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# IMPLEMENTATION OF TIME MANAGEMENT TECHNIQUES IN HIGHWAY PROJECTS FOR IMPROVED PERFORMANCE: CASE STUDY IN RWANDA TRANSPORT DEVELOPMENT AGENCY (RTDA)

**A THESIS**

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*Submitted in partial fulfillment of the requirements for the award of*

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## CERTIFICATE

This is to certify that the Thesis Work entitled **"Implementation of Time Management Techniques in Highway Projects for Improved Performance: Case Study in Rwanda Transport Development Agency (RTDA)"** is a record of the original bonifide work done by **KABURAME UMUGWANEZA Providence (Reg. No: 217302467)** in partial fulfilment of the requirement for the award of Master of Science Degree in Highway Engineering and Management of College of Science and Technology during the academic year 2016-2017.

13th June 2017

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## DECLARATION

I hereby declare that the thesis entitled **"Implementation of Time Management Techniques in Highway Projects for Improved Performance: case study in Rwanda Transport Development Agency (RTDA)"** 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, Associate ship, Fellowship of similar other titles. It has not been submitted to any other University or Institution for the award of any Degree or Diploma.

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## BONIFADE CERTIFICATE

Certified that this thesis titled **"Implementation of Time Management Techniques in Highway Projects for Improved Performance: Case Study in Rwanda Transport Development Agency (RTDA)"**is the bonafide work of **KABURAME UMUGWANEZA Providence Reg. No 217302467** who carried out the research under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion for this or any other candidate.

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## ABSTRACT

Road Construction Industry is an essential component for driving the economy of any country. The number of road construction projects is increasing from time to time in Rwanda. However, it becomes difficult to complete projects in the allocated cost and time. Taking this into consideration, time overrun is one of the major problems Rwanda road projects encountered. **Effective time management** is very important in determining a success of any project. Thus, without proper controlling of time will cause project delay and consequently budget overrun. There are various techniques and software which can be adopted for controlling time in construction projects. Therefore, the aim of this research is the implementation of effective Time Management Techniques in Highway Projects in Rwanda for improving performance, through the identification of Critical Success Factors and Provision of an appropriate Guidance. In order to achieve that aim a detailed literature review was conducted, both Time Management Techniques and Critical Success Factors (CSF) associated with the effective use and implementation of Time Management Techniques for Highway Projects in Rwanda were identified. Therefore time management tools and techniques identified through the literature are CPM, PERT, GERT, Gantt charts, simulation, milestone charts, and variance analysis, project management software, and Precedence Network Diagram together with a total of seventy-six factors influencing construction project delivery time either positively or negatively grouped into twelve major headings namely: The client's understanding of the design, procurement, and construction processes; Quality management during design; Quality management during construction; Management techniques used for planning and control; Economic policy; Constructability of design; Site ground conditions; Motivation of staff; Management style; Site access; Physical environment considerations, and Socio-political considerations.

Afterward a designed questionnaire for ***preliminary survey*** was distributed to the selected Road construction stakeholders and all aforementioned factors and time management techniques were ranked according to ***the computed relative importance indices***. The most and least important performance factors, categories of factors, and time management tools are also achieved according to these rankings.

The findings from preliminary survey (10 criteria) corresponding to the two (2) alternatives such as Time Management Techniques and critical success factors in term of time management, served to determine new set of criteria to be used for construction of Framework for evaluating, ranking and compare those two alternatives for ***second survey using Fuzzy Vikor Method.***

This survey (Fuzzy VIKOR Questionnaire) prioritized these critical factors and tools and investigated the interdependent relationship between the alternatives. By the Best Non Fuzzy Performance (BNP) value, the highest influential performance criteria for implementation of time management techniques in highway projects for improved performance were computed. According to all responses from experts in road construction projects, Time Management Techniques is the most important alternatives with respect to the project performance compared to the Critical Success Factors with time management as it has been ranked the first; and the following factors; Client understanding of Design, Procurement, and Construction Process, Techniques for Planning and Control (Critical Path Method CPM), Gantt Chart, Quality of Management During Construction , Management Style and Economic policy are the highest influential factors for improving highway projects performance.

The findings of this study imply that Critical Path Method (CPM) is an effective tool for project managers to improve highway project performance in term of time delivery and as well Client understanding of Design, Procurement, and Construction Process, is the most influential factor for improving highway projects performance**.**

Further the appropriate project management practice and training for successful execution of Highway Projects in Rwanda Transport Development Agency (RTDA) have been recommended.

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IDA: International Development Association (World Bank)

EU: European Union

AfDB: Africa Development Bank

BADEA: Arab Bank for Economic Development in Africa

JICA: Japan International Co-operation Agency

China EXIM Bank: Export-Import Bank of China

OPEC: Organization of the Petroleum Exporting Countries

RTDA: Rwanda Transport Development Agency

MININFRA: Ministry of Infrastructures

MINECOFIN: Ministry of Finances and Economic Planning

EDPRS: Economic Development and Poverty Reduction Strategy

GDP: Gross Domestic Product

MDG: Millennium Development Goals

RMF: Road Maintenance Fund

NAS: National Agricultural Survey

CSI: Construction Specifications Institute

CSF: Critical Success Factors

KPIs: Key Performance Indicators

PPI: Project Performance Indicators

ECI: Early Contractor Involvement

ESI: Early Supplier Involvement

PPE: Project Performance Evaluation

WBS: Work Breakdown Structure

CPM: Critical Path Method

PERT: Project Evaluation and Review Techniques

GERT**:** Graphical Evaluation and Review Technique

PMBK: Project Management Body of Knowledge

## CHAPTER 1: GENERAL INTRODUCTION

### 1.1 Back ground

Road sector is an important sector in the economy of any nation due to its impact on the welfare of its citizens and the investment involved. This importance is propounded by the fact that transportation sector has a major role to play in the socio-economic development of a country as it provides access to markets, production, jobs, health, education and other social services.

Rwanda is landlocked country and far from maritime ports of Kenya and Tanzania. The distance to nearest port of Dar-Es-Salaam is approximately 1400 Km.

The road transport is a dominant mode of transport for both passengers and goods in Rwanda beside Air Transport with one International Airport and six airdromes spread across the country and lake transport which is limited mainly to Lake Kivu. Rwanda does not have a rail transportation system, but the rail road systems of neighboring countries (Tanzania, Uganda and Kenya) are used as transit routes, contribute to ascertain extent for goods originating or destined for Rwanda in a multi-modal railway-road combination.

The Total road network of Rwanda consists of almost 14,000 Km (including National, District, feeder and urban roads), corresponding to a road density of 0.53 km/km$^2$.
The classified road network consist of 1,172 Km of paved national roads, 1,688 km unpaved national road and 1,838 km of district road in class 1(unpaved). The remaining 8,235 km of the network consist of unclassified unpaved roads (urban and district roads in class 2). [Transport Sector Strategic Plan for EDPRS 2: August, 2013]. The transport sector contributes considerably towards poverty reduction and economic growth, and serves as support to other economic sectors. It plays a fundamental role in the economy

of Rwanda as it contributes about 7% to the Gross Domestic Product (GDP) and represents about 15% of total service delivery. [Transport Sector Strategic Plan for EDPRS 2: August ,2013].

The Ministry of Infrastructure (MININFRA), Rwanda Transport Development Agency (RTDA) and Road Maintenance Fund (RMF) have a major influence on the road construction industry as sponsors, regulators and purchasers of road projects. These road projects are ranging in size from repair works to large road projects.

Road construction industry's turnover is mainly funded by the Government and donors. Construction and repair of roads utilizes a great part of government expenditure in the 2013/2014 budget. The estimates for roads transport sector amounts to almost 170.9 billion Rwandan Francs, equal to 10% of the national budget. [MINECOFIN]

Rwanda's underdeveloped transportation network remains a key structural weakness. Nearly 84% of the population still lives in rural areas, engaged in agricultural activities. [The report of the National Agricultural Survey 2008 (NAS 2008)].

These rural areas are not adequately served by the transportation system. Moreover, the country's transportation system also serves to handle transit traffic for Rwanda landlocked neighbors including Burundi, Uganda and Congo –Kinshasa.

Irrespective of the importance and expenditure recorded above, the road construction sector is evidenced from many studies to experience extended problems. These problems are mainly grouped into three types. One problem concerns time management, i.e. road works are not completed within the agreed time and benefits of the works to the public are delayed. Another problem concerns cost overruns, i.e. additional but avoidable costs to the decided budgets for varying reasons. A third problem concerns the quality of the road works, i.e. rates of deterioration are higher than anticipated which implies early repair and maintenance.

These are chronic problems for Rwanda Transport Development Agency today. Time delay, cost overruns and change orders are generally due to factors such as design errors, unexpected site conditions, increases in project scope, weather conditions, and other project changes. A cost overrun may be generally expressed as a percent difference between the final cost of the project and the contract award amount. A time delay is simply the difference between a project's original contract period at the time of bidding and its overall actual contract period at the end of construction.

In order to avoid or minimize the above mentioned problem, my research is being conducted on "**Implementation of Time Management Techniques in highway projects for Improved Performance: Case study in Rwanda Transport Development Agency (RTDA)"**

**1.2 Problem statement and justification of the research**

In order to achieve the objectives of MDG, the government of Rwanda decided to set up RTDA specifically to manage and monitor all activities in the transport sector.

Rwanda Transport Development Agency (RTDA) is a public institution with legal personality, administrative and financial autonomy. It is under the Ministry of Infrastructure (MININFRA) responsible for managing all day-to-day aspects of the transport sector in Rwanda. It was put in place by Organic Law No 02/2010 of 20/01/2010 establishing its mission, structure and functioning. The Mission of RTDA is to contribute towards the realization of the development and poverty reduction objectives as formulated in strategic policy guidance, such as Vision 2020 and EDPRS, by the establishment and rational management of transport infrastructure and services.

Most of Rwanda's capital-intensive projects such as roads, airports, bridges and others facilities are partly or wholly funded with donor funds. These funds are either loans or grants from Multilateral or Bilateral Donors such as:

1. IDA : International Development Association (World Bank)
2. EU : European Union
3. AfDB : Africa Development Bank
4. BADEA : Arab Bank for Economic Development in Africa
5. JICA : Japan International Co-operation Agency
6. China EXIM Bank : Export-Import Bank of China
7. OPEC : Organization of the Petroleum Exporting Countries

Government of Rwanda (GoR) in an effort to utilize effectively these donors' funds procures experienced consultants and contractors to execute these projects according to specification and within specified period. Therefore, the client, consultant and the contractor becomes parties to this project and have to work together in order to execute the projects. The big challenge for RTDA is the inability to complete the projects on time and within budget. Among the 50 Road projects executed from 2010-2014 by RTDA, only two projects were completed on time and within budget such as Bugarama-Ruhwa Road Rehabilitation Project (7.5 Km) and Maintenance works of Gakoma-Rukarara access road to Rukarara Hydropower plant (Appendix 3). That is why this research topic "Implementation of Time Management Techniques in Highway Projects for Improved Performance: Case Study in Rwanda Transport Development Agency (RTDA)" was chosen in order to increase project performance in RTDA, in using and implementing of appropriate techniques for time management to avoid or reduce delays and cost overruns.

### 1.3 Objectives of the research

The aim of this research is the implementation of effective Time Management Techniques in Highway Projects in Rwanda for improving performance, through the identification of Critical Success Factors and Provision of an appropriate Guidance.
The aim of this research can be broken into the following objectives:

1) To thoroughly review the literature in the general areas of Time management techniques and processes, and with particular reference to Highway Projects,
2) To identify the main challenges that affect Highway projects in terms of time management, and the use and implementation of appropriate techniques for time management,
3) To identify and document the Critical Success Factors (CSF) associated with the effective use and implementation of Time Management Techniques for Highway Projects in Rwanda,
4) To establish and document the extent to which effective use and implementation of time management techniques lead to improved project performance,

### 1.4 Research methodology and methods

The study would employ various methods to obtain information and data from appropriate respondents including the use of survey questionnaire methods. The Relative Importance Index (RII) method will be used as data analysis method to assess the relative importance of time management techniques and critical success factors for improving highway project performance. A five-point Likert Scale will be adopted. The results obtained will be used to determine Fuzzy Vikor Approach.

### 1.5 Scope and organization of research

Due to ease of access to information, this research is narrowed in scope to the Rwanda Transport Development Agency (RTDA) with Road Construction and rehabilitation projects within the period of 2010 to 2014 as RTDA was established legally by the law N°02/2010 of 20/01/2010.

The aim of this research is implementation of effective Time Management Techniques in Highway Projects in Rwanda for improving performance, through the identification of Critical Success Factors and Provision of an appropriate Guidance. A questionnaire for preliminary survey was developed to evaluate the frequency of occurrence severity and importance of time management techniques in highway project for improving project performance. The information will be collected from locals and Internationals Consultant and Contractors which work together with RTDA and RTDA's Project Engineers and consultants. Afterward second survey was conducted to evaluate compare and prioterize the finding from first survey using fuzzy vikor method. The designed questionnaire for second survey was send to the road sector experts.

This research consists of five main chapters as followings:

- **Chapter one**: Introduction: this chapter shows the main objectives of research, statement of the problem and justification of research.
- **Chapter two**: Literature review: this chapter shows a historical review from previous studied to identify the main challenges that affect Highway projects in terms of time management, and the use and implementation of appropriate processes and techniques for time management.
- **Chapter three**: Methodology: this chapter shows the main methodologies used in previous studies and the methodology used in this research in order to achieve the required objective

- **Chapter four**: Results analysis: this chapter shows analysis, description and discussion of research results.
- **Chapter five**: Conclusions and Recommendations This chapter summarizes the contributions and achievements of this research and also addresses future research associated with the work presented in this study.
- ***Appendices***

### 1.6 Contribution of the research

This research will contribute to the improvement of road projects performance for RTDA. This thesis identifies time management techniques for ensuring that projects are on time and within budget. It has offered project managers with effective ways to estimate the time needs of the project.

Completing a project on time, within budget and up to the required quality can help contractors and consultants build a reputation for reliability on the market. "Scope management, cost management, and time management" are important variables for projects. (Anbari, 2003)" Therefore time management tool and techniques are both also valuables that Contractor, Consultant and Client can use successfully to manage their projects.

## CHAPTER 2: LITERATURE REVIEW

### 2.1 Project Time Management

The unique nature of the construction process presents complexities, uncertainties and changing circumstances, which must be accommodated within the planning and control system used. Small and large projects comprise a large number of interdependent items of work and involve many participants. For this reason, reliable plans and accurate progress-recording mechanisms become all the more essential to project success. The mismanagement of time could have an adverse effect on the outcome of the project with respect to cost and quality. The time taken to execute the project tasks from inception of site to delivery of the project is known as project duration. There are techniques employed in the management of time called construction planning tools. Some of these tools include the bar chart, the critical path method (CPM), the flow chart, and the line of balance. All of these are used to monitor the progress of the work and measure the amount of work done. Time control concerns the effort made in adhering to the initial specified time of project. The various aspects of projects to be controlled are human resources, materials, machine control and maintenance, and the various actions of parties to a contract who are the client, consultant, and contractor. These all influence project time delivery.

Success in time performance depends on choice of construction method, management of construction resources, schedule management, supervision and control, and communication. Quality management, budget management, human resource management, owner involvement, and team relationships impede time performance**.**
Project time management requires the use of tools and policies in order to create a standard for monitoring and measuring project work. The tools utilized in this process must be able to capture and manage time, both by individual and assigned tasks. Most organizations will use a combination of tools to accomplish this. While tools are necessary, they are not sufficient.

### 2.1.1 Project Time Management Processes

Project Time Management includes the processes required to ensure timely completion of the project. This Knowledge Area is concerned with estimating the duration of the project plan activities, devising a project schedule, and monitoring and controlling deviations from the schedule. Collectively, this Knowledge Area deals with completing the project in a timely manner. Time management is an important aspect of project management because it concerns keeping the project activities on track and monitoring those activities against the project plan to ensure that the project is completed on time. Although each process in this Knowledge Area occurs at least once in every project (and sometimes more), in many cases, particularly on small projects, Sequence Activities, Estimate Activity Durations, and Develop Schedule are completed as one activity. Only one person is needed to complete these processes for small projects, and they're all worked on at the same time. The Project Time Management Knowledge Area has six processes, as shown in table below.

