs

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

11. Contractors' poor communication

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

12. Subcontractors coordination problems/incompetent subcontractors

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

13. Contractors failure to comply with HSE guidelines which force the consultant to instruct to hold the works

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

14. Poor quality that leads demolition and redoing works

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

SECTION 7: THIRD PARTY'S/EXTERNAL TIME OVERRUN CAUSES

Please give your opinion on the significance of the following time overrun (delay) Consultant's factors in road construction projects in Rwanda. Factors rank: 1=Not significant, 2 =Low significant ,3 =Uncertain, 4+ significant and 5=Very significant

1. Unforeseen ground conditions

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

2. Force Majeure

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

3. Adverse weather conditions

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

4. Traffic management issues during construction

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

SECTION 8: FUNDERS/EMPLOYERS' COST OVERRUN CAUSES

Please give your opinion on the significance of the following time overrun (delay) Consultant's factors in road construction projects in Rwanda. Factors rank: 1=Not significant, 2 =Low significant ,3 =Uncertain, 4=significant and 5=Very significant

1. Additional works not envisaged on the original scope

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

2. Variation works

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

3. Employers' orders to change the design

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

4. Delays in relocating the existing utilities (water, electrical, telecommunications lines)

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

5. Delays in land acquisition for right-of-way (Expropriation)

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

6. Lack of risk management plan by client prior to award a tender to the contractor

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

7. Delays payment by client that lead to the project delays and price adjustments

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

8. Lack of cost contingency while estimating the project cost

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

9. Suspension of works due to the shortage of funds by employer

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

10. Clients' instruction to change the designs

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

11. Works omissions by client

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

12. Awarding contract to the lowest bidder with no capacity

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

SECTION 9: CONSULTANTS' COST OVERRUN CAUSES

Please give your opinion on the significance of the following time overrun (delay) Consultant's factors in road construction projects in Rwanda. Factors rank: 1=Not significant, 2 =Low significant ,3 =Uncertain, 4=significant and 5=Very significant

1. Poor design/changes in the designs

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

2. Delayed approvals by consultants that lead to poor designs/contractor supervision

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

3. Consultant personnel not experienced

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

4. Suspension of work by consultant

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

5. Consultants' lack of expertise in road design and supervision

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

6. Design complexity/lack of design details/delay in issuing details to the contractor

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

7. Poor contract management by consultant

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

8. Vagueness and poor interpretation of the technical specifications

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

SECTION 10: CONTRACTORS' COST OVERRUN CAUSES

Please give your opinion on the significance of the following time overrun (delay) Consultant's factors in road construction projects in Rwanda. Factors rank: 1=Not significant, 2 =Low significant ,3 =Uncertain, 4=significant and 5=Very significant

1. Poor planning by contractor

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

2. Poor site management by contractor

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

3. Currency fluctuation issues

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

4. Delays/procurement issues

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

5. Contractors' lack of enough expertise in road construction

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

6. Delayed- submittals by contractors

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

7. Suspension of works by contractor

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

8. Extensions of time

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

9. Equipment breakdowns and delays in attending their repairs

   ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

10. Heavy bank loan interest rate and charges

    ☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

11. Contractors delay penalties

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

12. Poor pricing during bidding period

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

13. Lack of risk management plan by contractors

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

14. Contractors' low productivity

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

SECTION 11: THIRD PARTY's/ EXTERNAL COST OVERRUN CAUSES

Please give your opinion on the significance of the following time overrun (delay) Consultant's factors in road construction projects in Rwanda. Factors rank: 1=Not significant, 2 =Low significant ,3 =Uncertain, 4=significant and 5=Very significant

1. Unforeseen ground conditions

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

2. Force Majeure

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

3. Adverse weather conditions

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

4. Traffic management issues during construction

☐ 1=Not significant ☐2=Low significant ☐3=Uncertain ☐ 4=Significant ☐5=Very significant

SECTION 12: RECOMMENDATIONS

a. Have you ever heard about Lean Construction?

☐ Yes

☐No

b. If yes, would you recommend road construction industry in Rwanda to adopt Lean Construction Method to mitigate time and cost overruns?

☐ Yes

☐No

c. If yes, at which % do you think Lean Construction can reduce time and cost overruns in road construction project in Rwanda?

☐ 1-20%

☐20-40%

☐ 40-60%

☐60-80%