**Table 1:** Time management process

| **Process Name** | **Description** | **Project Management Process Group** |
|---|---|---|
| Define Activities | The process of identifying the specific actions to be performed to produce the project deliverables | Planning |
| Sequence Activities | The process of identifying and documenting relationship among project activities | Planning |
| Estimate Activity Resources | The process of estimating the type and quantities of material people equipment or supplies required to perform each activity | Planning |
| Estimate Activity Durations | The process of approximating the number of work period need to complete individual activities with estimated resources | Planning |
| Develop Schedule | The process of analyzing activities sequences, durations, resource requirements and schedule constraints to create the project | Planning |
| Control Schedule | The process of monitoring the status of the project to update project progress and managing change to schedule baseline. | Monitoring and Controlling |

Source: *(PMBOK® Guide)*, Fourth Edition

### 2.1.2 Project Time Management Techniques

Tools and techniques play important role in project management. Frimpong et al. (2003) revealed that project management tools and techniques play an important role in the effective management of a project. PMBOK defines Project Management as the application of knowledge, skills, tools and techniques to project activities to meet the project requirements (PMI, 2008). Project management involves managing the resources workers, machines, money, materials and methods used (Giridhar and Ramesh, 1998). According to a Comparative Study between Kedah and Kelantan: Application of Time Management Tools and Techniques by Construction Industry Players, there are several techniques commonly used in construction projects. These techniques have difference function and aim to manage the time in completion of project. It includes:

1) Gantt Bar Chart
2) Critical Path Networks/Method
3) Milestone Date Programming Techniques
4) Program Evaluation and Review Technique (PERT)
5) Elementary Trend Analysis/Line of Balance Method (LOB)
6) Precedence Network Diagram
7) Simulation

Thomas Carlyle, a famous historian and author, stated, "Man is a tool-using animal. Without tools he is nothing, with tools he is all." As the world continues to become more complex, it is even more important for people to develop and use tools, especially for managing important projects. **Project management tools and techniques** assist project managers and their teams in carrying out work in all nine knowledge areas. For example, some popular time-management tools and techniques include Gantt charts, project network diagrams, and critical path analysis.

A 2006 survey of 753 project and program managers was conducted to rate several project management tools. Respondents were asked to rate tools on a scale of 1–5 (low to high) based on the extent of their use and the potential of the tools to help improve project success. "Super tools" were defined as those that had high use and high potential for improving project success. These super tools included software for task scheduling (such as project management software), scope statements, requirement analyses, and lessons-learned reports. Tools that are already extensively used and have been found to improve project performance include progress reports, kick-off meetings, Gantt charts, and change requests.

By an empirical study on the use of project management tools and techniques across project life-cycle and their impact on project success Peerasit Patanakul Stevens Institute of Technology, New Jersey, USA, the time management tools and techniques are CPM, PERT, GERT, Gantt charts, simulation, Monte Carlo analysis, buffer management, schedule crashing, milestone charts, and variance analysis. *Therefore, for all that, this study will be focused on the following tools: Critical Path Methods (CPM) and Gantt Bar Chart, Project Evaluation and Review Techniques (PERT), Graphical Evaluation and Review Technique (GERT), Milestones chart, Precedence Network Diagram, Simulation, Elementary Trend Analysis/Line of Balance Method (LOB) and project management software.*

## 1. Critical Path Methods (CPM)

A critical path method (CPM) is a scheduling technique using networks for graphic display of the work plan (Mubarak S. A. 2005). The method is used to determine the length of a project and to identify the activities critical to project completion. It was developed during the 1950s by DuPont and US Navy. It is one of the common techniques used in practice for construction planning and scheduling. Microsoft Project (2003) is one of the common software product used for project scheduling. The typical CPM is used to provide an overall view of the project including durations of activity,

sequence of activity, and criticality of activities. It can show the use of resources, the cost of construction activities and the shortest project duration among all the sequence of activities. However, it does not describe how a construction work is built.
To understand CPM further let's first understand nature of the task. According to PMBOK every scheduled task can be defined by the following four parameters.

- Early Start (ES): Earliest possible point in time on which a task can start.
- Early Finish (EF): Earliest possible point in time on which a task can finish.
- Late Start (LS): Latest possible point in time on which a task can start.
- Late Finish (LF): Latest possible point in time on which a task can finish.

## 2. Gantt Chart

A bar chart is "a graphic representation of project activities showed in a time-scaled bar line with no links shown between activities" (Popescu and Charoenngam 1995, 96). It was originally developed by Henry L Gantt in 1917 and also called as "Gantt Chart". It involves the duration of activities/tasks, the position of timescale and identification of work sequence. A bar chart is simply as a calendar which shows the timescale horizontally and flow of activities vertically. The vertical column also shows the timescale, duration and sequence of activity. It is commonly used in construction industry due to simplicity and ease of preparation and understanding. However, it lacks logical representation (relationships), too simple and insufficient to show the details of multitude of inter-related activities. It commonly used in small-sized project.

A Gantt chart is easy to read and provides sufficient information for project team members to plan activities within a short time frame. For many larger projects, a two-week bar chart, extracted from the larger master schedule, provides the information needed for team members and contractors to coordinate activity details. The Gantt chart provides information for simple planning but is limited because a Gantt chart does not illustrate complex relationships well.

Callahan *et al.* (1992) defines bar charts as "a collection of activities listed in vertical column with time represented on a horizontal scale". Bar charts show duration, start and finish times of project activities in chronological order. Henry L. Gantt developed bar charts during World War I. This tool is widely preferred since it is simple, easy to prepare and has an easily understandable format.

## 3. Gantt Bar Chart and Critical Path Example

Project schedule plan is the main plan included in any Project Management Plan. Project schedule is responsible for bringing project time, cost and quality under control. Project schedule links resources, tasks and time line together. Once a Project Manager has list of resources, work breakdown structure (WBS) and effort estimates, he is good to go for planning project schedule. Schedule network analysis helps Project Manager to prevent undesirable risks involved in the project. Critical Path Method (CPM) and Gantt Bar Chart are key elements of schedule network analysis.

To establish Gantt Bar Chart and Critical Path is depending on Work Breakdown Structure (WBS). The project management work breakdown structure (WBS) is utilized at the beginning of the project to define the scope, estimate costs and organize Gantt schedules. More often the work breakdown structure, WBS is listed in a hierarchical tree that captures deliverables and tasks needed to achieve project completion. When identifying the scope of a project it is important to create a work breakdown structure regarding the tasks that must be performed in order to achieve the deliverables of the project. The WBS presented in table below is pertained to the main activities of Bugarama-Ruhwa Road Rehabilitation (7.5 Km) which is one of projects completed on time and within budget in RTDA during the period of 2010-2014. (Appendix 3)

**Table 2**: WBS development

| S/N | Activities | Time (Days) | Dependencies |
|---|---|---|---|
| I | Site Installation | 10 | |
| II | Topography before | 7 | |
| III | Demolitions of existing structures | 14 | |
| IV | Cut, fill and dump away from the site | 12 | II, III |
| V | Scarification of existing, compaction and Leveling of the formation level | 5 | IV |
| VI | Sub base course in selected material(murram) | 7 | V |
| VII | Base course (Grave Non Traitée) | 5 | VI |
| VIII | Prime Coat | 2 | VII |
| IX | Double layer surface coating | 20 | VIII |
| X | Supply and fix concrete kerbs | 14 | VII |
| XI | Laying Reinforced concrete Culvert | 18 | V |
| XII | Masonry ditches | 22 | VII |
| XIII | Road Marking (Vertical and Horizontal) | 3 | IX |
| XIV | Topography after | 4 | IX |
| XV | Demobilization | 3 | I |

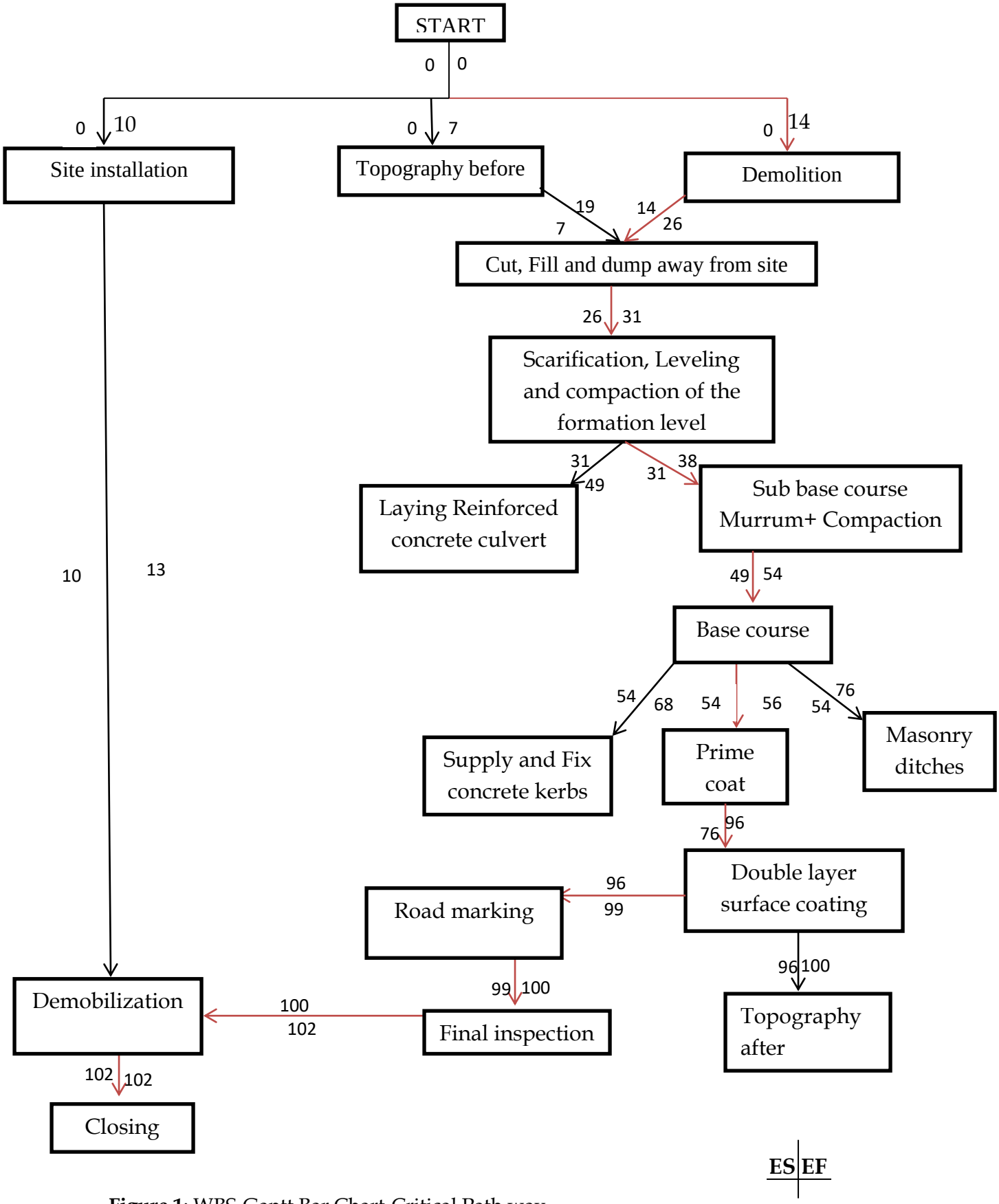


**Figure 1**: WBS-Gantt Bar Chart-Critical Path way

## 4. Milestones chart

Milestone is a special event that needs an attention in the framework of project management. Milestones do not have durations or resources, but should be considered zero duration activities because that is how they are handled when placed in a schedule and computed with CPM. Besides that, most of the progress shown in the milestone is only on the critical path and ignore non-critical activities. This is to ensure that the milestones of the project are met even when actually some activities are being ignored.

### 4.1 Example of Milestone chart

This example was elaborated based on WBS developed below. The duration of main activities selection from bill of quantities of Bugarama-Ruhwa Road Rehabilitation is 146 days (5 months). The project was started on November, Eleven 2011.

| No | EVENT | DURATION (MONTH) | | | |
|---|---|---|---|---|---|
| | | November | December | January | February |
| 1 | Site Installation | | | | |
| 2 | Topography before | | | | |
| 3 | Demolitions of existing structures | | | | |
| 4 | Cut, fill and dump away from the site | | | | |
| 5 | Scarification , compaction and Leveling of the formation level | | | | |
| 6 | Sub base course in selected material(murram) | | | | |
| 7 | Base course (Grave Non Traitée) | | | | |
| 8 | Prime Coat | | | | |
| 9 | Double layer surface coating | | | | |
| 10 | Supply and fix concrete kerbs | | | | |
| 11 | Laying Reinforced concrete Culvert | | | | |
| 12 | Masonry ditches | | | | |

**Figure 2**: Example of Milestone chart

## 5. Time Management Software

The time management software system helps to control and monitor the project whether or not the project the most advantages of time management software's using for construction planning is that the mathematical computations are instant and errors free.

The commonly used software within the construction industry for time management are Microsoft excel, Microsoft project, and primavera project planner. In Microsoft excel there are various kind of templates which will be used for the project planning like

excel project management templates, Gantt Chart and project planning, project reporting, Microsoft Excel formulas for project managers and etc. Microsoft Project has various choices to support project management like manual planning where this choice could also be accustomed set task durations and, starts and finish date with purpose and clicks on. Primavera Project Planner can be presented as numbers, PERT, Gantt charts, bar chart, and diagrams.

**2.2 Previous predictive studies on construction duration**

One of the early studies in the area of prediction of construction duration was carried out by Bromilow (1988). Bromilow (1988) considered two factors, construction cost and time, for his prediction.

Other studies have considered additional factors, such as the construction floor area, project scope, extent of varying construct period and fixed budget construction (Ling *et al.*, 2004) in Singapore; concrete pumping method, type of formwork, productivity of erecting formwork to floor slabs and number of supervisors (Proverbs and Holt, 2000) in the UK; numbers of days of actual construction and numbers of days specified in the contract (Al-Momani, 2000) in Jordan, as well as time of completion and projected estimated cost (Chan, 2001) in Malaysia.

Apart from the above documented studies on construction project delay, other studies which have been undertaken to determine the underlying causes of delay in projects are enumerated below. These studies investigated issues that lead to delays in projects. These include: causes of project delay investigated by Frimpong *et al.* (2003); Nkado (1995); Odeh and Battaineh (2002) and Oladapo (2000); human resources issues discussed by Belout and Geuvreau (2004); risk factors leading to delays studied by Ward and Chapman (2003) and Zwikael *et al.* (2006); materials and equipment management issues causing delays, researched by Manavazhi and Adhikari (2002), Koushki *et al.* (2005) and Assaf and Al-Hejji (2006); change orders causing project delay assessed by Moselhi *et al.* (2005); motivation and productivity studied by Andawei

(2002) and Ng *et al.* (2003); weather impact on project duration investigated by Ameh and Odusami (2002); planning techniques studied by Andawei (2003a), Andawei (2003b) and Dvir *et al.* (2003); client contribution to delay investigated by Kehinde *et al.* (2003) and Yu *et al.* (2006); impact of construction techniques studied by Nkado and Mbachu (2001) and Tam *et al.* (2001); impact of design on project delays investigated by Andi and Minato (2003); management functions and supervision contribution to delay discussed by Edum-Fotwe and McCaffer (2000) and Jha and Iyer (2005), and finally, effects of delays on project analysed by Aibinu and Jagboro (2000).

The above-mentioned studies are related to this study based on the parameters set out to measure by this study. The methodology, sampling techniques, statistical tools for analysis and recommendations are studied and applied to this research.

**2.3 Stakeholders' influences on project time**

Based on the foregoing studies, the theoretical framework of this study was established and a total of seventy-six factors influencing construction project delivery time either positively or negatively is identified. These could be grouped into twelve major headings namely:

1. **The client's understanding of the design, procurement, and construction processes**;

The following are various factors related to the Client which contribute to the project delivery time: understanding of the project constraints, ability to effectively brief for design team, ability to contribute ideas to the design process, ability to quickly make authoritative decisions, stability of decisions, ability to contribute ideas to the construction process.

2. **Quality of management during design**;

The factors of Quality of management during design that influence project delivery time are: Conflicting design information, Timeliness of issuing of revised drawings, Missing information, Dimensional inaccuracies, Expediting shop drawings.

3. **Quality management during construction;**

The factors of Quality of management during construction that influence project delivery time are: Forecasted planning date such as activity duration, resource quantities required, Forecasted planning date such as activity duration, resource quantities required, Analysis of construction methods Analysis of construction methods, Resource movement to, on and from site, Work sequencing to achieve and maintain work flow, Monitoring and updating of plans to appropriately reflect work status, Responding to, and recovering from problems or taking advantage of opportunities present, Effective coordination of resources, Development of an appropriate organization structure to maintain workflow, Inspection and construction.

4. **Management techniques used for planning and control;**

Two types of planning tools are generally used on any kind of project, namely the CPM and the bar chart. There are others which are used for specific types of projects, such as heavy engineering projects. These are the horse blanket and S-curves.

5. **Economic policy;**

The factors of economic policy that influence project delivery time are the availability of materials; the availability of equipment; the availability of trades operatives the availability of supervision, management staff, as well as the indirect impact of interest rates, inflation and insolvency, and bankruptcy.

6. **Constructability of design**;

The following factors are employed in the assessment of design constructability: the scope of off-site fabrication; complexity of offsite fabrication components; appropriateness of design tolerances; appropriateness of working space; implication upon trade coordination; implication upon trade coordination; impact of materials storage and movement and impact, on smooth activity workflow and activity sequence.

7. **Site ground conditions**;

The following site ground conditions that influence project delivery time are listed below: Nature of demolition work; Nature of restoration work; Structural stability of ground; Extent of ground contamination; Extent of archaeological finds; Impact of the water table; Impact of underground services, and Impact of underpinning existing structures.

8. **Motivation of staff;**

The factors of motivation that can influence workers‟ attitudes either negatively or positively regarding productivity are: pay and allowances; job security; a sense of belonging and identification with the project team; recognition of contribution; opportunity for extending skills and experience through learning as a means of job satisfaction and higher productivity; equitable reward relative to others‟ input to the project; exercise of power, and opportunity to career advancement for future benefit.

9. **Management style;**

The following factors could be used in assessing the management style of those in positions of authority: setting specific goals employees are to accomplish; organizing the work environment for people; setting timelines; providing specific direction; conducting regular updates on progress; providing support and encouragement;

involving team members through discussion of work, and seeking people's opinions and concerns.

**10. Site access**;

The factors of site access that influence project delivery time are: Proximity to required resources; Narrowness of road, therefore putting projects at a disadvantage; Congestion at site entry / exit points; Storage space at or near ground level; Storage space at upper levels, and Requirements in terms of restrictive hours.

**11. Physical environment considerations,**

They include the impact of natural hazards (fire, flood and many others); adverse local weather conditions (rainfall and high temperature); ambient noise (beyond tolerance level), and the condition of light (lack or intense thereof).

**12. Socio-political considerations.**

Factors which constitute this are civil strife or riots; the influence of civil action-groups and disruptions due to environmental concerns.

## 2.4 Challenges that affect highway projects in term of time management

The major factor of construction problems is project's delay. Delay means loss of income according to and for the owner or client. In case of contractor, delay refers to the higher costs due to longer work time, labor cost increase and higher fabrication costs. There is an increase in the number of construction projects experiencing extensive delays leading to exceeding the initial time and cost budget. Although the contract parties agreed upon the extra time and cost associated with delay, in many cases there were problems between the owner and contractor as to whether the contractor was entitled to claim the extra cost. Such situations, usually involved questioning the facts,

causal factors and contract interpretation. Therefore, delays in construction projects give rise to dissatisfaction to all the parties involved and the main role of the project manager is to make sure that the projects are completed within the budgeted time and cost.

The biggest customer of the construction industry in most countries is the government (Okpala and Aiekwu, 1988). To the dislike of owners, contractors and consultants, many government projects experience extensive delays and thereby exceed the initial time and cost estimates (Odeh and Bataineh, 2002). **This problem is more evident in the traditional type of contracts in which the contract is awarded to the lowest bidder.** This procurement strategy is adopted by majority of government projects in developing countries. The Latham Report (Latham, 1994) suggested that ensuring timely delivery of projects is one of the important needs of clients of the construction industry.

Contractors are primarily concerned with quality, time and cost and yet the majority of construction projects are procured on the basis of only two of these parameters, namely time and cost (Bennet and Grice, 1990).

Any construction project comprises two distinct phases: the preconstruction phase (the period between the initial conceptions of the project to awarding of the contract) and the construction phase (period from awarding the contract to when the actual construction is completed). Delays and cost overruns occur in both phases. However, the major instances of project overruns usually take place in the construction phase (Frimpong et al., 2003). Unfortunately, due to various reasons, project successes are not common in the construction industry, especially in developing countries. From several studies and empirical evidence, it is clear that project overruns comprising delays and cost overruns occur during the 'construction' phase. Therefore, professionals and scholars have been motivated to take steps to meet this challenge.

### 2.4.1 Types of delays

According to Wail Menesi (2007), delays are classified into two different types according to liability: excusable and inexcusable (Fig. 3).

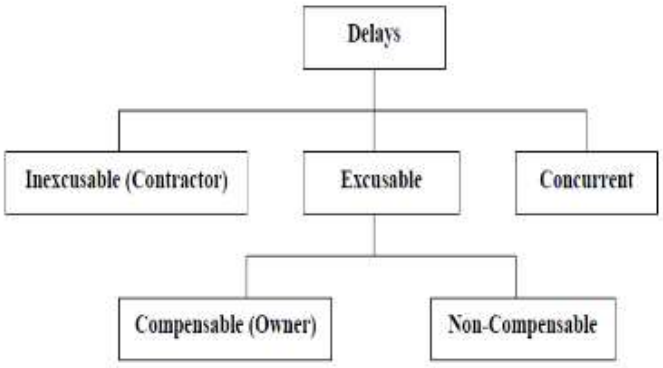


**Figure 3:** Type of delays

**Source:** Wail Menesi (2007)

Delays that affect project completion date as agreed on contract are considered as critical delays, while delays that do not affect project completion date are known as non-critical delays. An excusable delay is beyond the contractor control i.e delay due to unforeseeable activity beyond the contractors or the sub-contractors control. Excusable delays without compensation are delays caused by neither the client nor the contractor. Non-excusable delays (NEDs) are within contractor control. NEDs are the responsibility of contractor and the client may be entitled to claim the damages. Only excusable delay can be compensable delay. A compensable delay is a delay where the contractor is entitled to a time extension and to additional compensation. Under non-compensable delay the contractor is not entitled to any compensation resulting from the excusable delay when the same type of delay happens more than one time, either alone or consequently, impact the projects critical activity schedule, a concurrent delay occurs.

**Table 3:** Classification of concurrent delay according grant to the contractor (Wei 2010)

| **Delays that occur concurrently** | **Entitlement to the contractor** |
|---|---|
| Excusable and non-excusable | Only time extension granted |
| Excusable with compensation and excusable without compensation | Entitled to time extension but not to damages |
| Two excusable with compensation | Entitled to both time extension and damages |

**Source**: *Wei 2010*

### 2.4.2 Causes and effects of construction project delays

In construction, the word "delay'' refers to something happening at a later time than planned, expected, specified in a contract or beyond the date that the parties agreed upon for the delivery of a project (Pickavance, 2005). Lo, Fung and Tung (2006) define delay as the slowing down of work without stopping construction entirely and that can lead to time overrun either beyond the contract date or beyond the date that the parties have agreed upon for the delivery of the project.

**1. Causes of Delays**

Noulmanee *et al (*1999) investigated causes of delays in highway construction in Thailand and concluded that delays can be caused by all parties involved in projects; however, main causes come from inadequacy of sub-contractors, organizations that lack sufficient resources, incomplete and unclear drawings and deficiencies between consultants and contractors. Al-Momani (2000) investigated causes of delay in 130 public projects in Jordan and found that main causes of delay were related to designer,

user changes, weather, site conditions, late deliveries, economic conditions and increase in quantity.

Other researchers looked into delay factors in construction projects. Chan and Kumaraswamy (1997) identified five principal delay factors which are: poor risk management and supervision, unforeseen site conditions, slow decision making, client-initiated variations and work variations. Other delay factors in a study by Kaming, Olomolaiye, Holt and Harris (1997) are classified under cost and time overruns. The study reveals that the major factors influencing cost overrun are: material cost increase due to inflation, inaccurate material estimation and degree of complexity. On the other hand, under time overrun, the most important factors causing delays are: design changes, poor labor productivity, inadequate planning, and resource shortages.

The Murali Sambasivan *, Yau Wen Soon (November 2006) study identified Ten most important causes were: (1) contractor's improper planning, (2) contractor's poor site management, (3) inadequate contractor experience, (4) inadequate client's finance and payments for completed work, (5) problems with subcontractors, (6) shortage in material, (7) labor supply, (8) equipment availability and failure, (9) lack of communication between parties, and (10) mistakes during the construction stage. These causes were categorized into the following eight major groups:

1. Client related factors: finance and payments of completed work, owner interference, slow decision making and unrealistic contract duration imposed by owners.
2. Contractor related factors: delays caused by subcontractor, site management, improper construction methods, improper planning and errors during construction, and inadequate contractor experience.
3. Consultant related factors: contract management, preparation and approval of drawings, quality assurance and waiting time for approval of test and inspection.
4. Material related factors: quality of material and shortage in material.

5. Labor and equipment related factors: labor supply, labor productivity and equipment availability and failure.
6. Contract related factors: change orders and mistakes or discrepancies in contract document.
7. Contract relationship related factors: major disputes and negotiations, inappropriate overall organizational structure linking to the project and lack of communication between the parties.
8. External factors: weather condition, regulatory changes, problem with neighbors and unforeseen site condition.

**2. Effects of project delays**

The impact or consequences of delay in project completion is termed the effect of project delay. Memon, et al, state that effect of delay is a change or impact due to delay.

A study by Aibinu and Jagboro, (2002) reveals **six effects of delay** on project delivery in Nigerian construction industry which are: *time overrun, cost overrun, dispute, arbitration, total abandonment and litigation*. Sambasivan and Soon (2007) disclose the same effects of delay in Malaysian construction industry. Haseeb*et al* (2011) identifies effects of delays in Pakistan construction industry as clash, claims, total desertion and slowing down the growth of the construction sector. Ramabodu and Verster (2010) identify critical factors that cause cost overruns in construction projects as changes in scope of work on site, incomplete design at the time of tender, contractual claims (extension of time with cost), lack of cost planning and monitoring of funds, delays in costing variations and additional works. These critical factors in turn are the delay factors.

## 3.Relationship between the causes and effects of delay

### 3.1 Time overrun

Time Overrun is one of the most significant issues being faced by the construction industry today. There are various factors responsible for the time overrun which require serious attention to understand and address in order to achieve successful completion of projects on time. This is because time overrun has great impact to construction cost which can never be recovered.

Client-related and contractor-related factors have impact on the time overrun. Out of the ten most important causes of delay discussed earlier, six causes belong to client related and contractor-related factors. Factors such as inadequate planning by the contractors, improper site management by the contractors, inadequate project handling experience of contractors, and delay in the payments for the work completed directly affect the completion of the project and cause time overrun.

### 3.2 Cost overrun

Contract-related factors such as change orders (changes in the deliverables and requirements) and mistakes and discrepancies in the contract document result in cost overrun. Mistakes and discrepancies in the contract document can be in scope, deliverables, resources available and allocated, payment terms, achievement of various milestones, and the project duration. In most of the instances, time overrun leads to cost overrun. Correlation analysis between cost and time overruns indicated a strong linkage (correlation coefficient = 0.487, significant at 0.01 level of significance)

### 3.3 Disputes

Client-related, contract-related, contract relationship related, and external factors have impact on the disputes that arise during the course of the project. Factors such as delay in the payments for completed work, frequent owner interference, changing

requirements, lack of communication between the various parties, problems with neighbors, and unforeseen site conditions give rise to disputes between the various parties. The disputes, if not resolved amicably, can lead to arbitration or litigation.

**3.4 Arbitration**

Client-related and contract relationship-related factors escalate disputes to be settled by arbitration process. A competent third-party can settle the disputes amicably without going to the court.

**5.5 Litigation**

Client-related, labor-related, contract-related, contract relationship-related and external factors escalate disputes to be settled by the litigation process. The parties involved in the projects use litigation as a last resort to settle disputes.

**3.6 Total abandonment**

Client-related, consultant-related, labor-related, contract-related, and external factors contribute to the total abandonment of the projects. In Malaysia, many projects were temporarily abandoned during the financial crisis between 1997 and 2000. Promoters of various projects backed out because of poor cash flow and economic conditions. Many of these projects have now become so prohibitive that they have been abandoned permanently.

Based on the discussions above, the next step is to provide suggestions to clients, contractors, and consultants to reduce delays. These suggestions, we hope, will alleviate the problems faced by the construction industry in Malaysia.

# CHAPITER 3: RESEARCH METHODOLOGY

A careful selection of appropriate methods is an important component of the strategy in the overall design of any study. The understanding, of which research methodology and methods are appropriate, is important in development for successful data collection in the construction industry (Abowitz and Toole 2010).

## 3.1 Research strategy

Naoum (1998) defined the research strategy as the way in which the research objectives can be questioned. Two types of research strategies are used at studies, quantitative and qualitative research. Quantitative approach is used to gather factual data and to study relationships between facts and how such facts and relationships accord with theories and the findings of any research executed previously, but the qualitative approach seek to gain insights and to understand people's perception of "the world" whether as individuals or groups (Fellows and Liu, 1997). The research strategy adapted for this research is quantitative research. Quantitative research is chosen to know stakeholder's perception regarding time management techniques and Critical Success Factors (CSF) associated with the effective use and implementation of Time Management Techniques for Highway Projects in Rwanda.

## 3.2 Research design

This study was designed to address the problem identified in Section 1.2 and achieve the objectives outlined in Section 1.3. It was considered essential to obtain a full understanding of the study by setting out the various elements in a logical sequence, so as to avoid misunderstanding at any point in the research. The problem statement, aims and objectives of the research were therefore stated at the outset.

In order to present clear perspectives about implementation of effective Time Management Techniques in Highway Projects in Rwanda for improving performance,

through the identification of Critical Success Factors and Provision of an appropriate Guidance, it was decided to conduct the study in four phases. The first was comprehensive literature review. This phase overlapped all the other phases as it was important that even latest information on the research subject be incorporated. Data collection which was done through questionnaire surveys constituted the second phase. The third phase was the analysis of the data collected using **fuzzy** logic incorporated with relative importance index (RII) method. The information from the earlier stages was then used in the fourth phase as the input data. The fourth phase was to provide appropriate sets of guidance on the effective use and implementation of Time Management techniques in Highway Projects for improved performance and for the benefit of project teams involved in Highway projects in Rwanda.

### 3.3 Data Collection

The choice of data collection technique is a final step in the methodology design process (Saunders et al., 2007).

There are various research methods available in the world today. Different research types also have different data gathering methods. Data collection techniques can be broadly classified as: primary; and secondary

#### 3.3.1 Primary technique

This is the technique used to collect one's own data or information. The collector of such data is the first to ever embark on collecting it. This technique includes methods such as observations, interviews and administration of questionnaires (Nkhata 1997). Focus Group Discussion is also one of the primary techniques of data collection.

The primary data used in the study was acquired by surveying existing literature related to the time management techniques and Critical Success Factors (CSF)

associated with the effective use and implementation of Time Management Techniques for Highway Projects in Rwanda.

This process marked the development of the framework of the study, after which two questionnaires were designed for data gathering.

Nine tools and Seventy-six factors influencing road construction project delivery time either positively or negatively were identified and categorized into twelve major headings. A first survey using administrative questionnaire was conducted. Principally, the select Government establishments, Civil Works Consultants, and Road Contractors working together directly or indirectly with RTDA were surveyed. However, from the result both nine technical tools and twelve critical success factors were reduced to five. From those results a second survey fuzzy Vikor questionnaire was designed to prioritize these critical factors and tools (criteria) and investigate the interdependent relationship between the alternatives. The fuzzy vikor questionnaire is destined to the 11 experts in Road Construction field.

### 3.3.2 Secondary technique

This technique involves the use of available information that was collected by somebody else. The researcher in this case is the secondary user of the information. An example of such a technique is literature review (Bryman 2001).

In getting a better understanding of the subject, it was decided to collect secondary data from what other researchers elsewhere have done. This method was used based on the fact that it is cheaper to lay the foundation of the research, and build it up on what has been established by others (Nkhata 1997). In order to achieve the objectives, a systematic literature review was conducted. The various literature sources of information are: journal articles, books, conference proceedings, government and corporate reports, newspapers, theses and dissertations and the internet (Languages Centre 2005)

Based on the survey of the literature, the theoretical framework of this study was established, a total of seventy-six factors influencing construction project delivery time either positively or negatively grouped into twelve major headings were identified. Technical tools and Main challenges that affect Highway projects in terms of time management; on highway projects are also identified.

### 3.3.3 Questionnaire Survey

The study used two questionnaire survey types for gathering information. The first questionnaire was developed to assess the perceptions of client, consultants, and contractors due to the importance index of time management techniques and Critical Success Factors (CSF) influencing time delivery for Highway Projects in Rwanda. Factors influencing time delivery and time management techniques for road construction projects in Rwanda were first examined and identified through a relevant literature review. The findings from quantified time management techniques and Critical Success Factors (CSF) influencing time delivery for Highway Projects in Rwanda by relative importance index (RII) method will serve to determine the fuzzy rules 'weight to develop the fuzzy vikor approach assessment model. Hence a second questionnaire related to fuzzy vikor will be designed.

**1.Self-administrative questionnaire**

The self-administered questionnaire survey was adopted as the main research instrument based on the advantages that a representative sample would be realized with little time or costs. This method allowed respondents to have adequate time to consult where they were not sure, thereby answering the questions more appropriately. These factors made this method more advantageous compared to the other methods available. With the above advantages noted, the questionnaire was designed to meet the research aim and objectives.

In addition, it was expected that the respondents' knowledge and experiences would differ from one to another, and that this might have an impact on their answers, so attention was paid to addressing this point. In order to present the questionnaire in a systematic way, it was decided to divide the questions into three sections:

- **Section 1**: questions concerned with respondents 'information. This contained general questions about the profession, period of experience, sector and type of work specialty;
- **Section 2:** Closed-ended or structured questions dealing with Time management techniques

  **Section 3:** Closed-ended or structured questions dealing with Critical Success Factors (CSF) associated with the effective use and implementation of Time Management Techniques for Highway Projects in Rwanda.

According to Haksever and Manesali (2006), questionnaires can be used for the acquisition of qualitative data using quantitative scales. Similarly, the first questionnaire used in this study incorporated the Likert five point scales to facilitate an evaluation of responses between the minor to major ranges. The Likert Scale is an ordered, one-dimensional scale from which respondents choose one option that best aligns with their view. There are typically between four and seven options. Five is very common. A five-point Likert Scale, which had a common use in the previous literature, ranged from 1(low performance) to 5 (high performance) was adopted in this thesis as shown in Figure 4

| Chance of occurrence | Low performance …… Extremely high performance | | | | |
|---|---|---|---|---|---|
| scale | 1 | 2 | 3 | 4 | 5 |

**Figure 4**: A five point scale

The first questionnaire was written in one format and distributed to professionals working for contractors, consultants, Clients and stakeholders (Government Institution involved in highway project construction such as RTDA, Kigali City, MININFRA, MINECOFIN, and RMF)

It was decided to use appropriate distribution method for each respondent. For speed of response, some questionnaires were distributed personally and collected by hand. This method was effective as it ensured that the questionnaires reached the targeted organizations in good time and within budget. For the other respondents who could not be easily reached, the questionnaires were distributed and collected via mail.

**2. Fuzzy Vikor questionnaire**

In order to want a solution which must be closest to the ideal, the paper proposes a fuzzy VIKOR framework for evaluating and ranking time management techniques and critical success factors influencing time delivery obtained after analyzing the data from preliminary survey under a fuzzy environment where uncertainties and subjectivities are catered for with linguistic variables. Linguistic variables with triangular fuzzy numbers (TFN) are used to evaluate weights of the evaluation criteria and the rankings of each Tools and critical factors with time management. This study makes a contribution by using fuzzy mathematics and VIKOR multi-criteria decision making (MCDM) technique.

This study first proposes a new set of criteria for evaluating time management tools and critical success factors with time management culled from first phase of survey. Secondly, the criteria are used to construct a framework for evaluating, comparing and rating time management techniques in highway projects for improved performance using fuzzy VIKOR method. For the second phase of survey the questionnaire was organized in two sections. The first section contained the questions related to time management techniques and factors influencing time delivery ranking as second section is related to the alternatives ranking.

The questionnaire will be distributed to the eleven experts from RTDA, Kigali Council, MININFRA, RMF, MINECOFIN, Contractor and Donors.

### 3.3.4 Sample Design

Design a suitable sample for data collection is an obvious necessity, since it is rarely possible to investigate an entire population due to source restrictions in most research studies. According to the Fellows and Liu (2008)" the objective of sampling is to provide a practical means of enabling the data collection and processing components of the research to be carried out whilst ensuring the sample provides a good representation of population". This section outlines the specific criteria used to select the respondents for the questionnaire.

There are different types of sample designs based on two factors viz., the representation basis and the element selection technique. On the representation basis, the sample may be probability sampling or it may be non-probability sampling. Probability sampling is based on the concept of random selection, whereas non-probability sampling is 'non-random' sampling. On element selection basis, the sample may be either unrestricted or restricted. When each sample element is drawn individually from the population at large, then the sample so drawn is known as 'unrestricted sample', whereas all other forms of sampling are covered under the term 'restricted sampling'. The following chart exhibits the sample designs as explained above.

Thus, sample designs are basically of two types viz, non-probability sampling and probability sampling. We take up these two designs separately.

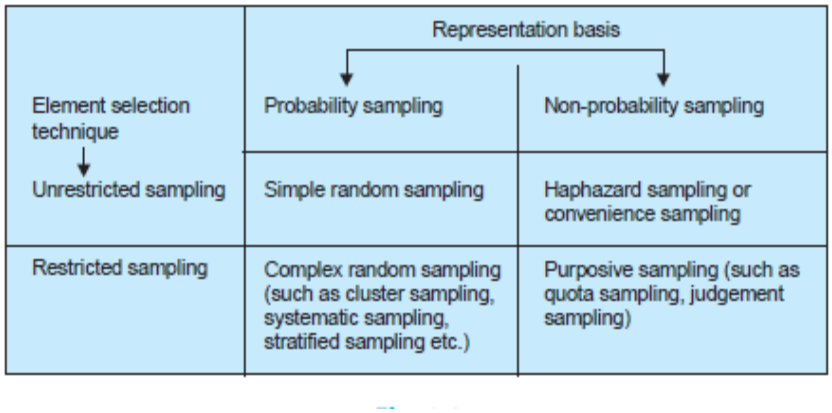


**Figure 5**: Basic sampling design
**Source:** CR Kothari (ebook, 2004)

With this guidelines being taken into account this study adopted complex probability sampling designs in particular, **stratified random sampling**.

The stratified random sampling is a method employed to randomly choose a number of sample representing each stratum of a population (Fink 2009); it has advantages of high generalizability of findings, and is the most efficient among all probability designs (Sekaran and Bougie 2009). This method was used to select respondents representing typical road construction practitioner i.e Client representatives, Contractors, Consultants and Financials.

Due to ease of access to information, and time this research is narrowed in scope to the Rwanda Transport Development Agency (RTDA) Road Construction and rehabilitation projects within the period of 2010 to 2014 as RTDA was established legally by the law N°02/2010 of 20/01/2010 and Government Institution involved in highway project construction such as, Kigali City, MININFRA, MINECOFIN and RMF). The total numbers of the projects under examination in RTDA are 50 projects**.**

The questionnaires of first survey were sent to select Government establishments, selected Civil Works Consultants, Road Contractors and donors working together directly or indirectly with RTDA.Whereas the second questionnaire (Fuzzy Vikor) was sent to the selected experts from consultants, contractors, donors and government establishments. The Government establishments were bodies that implement road projects in the country. These were composed of Ministry of Infrastructure, RTDA, Road Maintenance Fund, Ministry of Finance and Economic Planning.

### 3.3.5 Sample Size and Population

Israel (2003) presents the strategies for determining sample size, either by using published tables or formulas to calculate an appropriate sample size.Guidelines for the minimum sample size needed to conduct factor analysis suggested a minimum sample size of 100 to 200 observations (Guadagnoli and Velicer, 1998).Tabacknick and Fidell (2012: 588) have advised the following regarding sample size: 50 observations are very poor, 100 is poor, 200 is fair, 300 is good, 500 is very good and 1000 or more is excellent. As a rule of thumb, a bare minimum of 10 observations per variable is desirable to avoid computational difficulties.

The population sample of this research was composed of four strata: clients (RTDA and Government Institution involved in highway project construction such, Kigali City, MININFRA, MINECOFIN and RMF) and their representatives (Project Engineers, design Engineer, Quantity Engineer, Financial,), Consulting Firms (project managers) contractors and donors working in the highway construction field within RTDA.

In order to reduce bias, all the sampling within a stratum, i.e. the respondents' type was done at random without any regards to its social or geographical status. However, it was extremely important to collect at least statistically significant sample from each stratum. The total sample size for first phase of questionnaire survey was 78 engineers and project managers including 20 on the side of the contractors, 21 from the side of consultants, 34 from the side of owner/client (different government officials, like

MINECOFIN, MININFRA, RMF and RTDA) and 3 donors (World bank, European Union, and Africa Development Bank).

**Table 4**: Sample size for preliminary survey

| No | Institutions/Companies | Minimum Sample Size | Number of Questionnaires Allotted |
|---|---|---|---|
| 1 | Public Institutions | 34 | 34 |
| 2 | Consultants Companies | 21 | 21 |
| 3 | Contractors | 20 | 20 |
| 4 | Donors | 3 | 3 |
| | Total | **78** | **78** |

Concerning sample size for the second survey, it is advised to use Experts or experienced people in the field when you are using Fuzzy Vikor Method. The total sample size for Fuzzy Questionnaire was 11 Experts in the field.

**Table 5**: Sample size for second survey

| No | Proposed Decision Makers | Sample Size |
|---|---|---|
| 1 | Public Institutions Experts | 8 |
| 2 | Consultant Expert | 1 |
| 3 | Contractor Expert | 1 |
| 4 | Donor expert | 1 |
| | **Total** | **11** |

### 3.3.6 Data Analysis method

The method of data analysis employed in this work comprises both Relative Importance Index and Fuzzy Vikor methods. All data collected during the preliminary survey was recorded into the Excel sheet and analyzed using Relative Importance Index, where frequencies, means, and RII were computed to analyze the data obtained from respondents citing their experience in the Road/highway construction industry. The findings (critical criteria) from first survey were also recorded into Excel sheet computed and analyzed by Fuzzy Vikor Approach to prioritize these critical factors and tools (criteria) and investigate the interdependent relationship between the alternatives.

#### 3.3.6.1 Relative Importance Index (RII)

Kometa, S.T. et al. (1994) and Sambasivan, M. and Soon, Y. W. (2007) used the Relative Importance Index (RII) method to determine the relative importance of the various causes of delays. The same method was adopted in this study. The five-point Likert scale ranged from 1 (low performance) to 5 (high performance) was adopted and transformed to relative importance indices (RII) for each factor as follows:

$$RII = \Sigma \frac{w}{A * N}$$

Where: W is the weighting given to each factor by the 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.

The RII value had a range from 0 to 1 (0 not inclusive), higher the value of RII, more performance was critical success factors and tools for road/highway project time

delivery. The RII was used to rank (R) the different time management techniques and factors influencing time delivery to road /highway projects. These rankings made it possible to cross compare the relative importance of the factors as perceived by the respondents. The first five critical factors and tools have been retained and analyzed in the second stage with mathematical model Fuzzy-Vikor.

#### 3.3.6.2 Fuzzy Multi-Criteria Decision Making (MCDM)

Multi-criteria decision making (MCDM) as a modeling and methodological tool is used to deal with complex decision-making problems. MCDM has over the years become one of the most well-known branches of decision making applied in many disciplines. Fuzzy logic has proven to be a useful and efficient way in approaching MCDM in situations of imprecise or subjective data in our natural language expression of thoughts and judgments. Since Bellman and Zadeh proposed decision making in fuzzy environment, many extended theories and applications have been carried out to tackle various forms of MCDM. Among few of the Fuzzy MCDM applications are where fuzzy Entropy and t-norm based fuzzy compromise programming is used in locating nuclear power plants in Turkey. In, a fuzzy linear programming MCDM model is used in allocating orders to suppliers in a supply chain under uncertainty environment, employed fuzzy MCDM to measure the possibility of successful knowledge management. A hybrid fuzzy MCDM approach based on DEMATEL, ANP and TOPSIS is proposed to evaluate green suppliers and in a conjunctive MCDM approach also based on DEMATEL, fuzzy ANP, and TOPSIS is modeled as an innovation support system for Taiwanese higher education.

Fuzzy logic has been extended to almost all other MCDM techniques such as Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), ELimination and Choice Expressing REality (ELECTRE), Grey Relational Analysis (GRA), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE), Technique for Order

Preference by Similarity to Ideal Solution (TOPSIS), Weighte Product Model and **VI**sekriterijumska optimizacija i **KO**mpromisno **R**esenje (VIKOR).

### 3.3.6.3 Fuzzy Vikor Method

VIKOR is a compromise ranking method introduced by Opricovic [24]. The VIKOR method first establishes (1) a compromise ranking-list, (2) a compromise solution, and (3) the weight stability intervals for the compromise solution. It then determines the positive-ideal solution and the negative-ideal solution to aid in ranking and selection. The underlying principle of the VIKOR MCDM method is to deal with ranking and selection of alternatives which have multi-conflicting or non-commensurable criteria.

As is usual of most MCDM techniques, the VIKOR method was also extended to accommodate subjectivity and imprecise data under fuzzy environment. A number of applications from various disciplines have been carried out using the fuzzy VIKOR method. Fuzzy VIKOR is used in selecting insurance companies in a group decision making process whiles employed fuzzy VIKOR to resolve multi-criteria decision making problems. The method is used for supplier selection problems. However, the method is modified using entropy measure for objective weighting. Fuzzy VIKOR is utilized for optimized partners' choice in IS/IT out sourcing projects. The compromise method is used to select renewable energy project in Spain. Similarly, an integrated fuzzy VIKOR and AHP methodology is used to plan renewable energy in Istanbul. A combined form of fuzzy VIKOR and GRA techniques is utilized to evaluate service quality of airports, applied fuzzy VIKOR for material selection and used fuzzy VIKOR in a robot selection. Again in [39], fuzzy VIKOR based on DEMATEL and ANP is utilized in assessing information security risk control. The literature reviewed portrays the underlying principle of the VIKOR method for selecting and ranking problems but seldom applied in evaluation of service quality.

## 1.Fuzzy Set Theory

The human language is filled with imprecision, subjectivities and vagueness when used to judge, describe and communicate information. In view of this, Zadeh introduced the fuzzy set theory to model human judgments. The following are some useful definitions of the fuzzy set theory.

**Definition 1**: **Fuzzy Set**.

Let X be a nonempty set, the universe of discourse X = {$x_1$, $x_2$, $x_n$}. A fuzzy set A of X is a set of ordered pairs: {($x_1$, $f_A$ ($x_1$)), ($x_2$, $f_A$ ($x_2$)), $x_n$, $f_A$ ($x_n$))}, characterized by a membership function $f_A$ (x) which maps each element x in X to a real number in the interval [0,1]. The function value $f_A$ (x) stands for the membership degree of X in A. To capture the vagueness and variations in the subjective ratings of a decision maker, a fuzzy number is used. A Fuzzy number is an expression of membership functions of a linguistic term and ascribe a rating set between the interval [0, 1] for subjective ratings. The two most popular fuzzy numbers are the trapezoidal and triangular fuzzy numbers. In this paper we use the Triangular Fuzzy Number (TFN).

**Definition 2**: **Triangular fuzzy number**.

A triangular fuzzy number (TFN) is expressed as a triplet (a,b,c).The membership function $f_A$ (x) of a triangular fuzzy number is as defined in

Eqn 1:

$$f_A(x)=\begin{cases}0 & x<a, x>b\\ \dfrac{x-a}{b-a}, & a\le x\le b\\ \dfrac{c-x}{c-b}, & b\le x\le c\end{cases}$$

Fuzzy models that use TFNs prove to be effective for solving decision-making problems where the available information is subjective and vague.

**Definition 3**: **Basic TFN Operations**:

Assuming A= (a,b,c) and B= ($a_1$,$b_1$, $c_1$) are two TFNs, the basic operations on these two fuzzy triangular numbers are as follows:

$$A \oplus B = (a,b,c) + (a_1,b_1,c_1) = (a + a_1, b + b_1, c + c_1) \quad (2)$$

$$A - B = (a,b,c) - (a_1,b_1,c_1) = (a - c_1, b - b_1, c - a_1) \quad (3)$$

$$A \times B = (a,b,c) \times (a_1,b_1,c_1) = (aa_1, bb_1, cc_1) \quad (4)$$

$$A \div B = (a,b,c) \div (a_1,b_1,c_1) = \left(\frac{a}{c_1}, \frac{b}{b_1}, \frac{c}{a_1}\right) \quad (5)$$

## 2. Proposed Fuzzy Framework

The fuzzy VIKOR approach used in this study is organized in the following order. First, the importance weights of the evaluation criteria are determined and then the performance rating matrix is constructed. Second is the computation of the fuzzy best and worst values of the criteria. Normalized fuzzy difference and the separation values are also computed. Lastly, the triangular fuzzy numbers are defuzzified into crisp values to determine rankings of the alternatives and consequently a compromise solution is proposed. Moreover, an algorithm of the proposed fuzzy VIKOR method under fuzziness environment is described in the following:

### Step 1: Determining linguistic Variables

The first step in the fuzzy VIKOR method is to determine the linguistic variables; the criteria for evaluating the quality of internet health information. Linguistic terms

transformed into fuzzy numbers are used by the experts to rate each linguistic variable. Linguistic terms are qualitative words or phrases of a natural language that reflect the subjective view of an expert about the criteria per each alternative under consideration. In this study, triangular fuzzy numbers are used as shown in Table 8 and Table 9 respectively to capture the ratings of the criteria and alternatives on a scale of 0-1.

**Table 6**: Linguistic scale for importance of criteria

| Linguistic terms | | Triangular Fuzzy Number |
|---|---|---|
| Very low | (VL) | (0.0,0.1,0.3) |
| Low | (L) | (0.1,0.3,0.5) |
| Medium | (M) | (0.3,0.5,0.7) |
| High | (H) | (0.5,0.7,0.9) |
| Very High | (VH) | (0.7,0.9,1.0) |

**Table 7**: Linguistic scale for rating of alternatives

| Linguistic terms | Triangular Fuzzy Number |
|---|---|
| Very Poor (VP) | (0.0,0.0,0.2) |
| Poor (P) | (0.0,0.2,0.4) |
| Fair (F) | (0.2,0.4,0.6) |
| Good (G) | (0.4,0.6,0.8) |
| Very Good (VG) | (0.6,0.8,1.0) |
| Excellent (E) | (0.8,0.1,1.0) |

**Step 2: Determining importance weight of criteria**

To determine the importance weight of each criterion, the decision makers rate each criterion using the Linguistic terms in Table 8.

**Step 3: Constructing the fuzzy decision matrix**

Pull the decision makers' opinions to get the aggregated fuzzy importance weight of criteria, and aggregated fuzzy rating of alternatives. If there are *k* persons in a decision making committee.

**Step 4: Determine Fuzzy best value and fuzzy worst value** of all criteria functions.

Step 5: Normalized fuzzy difference

**Step 6: Computing separation Measures**

Computing the separation measures of alternatives from the fuzzy best value, similarly to the separation measures of alternatives from the fuzzy worst value.

**Step 7**: Computing triangular fuzzy number Qj

**Step 8***:* Defuzzification for triangular fuzzy number $Q_j$

In fuzzy logic, defuzzification is the process of converting the fuzzy numbers into crisp values. The defuzzification is computed by locating the Best Non fuzzy Performance (BNP). A range of defuzzification methods such as Center of Area (COA), mean of maximum and weighted average method can be used. This paper uses the defuzzification method of COA for ranking fuzzy numbers. The defuzzification process converts triangular fuzzy number into crisp value

**Step 9: Ranking the alternatives**

The crisp value of the alternatives for Q is ranked from the smallest value to the highest value.

# CHAPITRER 4: RESULTS AND ANALYSIS

This chapter presents findings from the Surveys and interpretation of the results (outputs) obtained using Relative Importance Index (RII) method for preliminary survey to extract factors and tools in order to obtain those which are critical for road project performance and multi criteria decision making (**MCDM)** with mathematical model Fuzzy Vikor. It describes also the demographic or personal information data of respondents

## 4.1 Personnel Information of Respondents

### 4.1.1 Age

Figure 6 indicates the frequency of respondents‟ age from public institutions, contractors and consultants. Respondents that are over the age of thirty predominate in the sample investigated. This group of respondents constitutes 85%. Respondents between the age of twenty-five and thirty constitute 15 %. It can be concluded that respondents that make up the survey sample are mature, have a high probability of being responsible, and sufficiently experienced.

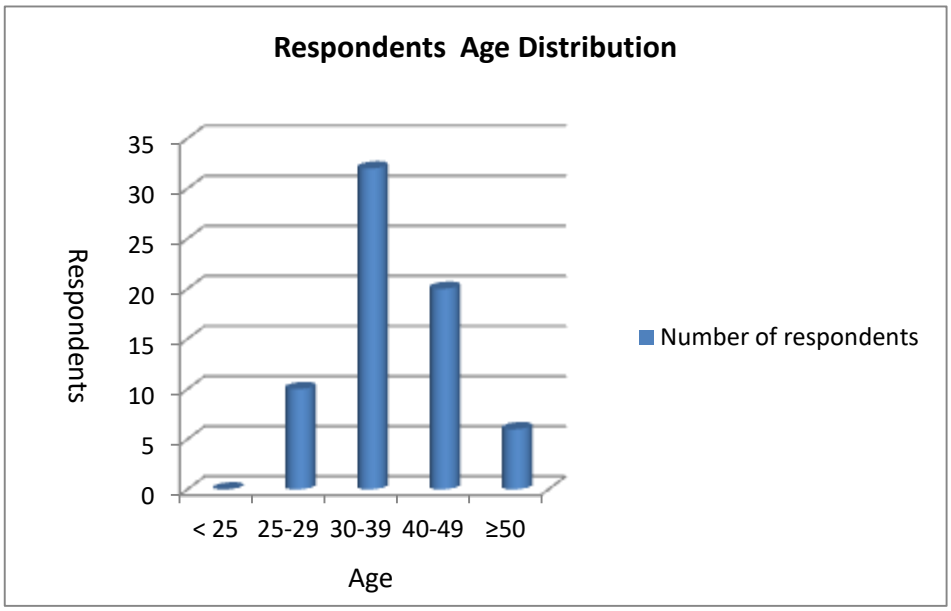


**Figure 6**: Respondents age distribution

### 4.1.2 Gender

Figure 7 reveals that the male gender predominates with 74% in both public and private road construction industry. This supports the statement that the industry is masculine-inclined.

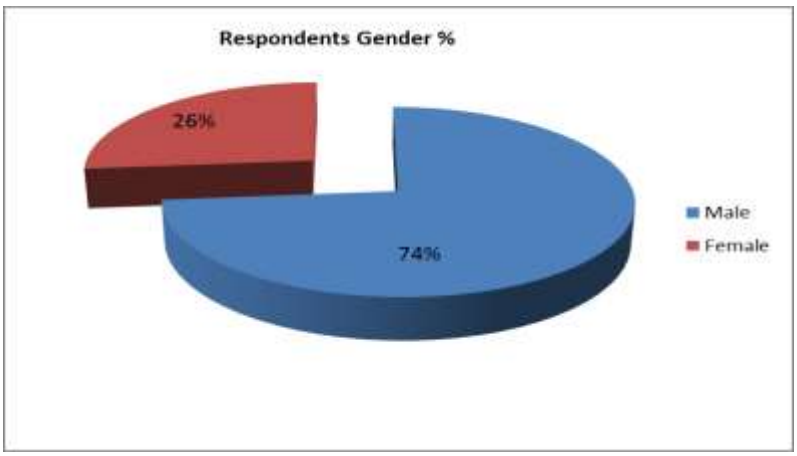


**Figure 7**: Respondents gender distribution

### 4.1.3 Education Level

Figure 8 indicates the academic qualification of the respondents. 73.5 % of the respondents have bachelors‟ degrees, and they predominate in the sample. Following are respondents Masters‟ degrees, totaling 14.7%. Respondents with Pre- University qualification rank next in the form of 11.8 %. This analysis reveals that well qualified personnel are employed in the road construction industry therefore performance is expected to be optimal. It also indicates that their perceptions can be relied on.

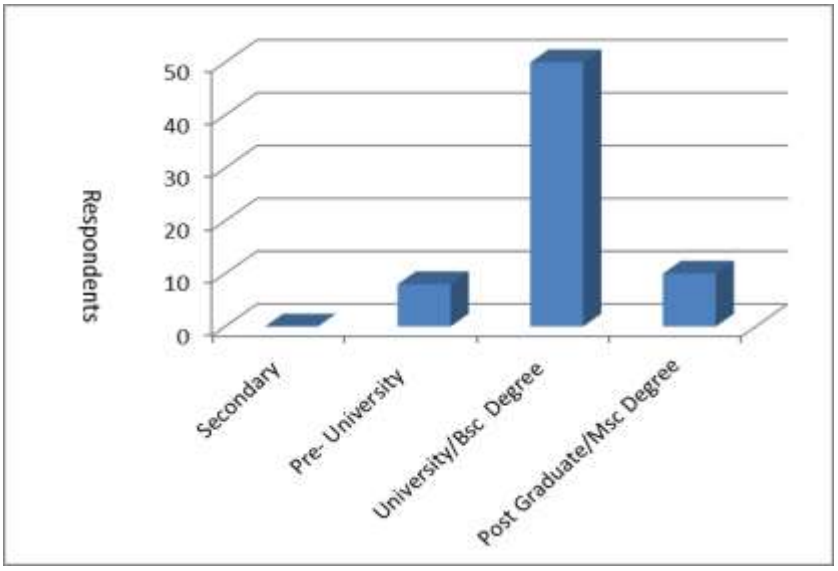


**Figure 8**: Qualification level of respondents

### 4.1.4 Organization types

Figure 9 indicates the organization types of the respondents. Roads construction industry has four stakeholders, Owner, Donor, Consultants and contractors. In this research all these stakeholders have been questioned as institutions which daily for up implementation of the projects. 44% are from Public institutions (Client) which dominate in the sample, 25% from Contractors, 26 from consultant firms and 5% from donors.

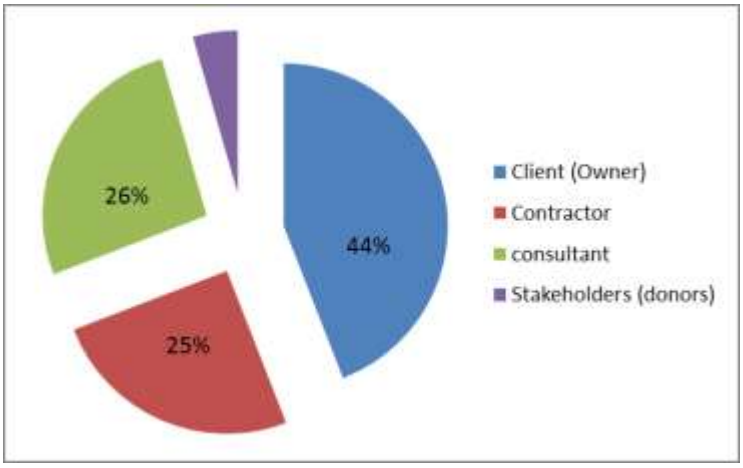


**Figure 9**: Organization types of respondents

### 4.1.5 Occupation level

Figure below indicates the respondents' positions or occupation levels in their organizations 65% are staff in charge of projects management in their daily activities whereby the executive and managerial levels have 23% and 12% respectively.

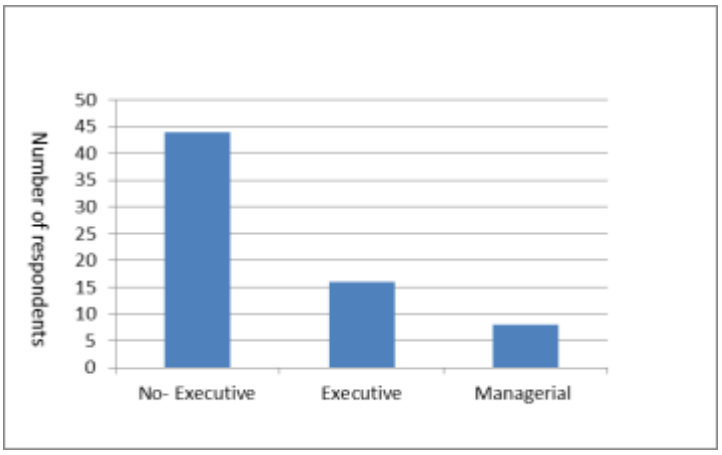


**Figure 10**: Respondents occupation level

### 4.1.6 Respondents Working Experience

Figure 11 indicates working experience of the respondents. 50% of the respondents have over four year of experience, and they predominate in the sample. Following are respondents of over Eight year of Experience, totaling 32%. The remaining 18% of Respondents have over Twelve year of experience. Therefore, the data obtained from these respondents can be deemed to be reliable.

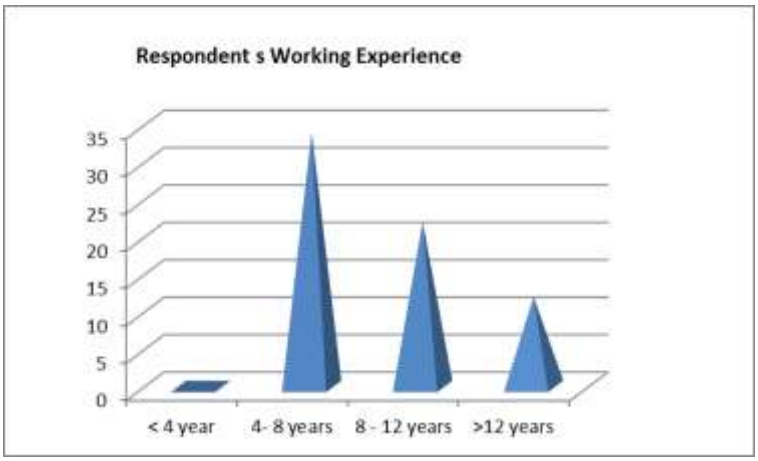


**Figure 11**: Respondents working experience

### 4.1.7 Size of Project based on Contract Sum

Figure 12 indicates Size of Project based on Contract Sum realized by respondents, 48% road projects have the size under $ One Million, these projects are mainly classified as in Road District Class One and Two and they predominate in the sample. Following are Road project with size above $ Ten Millions, totaling 43%. The last one pertained to the road District Class One Two and National. The remaining 9% of road projects are about over $ Ten Millions and they are especially classified as National road.

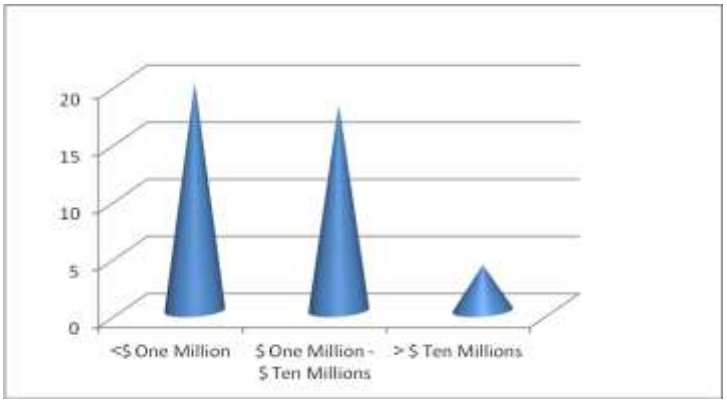


**Figure 12:** Size of project based on contract sum

### 4.2 Result and Analysis from questionnaire of preliminary Survey

The relative importance index, RII, was computed for each factor and sub-factor related to road project time delivery (Critical success factors), and time management tools to identify the most critical success factors to the road projects delivery time and most time management tools. A five-point Likert scale {low performance (1) to extremely high performance (5)} was used for respondents scoring. During this survey, for 78 questionnaires distributed, 68 were responded. According to the computed RII values, these factors, sub-factors and tools were ranked.

**Table 8:** Effective of time management tools

| **I** | **Time management Tools** | **Frequency** | | | | | **RII** | **RANK** |
|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | | |
| I.1 | Critical Path Method (CPM) | 0 | 2 | 10 | 25 | 30 | 0.835 | **1** |
| I.2 | Gantt Bar Chart (GC) | 4 | 6 | 10 | 20 | 28 | 0.782 | **2** |
| I.3 | PERT | 2 | 7 | 16 | 18 | 25 | 0.768 | **3** |
| I.4 | GERT | 11 | 14 | 17 | 10 | 16 | 0.618 | **8** |
| I.5 | Precedence Network Diagram | 9 | 12 | 11 | 16 | 20 | 0.676 | **6** |
| I.6 | Milestones Chart | 4 | 9 | 15 | 15 | 25 | 0.741 | **4** |
| I.7 | Microsoft Project | 8 | 11 | 10 | 17 | 22 | 0.700 | **5** |
| I.8 | Simulation | 10 | 13 | 12 | 14 | 19 | 0.656 | **7** |
| I.9 | Line of balance | 12 | 15 | 14 | 10 | 17 | 0.615 | **9** |

**Table 9:** Top five most effective time management tools

| **Time management Techniques** | **RII** | **RANK** |
|---|---|---|
| Critical Path Method (CPM) | 0.835 | 1 |
| Gantt Bar Chart | 0.782 | 2 |
| PERT | 0.768 | 3 |
| Milestone Chart | 0.741 | 4 |
| Microsoft Project | 0.700 | 5 |

According to table 9, the respondents rated Critical Path Method (CPM) is the most effective time management tool. This indicates that respondents believe that this technique is very effective in controlling and monitoring the progress of road construction projects. Coincidently, second most effective tool of time management is Gantt Bar Chart. However, third and fourth effective technique is PERT and Milestones Chart respectively. The least effective tool for Top Five most Effectiveness of time management tools is Microsoft Project (MP).

**Table 10:** Ranking of factors influencing road project delivery time according to RII

| **Factors influencing time delivery** | | **FREQUENCY** | | | | | **RII** | **RANK** |
|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | | |
| **clients' understanding of design, procurement and construction processes** | Understanding the project's constraints | 2 | 14 | 28 | 22 | 2 | 0.624 | 61 |
| | Ability to effectively brief the design team | 6 | 14 | 27 | 2 | 19 | 0.641 | 53 |
| | Ability to contribute ideas to the design process | 1 | 17 | 24 | 22 | 4 | 0.632 | 57 |
| | Ability to quickly make authoritative decisions | 2 | 21 | 25 | 12 | 8 | 0.609 | 66 |
| | Stability of decisions | 2 | 21 | 25 | 10 | 10 | 0.615 | 64 |
| | Ability to contribute ideas to the construction process | 10 | 7 | 22 | 29 | 0 | 0.606 | 67 |
| **Quality management during design**. | Conflicting design information | 2 | 3 | 47 | 7 | 9 | 0.653 | 49 |
| | Timeless of revised drawings issue | 0 | 18 | 25 | 25 | 0 | 0.621 | 62 |
| | Missing information | 0 | 14 | 27 | 27 | 0 | 0.638 | 54 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Dimensional inaccuracies | 2 | 14 | 35 | 17 | 0 | 0.597 | 70 |
| | Expediting shop drawings | 10 | 11 | 21 | 25 | 1 | 0.588 | 73 |
| **quality of management during construction** | Forecasted planning date, e.g. activity duration, resource quantities required, etc. | 7 | 6 | 12 | 15 | 28 | 0.750 | 18 |
| | Analyzing construction methods | 3 | 3 | 44 | 8 | 10 | 0.656 | 48 |
| | Analyzing resource movement to and on site | 10 | 4 | 14 | 26 | 14 | 0.688 | 37 |
| | Analyzing of work sequencing to achieve and maintain workflow | 3 | 4 | 16 | 22 | 23 | 0.771 | 14 |
| | Monitoring and updating plans to appropriately reflect work status | 4 | 7 | 17 | 20 | 20 | 0.732 | 24 |
| | Responding to recover from problems or taking advantage of opportunities | 7 | 1 | 17 | 17 | 25 | 0.744 | 20 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | presented | | | | | | | |
| | Effectively coordinating resources | 1 | 5 | 14 | 21 | 27 | 0.800 | 8 |
| | Developing an appropriate organizational structure to maintain workflow | 5 | 2 | 11 | 23 | 27 | 0.791 | 11 |
| **Constructability design** | Scope of site fabrication | 30 | 0 | 0 | 10 | 28 | 0.618 | 63 |
| | Complexity of off-site fabricated components | 3 | 16 | 23 | 21 | 5 | 0.626 | 59 |
| | Appropriateness of design tolerances | 2 | 14 | 35 | 17 | 0 | 0.597 | 70 |
| | Appropriateness of working space. Its impact on smooth activity workflow and sequencing | 7 | 3 | 23 | 17 | 18 | 0.706 | 33 |
| | Implication upon trade co-ordination's | 3 | 8 | 35 | 6 | 16 | 0.671 | 43 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Impact of materials storage and movement | 3 | 8 | 35 | 5 | 17 | 0.674 | 42 |
| | Extent of grouping simultaneous | 18 | 20 | 0 | 0 | 30 | 0.612 | 65 |
| | Extent of modular dimensions in design | 2 | 16 | 24 | 22 | 4 | 0.629 | 58 |
| | Knowledge of performance of materials and components | 8 | 0 | 20 | 20 | 20 | 0.729 | 25 |
| | Effective constructability review of design | 0 | 0 | 40 | 28 | 0 | 0.682 | 39 |
| | Participation in site inspection and control | 7 | 5 | 11 | 15 | 30 | 0.765 | 15 |
| **Techniques for planning and control** | Critical path methods | 0 | 0 | 18 | 19 | 31 | 0.838 | 3 |
| | Bar chart | 2 | 6 | 12 | 20 | 28 | 0.794 | 10 |
| **Management style** | Specified goals people are to accomplish | 2 | 3 | 10 | 22 | 31 | 0.826 | 4 |
| | Organized the work situation for people | 8 | 0 | 18 | 18 | 24 | 0.747 | 19 |
| | Set time lines | 0 | 1 | 12 | 20 | 35 | 0.862 | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Provided specific direction | 3 | 1 | 14 | 19 | 31 | 0.818 | 6 |
| | Required regular reporting on progress | 2 | 3 | 13 | 18 | 32 | 0.821 | 5 |
| | Provide support and Encouragement | 6 | 5 | 13 | 18 | 26 | 0.756 | 17 |
| | Involved team member through discussion of work | 4 | 3 | 13 | 16 | 32 | 0.803 | 7 |
| | Sought people's opinion and concerns | 9 | 0 | 17 | 32 | 10 | 0.700 | 34 |
| **Motivation staff** | Pay an allowance | 3 | 7 | 38 | 11 | 9 | 0.647 | 51 |
| | Achievement from meeting complex challenges | 10 | 5 | 10 | 40 | 3 | 0.662 | 46 |
| | Job security | 4 | 8 | 18 | 18 | 20 | 0.724 | 27 |
| | A sense of belonging and identification with project team | 10 | 4 | 10 | 17 | 27 | 0.738 | 22 |
| | Recognition (monitoring or kudos) of contribution made | 4 | 12 | 12 | 20 | 20 | 0.718 | 29 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Opportunity to extent skills and experience learning | 15 | 2 | 8 | 13 | 30 | 0.721 | 28 |
| | Equitable rewards relative to other's input to the project | 12 | 3 | 15 | 17 | 21 | 0.694 | 36 |
| | Exercise of power | 30 | 0 | 0 | 10 | 28 | 0.618 | 63 |
| | Opportunity for career advancement – i.e. for future benefit | 10 | 4 | 10 | 42 | 2 | 0.665 | 45 |
| **Site ground conditions** | Nature of demolition works | 5 | 15 | 28 | 0 | 20 | 0.644 | 52 |
| | Nature of restoration works | 10 | 4 | 15 | 25 | 14 | 0.685 | 38 |
| | Structural stability of work | 3 | 6 | 12 | 18 | 29 | 0.788 | 12 |
| | Extent of ground contamination | 3 | 8 | 35 | 3 | 19 | 0.679 | 40 |
| | Extent of archaeological finds | 2 | 3 | 47 | 7 | 9 | 0.653 | 49 |
| | Impact of water table | 5 | 9 | 13 | 25 | 15 | 0.697 | 35 |
| | Impact of underground services | 0 | 0 | 30 | 38 | 0 | 0.712 | 31 |
| | Impact of underpinning | 7 | 0 | 24 | 37 | 0 | 0.668 | 44 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | existing structure | | | | | | | |
| **Site access** | Proximity to required resources | 7 | 3 | 15 | 21 | 22 | 0.741 | 21 |
| | Access to site entry/exit point | 16 | 12 | 18 | 13 | 19 | 0.709 | 32 |
| | Congestion at site entry / exit points | 4 | 12 | 13 | 19 | 20 | 0.715 | 30 |
| | Storage space at or near ground level | 0 | 7 | 46 | 3 | 12 | 0.659 | 47 |
| | Storage at upper level | 5 | 15 | 28 | 0 | 20 | 0.644 | 52 |
| | Requirement for restrictive hours | 7 | 3 | 18 | 20 | 20 | 0.726 | 26 |
| **Physical Environmental** | Impact of natural hazards (fire, flood, etc) | 1 | 0 | 52 | 15 | 0 | 0.638 | 55 |
| | Local weather patterns on site | 3 | 8 | 35 | 4 | 18 | 0.676 | 41 |
| | Ambient noise condition | 7 | 15 | 25 | 15 | 6 | 0.594 | 71 |
| | Ambient light condition | 5 | 12 | 34 | 15 | 2 | 0.591 | 72 |
| **Economic policy** | Material availability | 3 | 0 | 10 | 22 | 33 | 0.841 | 2 |
| | Equipment availability | 1 | 4 | 15 | 23 | 25 | 0.797 | 9 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Trade /operative availability | 8 | 2 | 11 | 22 | 25 | 0.759 | 16 |
| | Supervision /management staff availability | 5 | 9 | 9 | 22 | 25 | 0.774 | 13 |
| | Indirect impact of interest rate /inflation | 0 | 15 | 25 | 27 | 0 | 0.626 | 60 |
| | Insolvencies and bankruptcies | 7 | 7 | 13 | 15 | 26 | 0.735 | 23 |
| **Social-political condition** | Civil strife or riots | 1 | 6 | 45 | 7 | 9 | 0.650 | 50 |
| | Influence of protest action groups | 0 | 0 | 52 | 14 | 1 | 0.638 | 56 |
| | Disruption due to environment concerns (fire, noise , floor etc | 14 | 0 | 25 | 29 | 0 | 0.603 | 68 |

Table 10 indicates the influence of seventy-six factors on project delivery time. Setting time lines has the highest influence with a RII of 0.862, which means that time lines must be defined for every activity on site. This will afford measurement of performance. The availability of materials is ranked second (RII = 0.841), no materials, despite the availability of other resources will result in no progress on the project. CPM is ranked third (RII = 0.838) in terms of influence on project delivery time, this planning and control tool has the advantage revealing critical activities of a project from start to the end. This affords good control of project activities and enhances prompt delivery. The specification of goals people is to accomplish is ranked fourth (RII = 0.826). This

provides the opportunity for the division of the whole tasks of the project. Allocating of tasks will assist in measuring performance. It is also a means of finding out whether the project is on or behind schedule. The performance of the project is seen and early corrective measures taken if need be.

Required regular reporting on the project is ranked fifth (RII = 0.821). Actual performance should be measured against planned performance to find out whether the project is progressing as planned. In the instance where this is not done regularly, the project might be delivered late. This may be a result of non-performance that is not detected early enough.

Provide specific direction is ranked sixth (RII = 0.818). The crew members should be aware of the specific direction the project is geared to. This will assist them in preparing for the various tasks to be executed in the form of the various equipment and materials that will be needed for the performance of these tasks.

Involving team members through discussion of works is ranked seventh (RII = 0.803). The concept of allowing workers to understand that they belong to the team secures their commitment to work, thereby positively affecting productivity. Project performance is negative when workers are not kept informed about the day-to-day running of an organization.

Effectively coordinating of resources is ranked eighth (RII = 0.800). Coordination of resources eliminates chaotic situations. The lack of coordination of resources may lead to non-sequencing of activities and may result in delays on project delivery.

Equipment availability is ranked ninth (RII = 0.797). The availability of equipment assists in getting jobs done quickly, while the lack of equipment leads to delays.

The bar chart planning and control tool is ranked tenth (RII = 0.794). The tool is simple to understand. This may be the reason for its ranking.

**Table 11**: Top ten most influence factors to the road project delivery time according to RII

| **Sub factors** | **RII** | **Rank** |
|---|---|---|
| Set time line | 0.862 | 1 |
| Material availability | 0.841 | 2 |
| Critical Path Method | 0.838 | 3 |
| Specified goals people are to accomplish | 0.826 | 4 |
| Required regular reporting on progress | 0.821 | 5 |
| Provided specific direction | 0.818 | 6 |
| Involved team member through discussion of work | 0.803 | 7 |
| Effectively coordinating resources | 0.800 | 8 |
| Equipment availability | 0.797 | 9 |
| Bar chart | 0.794 | 10 |

**Table 12:** Ranking category factors influencing road project delivery time according to RII

| **No** | **Category Factors influencing time delivery** | Frequency | | | | | RII | Rank |
|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | | |
| 1 | Client understanding of design, procurement, and construction Process | 1 | 2 | 5 | 14 | 46 | 0.900 | 2 |
| 2 | Quality management during design. | 1 | 3 | 6 | 22 | 36 | 0.862 | 6 |
| 3 | quality of management during construction | 0 | 4 | 4 | 18 | 42 | 0.888 | 3 |
| 4 | Constructability design | 3 | 3 | 4 | 20 | 38 | 0.856 | 7 |
| 5 | Techniques for planning and control | 0 | 0 | 0 | 24 | 44 | 0.929 | 1 |
| 6 | Management Style | 0 | 0 | 8 | 25 | 35 | 0.879 | 4 |
| 7 | Motivation staff | 1 | 3 | 9 | 22 | 33 | 0.844 | 9 |
| 8 | Site ground condition | 0 | 1 | 9 | 30 | 28 | 0.850 | 8 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | Site access condition | 2 | 7 | 13 | 17 | 29 | 0.788 | 12 |
| 10 | Physical Environmental | 0 | 8 | 11 | 19 | 30 | 0.809 | 10 |
| 11 | Economic policy | 2 | 2 | 8 | 16 | 40 | 0.865 | 5 |
| 12 | Social-political condition | 4 | 6 | 8 | 17 | 33 | 0.803 | 11 |

Table 12 indicates that the most effective means by which performance can be improved with time management on road projects, according to the perceptions of respondents, are through the use of effective planning and control techniques (RII:0.929). This is followed by and clients understanding of the design, procurement, and construction processes (RII: 0.900) and quality of management during construction (RII: 0.888). The categories of factors ranked fourth and fifth are: Management Style, (RII: 0.879) Economic policy (RII: 0.865), respectively.

The least influencing factors categories are, Physical Environmental, socio-political conditions and site access. These categories of factors were not commented upon.

**Table 13**: Top five most influence category of factors to the road project delivery time according to RII rank

| **Factors influencing time delivery** | **RII** | **Rank** |
|---|---|---|
| Techniques for planning and control | 0.929 | 1 |
| Client understanding of design, procurement, and construction Process | 0.900 | 2 |
| quality of management during construction | 0.888 | 3 |
| Management Style | 0.879 | 4 |
| Economic policy | 0.865 | 5 |

The results of this chapter have demonstrated the ranking of the factors, factors categories and time management tools according to their performance level on road project delivery time by using Relative Importance Index (RII) method.

The computed RII's of factors, categories factors and tools will make it possible to assign the fuzzy rules' weights to construct "the fuzzy framework to evaluate, compare and rating of Time Management Techniques and Critical Success Factors (CSF) with road project time delivery performance.

### 4.3 Result and Analysis from questionnaire of second Survey

The Twenty (21) criteria of two (2) alternatives such as time management tools and critical success factors with time management in road construction identified during the literature, were incorporated in questionnaire for preliminary survey and analyzed by Relative Importance Index (RII) method. The findings (10 criteria) for two (2) alternatives served to determine new set of criteria to be used for construction of Framework for evaluating, ranking and compare technical tools and critical success factors with time management for road construction project for second survey using Fuzzy Vikor Method. During the second survey the respondents were asked to rate with respect to technical tools and critical success factors with time management for road construction project. All questionnaire addressed to Eleven experts were responded.

**Figure 13:** Proposed fuzzy framework

**PROPOSED FUZZY FRAMEWORK**

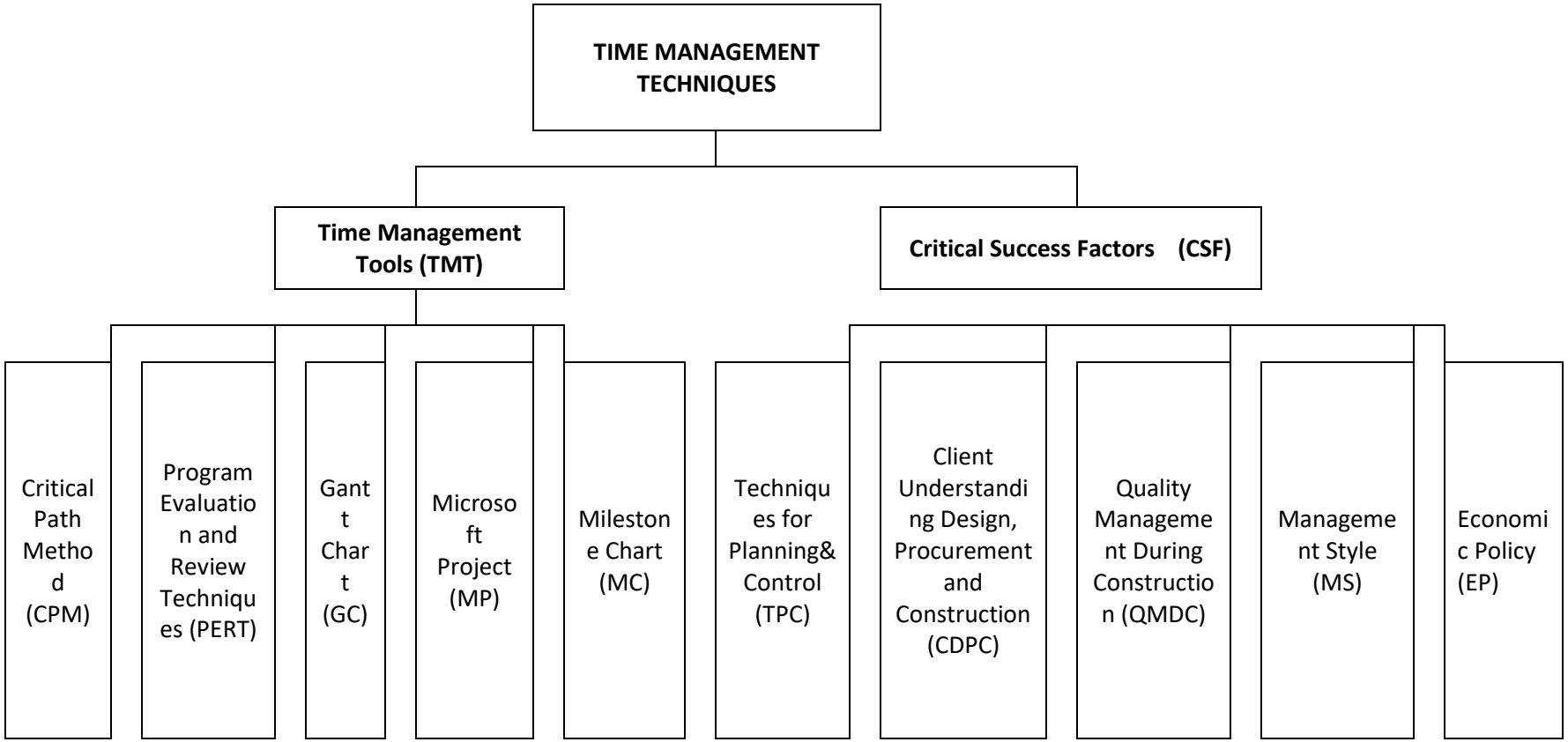

**Table 14**: Aggregate results with respect to technical tools and critical success factors with time management

| **Time management techniques Criteria** | **Weight (BNP)** | **Rank** |
|---|---|---|
| Client understanding of Design, Procurement, and Construction Process (CDPC) | 0.697 | 1 |
| Techniques for Planning and Control (TPC) | 0.690 | 2 |
| Critical Path Method (CPM) | 0.667 | 3 |
| Gantt Chart (GC) | 0.600 | 4 |
| Quality of Management During Construction (QMDC) | 0.587 | 5 |
| PERT | 0.570 | 6 |
| Management Style (MS) | 0.543 | 7 |
| Milestone Chart (MC) | 0.517 | 8 |
| Economic policy (EP) | 0.500 | 9 |
| Project Management Software(PMJ) | 0.487 | 10 |

Rating the most important criteria for the evaluation is guided by the linguistic terms in Table 6.

By the Best Non Fuzzy Performance (BNP) value computation, the 5 major influential criteria out of the 10 are Client understanding of Design, Procurement, and Construction Process with a rank of 1 and Techniques for Planning and Control, Critical Path Method (CPM), Gantt Chart, Quality of Management During Construction with a

rank of 2,3,4 and 5 respectively. The least important criterion would be Project Management Software with a rank of 10.

**Table 15**: Aggregates results for ranking two alternatives

| Alternatives | Time management tools (A1) | Critical Success factors with time management (A2) |
|---|---|---|
| Crisps value for alternatives | -0.008 | 0.00 |
| Ranking | 1 | 2 |

In this case rating the most important criteria for the evaluation guided by the linguistic terms in Table 7

*In the aforementioned table 15 the crisps value for alternatives is ranked from the smallest to the highest value*.

According to all responses, Time Management Techniques is the most important criteria with respect to the project performance as it has been ranked the first (more influential) compared to the Critical Success Factors with time management with -0.008 and 0.00 respectively.

# CHAPITER FIVE: CONCLUSION AND RECOMMANDATION

## 5.1 Conclusion

Timely completion of construction project is one of the criteria of the success in project, on the other hand many of Road construction project encounter time overrun and it became common issue in Rwanda Road construction Projects and this affect project performance. Through this study, Time Management Techniques and high influential factors for improving road construction performance were established in order to minimize or reduce delays.

The study further, established that Time Management Techniques is the most important criteria with respect to the project performance as it has been ranked the first compared to the Critical Success Factors with time management. It is concluded that the Critical Path Method, a technical tool employed in the planning and control of activities positively impacts on road project delivery time, probably as a result of its capacity to identify key construction activities of a project.

On the other hand, the following factors; Client understanding of Design, Procurement, and Construction Process, Techniques for Planning and Control (Critical Path Method and Gantt Chart) Quality of Management During Construction, Management Style and Economic policy are respectively ranked as the most influential factors for improving highway projects performance**.**

Enhanced performance contributes to the sustainability of the cycle through the reinforcement of client awareness and consequently, client commitment. Clients are the initiators of a project. Therefore, special attention and much effort are needed for all stakeholders operated in road industry, especially for Clients, (Owners) for implementing and selecting suitable and effective time management techniques which is very helpful in controlling road projects time performance through the support of Critical success factors in term of time management.

## 5.2 Limitations

The study reported should be considered with some limitations in mind. Due to ease of access to information, this research is narrowed in scope to the Rwanda Transport Development Agency (RTDA) for Construction and rehabilitation projects within the period of 2010 to 2014. Therefore, the results and recommendation are reflected directly to the Consultant and Contractors which work together with RTDA and RTDA's Project Engineers. Time, cost and quality are typically used as the key criteria for planning and assessing project performance in the construction industry. This study was focused only on the time management techniques, therefore further researchers are recommended to establish Awareness and Implementation of cost and quality management techniques in road projects for improving performance.

## 5.3 Guidance and Recommendations

In order to reduce or minimize delay for road project in Rwanda Transport Development Agency (RTDA), the time management techniques especially Critical Path Method with Critical success factors to road project time delivery identified in this study need to be understood and Implemented. On the other hand, it is important to ensure that project time delivery and client satisfaction enhancement factors are optimized.

The results of the study reported in this dissertation can help project managers and owners (clients) to carefully monitor their projects by looking out especially for factors with high importance indices on projects.

The time management techniques and Critical success factors to road project time delivery identified in this study need to be carefully monitored and studied by RTDA project managers to be implemented for improving road project performance.

This can be achieved by taking into considerations the following guidance and recommendations.

- Projects need to be carefully and proficiently planned in terms of time, cost and quality. In an event that they occur on a project, they are more likely to offset the project objectives and might result in project failure. To effectively deal with the problem of insufficient initial analysis of projects, there is need to ensure feasibility studies are conducted to a significant level of detail that outlines the possible outcomes of a project. Prior to tendering and subsequent awarding of contracts, adequate and comprehensive documents should be readily available. Such documents should be adequate in terms of the initial analysis of costs, scope of works to be executed and the expected duration.

- During the design stage, the team of RTDA undertakes the design and specifications. Constructability reviews should be conducted at the design stage. This will be useful in terms of ease of construction and realization of on schedule project. Investing quality time at the design stage is crucial to design being devoid of revisions, missing information and dimension ambiguity.

- Client (project Engineer) has to review the Soil investigation and testing conducted by Consultants before approval prior to the commencement of a project. This will assist in the designing of road structures and reveal the features of the site ground conditions.
- Clients should evaluate the quality performance of contractors before awarding a contract. The benefit of this is a motivation for contractors to improve and document their quality management in order to be competitive and maintain a continuous flow of business.

- For large projects, the evaluation of contractors' technical and financial performance. This will result in a better understanding of the contractors' overall

capabilities. The hiring of a materials manager to independently supervise and monitor the progress of the construction work will contribute significantly to on-time delivery of materials to sites.

- Clients should set aside the funding that is required for the completion of the project long before the contract is placed;
- Quality Management Guide line or standard established by RTDA should be enforced by consultant on projects. Stakeholders should be committed to quality management, designers included. Designers" quality management should focus on the following: Committed to providing a quality service; Production of correct and complete drawings and specifications; Coordinating and checking of design documentation; Conducting design verification through design analysis reviews, and conducting constructability reviews.
- Effective coordination, is also a tool for project success, therefore road construction projects require managers with excellent coordination skills that are not limited to organizing plant, materials, equipment and work items but also the human resource, which to a greater extent, have a significant impact on project outcomes.
- Construction activities are carried out by laborers, adequate motivation should be given to workers as motivation is defined as a tool for high productivity
- Applied appropriate procurement to facilitate the contractors and consultants pre-qualification. Competence and experience of contractors and consultants was identified to be crucial in assuring project success. Competent and experienced consultants would ensure that the documents prepared for projects are comprehensive and adequate. They should also have the right skills and expertise to deal with contractors during the construction supervision phase. On the other hand, competent and experienced contractors would ensure project success through timely and cost effective construction. Quality of works performed would also be assured.

- During the supervision stage, Consultant and Client are recommended to avoid, the late revision of design, late resolution of design ambiguity, late provision of information, late issuance of instruction, slowness in approval of works done and late payment
- During the survey conducted in this study, a gap in using time management tools in road construction stage was identified. RTDA has to improve project management training to all stakeholders operated in road project especially for Project managers.

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# APPENDICES

**Cover letter to the Questionnaire**

**DEPARTMENT OF CIVIL ENGINEERING, ENVIRONMENTAL AND GEOMATIC ENGINEERING**

**SCHOOL OF ENGINEERING**

**(Nyarugenge Campus)**

**COLLEGE OF SCIENCE AND TECHNOLOGY**

**MSc PROGRAMME IN HIGHWAY ENGINEERING AND MANAGEMENT**

**P.O. Box: 3900 Kigali, Rwanda.**

Name: KABURAME UMUGWANEZA Providence
Reg No: 217302467
10 May 2017

Dear Sir/Madam,

**Questionnaire survey on implementation of time management techniques in highway projects for improved performance: case study in Rwanda Transport Development Agency (RTDA).**

I'm presently pursing a Master of Engineering Degree in Highway Engineering and Management (HEM) by research at University of Rwanda (College of Science and Technology). My research topic is Implementation of Time management Techniques in Highway projects for improved performance: case study in Rwanda Transport Development Agency (RTDA).

The study seeks to assess the frequency of occurrence, severity of impact and atrociousness of implementation of time management techniques in highway project for improved performance.

It is also document the Critical Success Factors (CSF) associated with the effective use and implementation of Time Management Techniques for Highway Projects in Rwanda.

This questionnaire consists of three parts, the first one is for respondent information, and the second part is for Time Management Techniques while the third one is Critical Success Factors (CSF) associated with the effective use and implementation of Time Management Techniques for Highway Projects in Rwanda. The option of evaluation is based upon Likert scale ranging from low performance (1st level) to extremely high performance (5th level).

The result obtained from this study will provide empirical results that can be used in developing highway project management model in RTDA.
Enclosed herewith, please find a questionnaire, and based on your experience as a professional in the field of highway construction, kindly spare a few minutes of your valuable time to complete it. Please answer all questions where possible. All the information gathered will be kept strictly confidential and will be used for the research and analysis without mentioning the name of individuals or companies involved.

Should there any queries, please do not hesitate to get in touch with undersigned on e-mail k.umugwaneza@gmail.com or umupro354@yahoo.fr and phone number +250 788761199 or 250 728761199. Your assistance and cooperation will be highly appreciated.

Thank you in advance for your time and kind cooperative.

Yours faithfully,

K. UMUGWANEZA Providence

**Section I: Respondent's Information**

Please Tick on the appropriate answer below

**1. In what age group are you?**

- ◯ <25
- ◯ 25-29
- ◯ 30-39
- ◯ 40-49
- ◯ ≥50

**2. Gender**

- ◯ Male
- ◯ Female

**3. What language (s) can you speak, read and write?**

- ◯ Kinyarwanda
- ◯ English
- ◯ French
- ◯ Kinyarwanda and English
- ◯ Kinyarwanda and French
- ◯ English and French
- ◯ Kinyarwanda, English and French

**4. Education Background**

- ◯ Secondary
- ◯ Pre- University
- ◯ Bachelor's Degree

◯ University/Bsc Degree

◯ Post Graduate/Msc Degree _____

**5. Area of Specialization**

◯ Civil Engineering

◯ Architecture

◯ Electrical Engineering

◯ Mechanical Engineering

◯ Surveying

◯ Accountancy

◯ Others, please indicate _____

6. Type of organization

☐ Client (Owner) ☐ Contractor

☐ Consulting Firm ☐ donors

☐ Other please specify _____

7. Company's specialization

☐ Road Construction ☐ Building Construction

☐ Highway and Building Construction ☐ Others, Specify _____

8. Working position in the organization

☐ Main Contractor ☐ Project Manager

☐ Site Engineer ☐ Site Supervisor

☐ Quantity Surveyor ☐ Other, Specify _____

9. Respondent's Experience

☐ Below 5 ☐ 5 – 10

☐ 11 – 15 ☐ 16 – 20

☐ Above 20

10. Projects to date handled

☐ 1 – 3 ☐ 4 – 6

☐ 7 – 9 ☐ Above 10

**Section II** : **Time management techniques practice questions**

11. Extent to which effective use and implementation time management techniques lead to improved project performance,

Based upon Likert scale ranging low performance (1st level) to extremely high performance (5th level), kindly rate the following time management techniques used in highway project in Rwanda

| **I** | **Time management Techniques** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|---|
| I.1 | Critical Path Method (CPM) | | | | | |
| I.2 | Gantt Bar Chart | | | | | |
| I.3 | Project Evaluation and Review Techniques (PERT) | | | | | |
| I.4 | Graphical Evaluation and Review Technique (GERT) | | | | | |
| I.5 | Precedence Network Diagram | | | | | |
| I.6 | Milestones Chart | | | | | |
| I.7 | Microsoft Project | | | | | |
| I.8 | Simulation | | | | | |
| I.9 | Line of Balance | | | | | |

**Section Three**

Critical Success Factors (CSF) associated with the effective use and implementation of Time Management Techniques for Highway Projects in Rwanda,

12. Based upon Likert scale ranging from low performance (1st level) to extremely high performance (5th level), kindly rate the extent to which the following factors categories influence project delivery time

| No | **Factors influencing time delivery** | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | Client understanding of design, procurement, and construction Process | | | | | |
| 2 | Quality management during design. | | | | | |
| 3 | quality of management during construction | | | | | |
| 4 | Constructability design | | | | | |
| 5 | Management style | | | | | |
| 6 | Management style | | | | | |
| 7 | Motivation staff | | | | | |
| 8 | Site ground condition | | | | | |
| 9 | Site access condition | | | | | |
| 10 | Physical Environmental | | | | | |
| 11 | Economic policy | | | | | |
| 12 | Social-political condition | | | | | |

13. Based upon Likert scale ranging from low performance (1st level) to extremely high performance (5th level), kindly rate the extent to which the following factors influence project delivery time

| **Factors influencing time delivery** | | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|---|
| **clients' understanding of design, procurement and construction processes** | Understanding the project's constraints | | | | | |
| | Ability to effectively brief the design team | | | | | |
| | Ability to contribute ideas to the design process | | | | | |
| | Ability to quickly make authoritative decisions | | | | | |
| | Stability of decisions | | | | | |
| | Ability to contribute ideas to the construction process | | | | | |
| **Quality management during design**. | Conflicting design information | | | | | |
| | Timeless of revised drawings issue | | | | | |
| | Missing information | | | | | |
| | Dimensional inaccuracies | | | | | |
| | Expediting shop drawings | | | | | |

| Factors influencing time delivery | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **quality of management during construction** | Forecasted planning date, e.g. activity duration, resource quantities required, etc. | | | | | |
| | Analyzing construction methods | | | | | |
| | Analyzing resource movement to and on site | | | | | |
| | Analyzing of work sequencing to achieve and maintain workflow | | | | | |
| | Monitoring and updating plans to appropriately reflect work status | | | | | |
| | Responding to recover from problems or taking advantage of opportunities presented | | | | | |
| | Effectively coordinating resources | | | | | |
| | Developing an appropriate organizational structure to maintain workflow | | | | | |
| **Constructability design** | Scope of site fabrication | | | | | |
| | Complexity of off-site fabricated components | | | | | |
| | Appropriateness of design tolerances | | | | | |
| | Appropriateness of working space. Its impact on smooth activity workflow and sequencing | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Implication upon trade co-ordination's | | | | | |
| | Impact of materials storage and movement | | | | | |
| | Extent of grouping simultaneous | | | | | |
| | Extent of modular dimensions in design | | | | | |
| | Effective constructability review of design | | | | | |
| | Participation in site inspection and control | | | | | |

| **Factors influencing time delivery delay** | | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|---|
| **Management style** | Specified goals people are to accomplish | | | | | |
| | Organized the work situation for people | | | | | |
| | Set time lines | | | | | |
| | Provided specific direction | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Required regular reporting on progress | | | | | |
| | Provide support and management | | | | | |
| | Involved team member through discussion of work | | | | | |
| | Sought people's opinion and concerns | | | | | |
| **Motivation staff** | Pay an allowance | | | | | |
| | Achievement from meeting complex challenges | | | | | |
| | Job security | | | | | |
| | A sense of belonging and identification with project team | | | | | |
| | Recognition (monitoring or kudos)of contribution made | | | | | |
| | Opportunity to extent skills and experience learning | | | | | |
| | Equitable rewards relative to other's input to the project | | | | | |
| | Exercise of power | | | | | |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Site ground conditions** | Nature of demolition works | | | | | |
| | Nature of restoration works | | | | | |
| | Structural stability of work | | | | | |
| | Extent of ground contamination | | | | | |
| | Extent of ground contamination | | | | | |
| | Extent of archaeological finds | | | | | |
| | Impact of water table | | | | | |
| | Impact of underground services | | | | | |
| | Impact of underpinning existing structure | | | | | |

| Factors influencing time delivery | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **Site access** | Proximity to required resources | | | | | |
| | Access to site entry/exit point | | | | | |
| | Storage space at or near ground level | | | | | |
| | Storage at upper level | | | | | |
| | Requirement for restrictive hours | | | | | |
| **Physical Environmental** | Impact of natural hazards (fire, flood, etc) | | | | | |
| | Local weather patterns on site | | | | | |
| | Ambient noise condition | | | | | |
| | Ambient light condition | | | | | |
| **Economic policy** | Material availability | | | | | |
| | Equipment availability | | | | | |
| | Trade /operative availability | | | | | |
| | Supervision /management staff availability | | | | | |
| | Indirect impact of interest rate /inflation | | | | | |
| | Insolvencies and bankruptcies | | | | | |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Social-political condition** | Civil strife or riots | | | | | |
| | Influence of protest action groups | | | | | |
| | Disruption due to environment concerns (fire, noise , floor etc | | | | | |

**INVITATION LETTER-FUZZY VIKOR QUESTIONNAIRE**

**Analysis of Time Management Techniques together with factors influencing time delivery for Highways/Roads construction Projects in Rwanda: Using Fuzzy-Vikor Approach**

To WHOM IT MAY CONCERN

Dear Sir/Madam

This research study intends to investigate and evaluate the highway infrastructure projects performance by comparing two alternatives such as Time Management Techniques and Factors influencing time delivery for highway/road project. Previous survey (Questionnaire Survey) was designed to extract factors and tools in order to obtain those which are critical for road project performance.

This survey (Fuzzy VIKOR Questionnaire) aims to prioritize these critical factors and tools (criteria) and investigate the interdependent relationship between the alternatives.

Your inputs are greatly valuable and we do hope that you can participate in this final survey.

Your relevant experience and expertise in highway infrastructure is valuable and you are invited to participate in this survey. If you agree, please email me k.umugwaneza@gmail. We can arrange the time that suits to your schedule to conduct this survey. This survey will take about 10-15 minutes to complete. All the answers will remain confidential and all the information will be analyzed in general, without reference to specific individuals (See below of this letter for more details).

If you have any queries about this project, please contact me or my Principal Supervisor, Dr Bari Mahabubuli on (07)3416508.

Your contribution towards this study is greatly appreciated!

Yours Sincerely,

KABURAME UMUGWANEZA Providence
Postgraduate Candidate
University of Rwanda/College of Science and Technology
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**Additional Information**

The fuzzy Vikor Questionnaire consists of 2 sections, the first one is for evaluate and rating Time Management Techniques and factors influencing Road Project Performance. In this section the Linguistic Scale for the importance of criteria are used for evaluation and rating. (See table below)

Table I. Linguistic Scale for the importance of criteria

| **No** | **Linguistic Terms** | **Abbreviation** | **Triangular Fuzzy Number** |
|---|---|---|---|
| 1 | Very Low | VL | (0.0, 0.1, 0.3) |
| 2 | Low | L | (0.1, 0.3, 0.5) |
| 3 | Medium | M | (0.3, 0.5, 0.7) |
| 4 | High | H | (0.5, 0.7, 0.9) |
| 5 | Very High | VH | (0.7, 0.9, 1.0) |

The section two consists to investigate the interdependent relationship between the two alternatives such as Time Management Techniques and factors influencing Road Project Performance by using the linguistic scale in table below.

Table II. Linguistic Scale for rating alternatives

| **No** | Linguistic Terms | Abbreviation | **Triangular Fuzzy Number** |
|---|---|---|---|
| 1 | Very Poor | VP | (0.0, 0.0, 0.2) |
| 2 | Poor | P | (0.0, 0.2, 0.4) |
| 3 | Fair | F | (0.2, 0.4, 0.6) |
| 4 | Good | G | (0.4, 0.4, 0.8) |
| 5 | Very Good | VG | (0.6, 0.8, 1.0) |
| 6 | Excellent | E | (0.8, 0.1, 1.0) |

**FUZZY VIKOR QUESTIONNAIRE**

**Question 1**

**Rating the criteria for road project performance according to the linguistic terms**

| **No** | **Criteria** | **Linguistic terms** | | | | |
|---|---|---|---|---|---|---|
| | | **VL** | **L** | **M** | **H** | **VH** |
| 1 | CPM | | | | | |
| 2 | PERT | | | | | |
| 3 | GANT CHART | | | | | |
| 4 | Microsoft project (MP) | | | | | |
| 5 | MILESTONE CHART(MC) | | | | | |
| 6 | Techniques for Planning & Control (TPC) | | | | | |
| 7 | Management Style (MS) | | | | | |
| 8 | Economic policy (EP) | | | | | |
| 9 | Quality management during construction(QMDC) | | | | | |
| 10 | Client Understanding design, Procurement and Construction Process (CDPC) | | | | | |

**Question 2**

Compare Time Management tools (Alternative 1(A1) with factors influencing Road Project Performance Alternative 2(A2)

| **No** | **Alternatives** | **Linguistic scale for rating** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **VP** | **P** | **F** | **G** | **VG** | **E** |
| 1 | TOOLS | | | | | | |
| 2 | FACTORS | | | | | | |

| Project_Name | Project_Description | Project_Type | Length[Km] | Tender_No | Contract_No | Funding | Contractor | Supervisor | Contract_Amount | Contract_Date | Starting_Date | Contract period | End_Date | Amendment | Extension_Time_Months | Completion_Date | Division | Status | Amount_Paid | Engineer_in_Charge |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Improvement works for Kibugabuga-Ruhuha Road project** | Subgrade reshaping, lay a=of a new murram layer thick of 20 cm and provide an effective road drainage | Improvement works | 24.50 | No 086/T/2010-N/BAD/RPPA | 374/RTDA/011 | **BAD** | MAXWELL-PRIME JOINT VENTURE | INFRAMAD | 679,595,769 | 6-May-11 | 3-Jun-11 | 8 | 2-Mar-12 | | 0.87 | 4-May-12 | Development | 78% | **99%** | **KAGABO Achille** |
| **Kigali-Ruhengeli Road Rehabilitation Project** | Widening the existing road from 6 m to 7 m width by milling the existing road and make a 20cm thick subbase, lay a new 20cm base course layer and a new 5 | Rehabilitation (Upgrading) | 83.10 | No 071/T/2009-I/MININFRA/RPPA | 582/CGPT/09 | **W.B and GOR** | CHICO Co Ltd | ROUGHTON Internatioanal | 32,710,844,349 RWF | 30-Nov-09 | 28-Dec-09 | 27 | 28-Mar-12 | | 0 | 28-Sep-12 | Development | 98.50% | **99.60%** | **KAGABO Achille** |
| **MULTINATIONAL BURUNDI-RWANDA CYANGUGU(RUSIZI)-NTENDEZI-MWITYAZO ( 50 Km)** | Rehabilitation of Cyangugu-Ntendezi paved road section (30 km) Construction and asphalting the road Ntendezi-Mwityazo section(19 km) Sensitization on HIV/AIDS, environmental and road safety issues. | Rehabilitation and construction | 50.00 | 140/T/2009-I/MININFRA-FAD/RPPA | 448/TRAVAUX ROUTIERS/RTDA-CSEP/010 | **AfDB & GoR** | China Road and Bridge Corporation | CIRA | 29, 278, 660, 301 RWF | 2-Aug-10 | 8-Oct-10 | 26 | 8-Dec-12 | | Not yet | 8-Jul-13 | Development | 99% | **85.60%** | **MANIRAGUHA Jacqueline** |
| **REHABILITATION OF RUSIZI URBAN ROADS AND HEAVY TRUCKS BRIDGE AT RUSIZI II RIVER, LOTS 1,2 AND 3** | Lot 1: The intervention for the Rehabilitation of the steel arch bridge connecting Bukavu Town and Rusizi District will be done on: - Steel parts; - Reinforced concrete elements; - The aprons; | Rehabilitation; | 0.038 | 094/T/2010-N/MININFRA-UE/RPPA | 2010/007/EU/MT | **EU** | HORIZON Constuction | INFRAMAD | 161, 408, 840 RWF | 24-Dec-10 | 19-Jul-11 | 5 | 18-Dec-12 | | 5 | 31-May-12 | DEVELOPMENT | 100% | **98.70%** | **MANIRAGUHA Jacqueline** |
| **REHABILITATION OF RUSIZI URBAN ROADS AND HEAVY TRUCKS BRIDGE AT RUSIZI II RIVER, LOTS 1,2 AND 3** | Lot 2: The rehabilitation of 1.3 Km of the Rusizi Urban Roads has the following component: - Improving the drainage system of the road by setting up the drains under the ditches. - Replacement of the existing degraded hydraulic structures; Construction of | Rehabilitation; | 1.38 | 094/T/2010-N/MININFRA-UE/RPPA | 2010/008/EU/MT | **EU** | HORIZON Construction | None | 651, 261, 800 RWF | 25-Dec-10 | 19-Jul-11 | 5 | 18-Dec-12 | | 5 | 31-May-12 | DEVELOPMENT | 100% | **95.19%** | **MANIRAGUHA Jacqueline** |
| **REHABILITATION OF RUSIZI URBAN ROADS AND HEAVY TRUCKS BRIDGE AT RUSIZI II RIVER, LOTS 1,2 AND 3** | Lot 3: The rehabilitation of 1.5 Km of the Rusizi Urban Roads from the junction PENDEZA and KADASOMWA: - Improving the drainage system of the road by setting up the drains under the ditches | Rehabilitatipon; | 1.5 | 094/T/2010-N/MININFRA-UE/RPPA | 2010/009/EU/MT | **EU** | Joint Venture SEBULIKOKO N. EMMANUEL AND BERCO Construction | None | 941, 510 Euros | 26-Dec-10 | 19-Jul-11 | 5 | 18-Dec-12 | | 5 | 31-May-12 | DEVELOPMENT | 86% | **68%** | **MANANIRAGUHA Jacqueline** |
| **REHABILITATION OF BUGARAMA-RUHWA ROAD** | The rehabilitation of the Section Bugarama- Ruhwa (7.5) road. | upgrading of bituminous road | 7.5 | ( ) | 059/RTDA/011 | **AfDB & GoR** | SOGEA SATOM | GIBB AFRICA LIMITED | 4, 315, 480, 134 FRW | 2-Aug-11 | 14-Nov-11 | 8 | 31-May-12 | | 0 | 31-May-12 | DEVELOPMENT | 100% | 99% | **RWAKIGARAMA Fabien** |
| **SLOPE REHABILITATION AND PAVEMENT REINSTATEMENT AT PK 28 OF BUGARAMA-RUHWA ROAD** | Construction of the Concrete Retaining walls at both locations PK 28+400 and PK 28+700; Reinstatement of existing road pavement and Rehabilitation of the existing drainage works | Rehabilitation and construction | 0.02 | Single source | 2523/TRAVAUX ROUTIERS/RTDA-CSEP/010 | **AfDB & GoR** | CHINA ROAD AND BRIDGE CORPORATION | GIBB AFRICA LIMITED | 923,659,660 RWF | 14-Jul-12 | 20-Oct-10 | 6 | 20-Apr-11 | | 4.33 | 31-Aug-12 | DEVELOPMENT | 100% | 100% | **RWAKIGARAMA Fabien** |
| **Ngororero-Satinsyi** | Earth road, with drainage system of bridges was well as pipe culverts. The road is covered by marrum to strength the surface, construction of Satisyi dyke | Improvement | 21 | None | 350/RTDA/011 | **AfDB** | GM-CEC | Atlantis s.a.rl | 1,519,948,000 RWF | 27-Apr-11 | 9-May-11 | 7 | 9-Oct-11 | | 3 | 9-Mar-12 | Development | Stopped | **stopped** | **Gregory RWAKIGARAMA** |
| **Bulinga-Remera** | Earth road, with drainage system of bridges was well as pipe culverts. The road is covered by marrum to strength the surface. | Improvement | 36 | None | 050/RTDA/011 | **AfDB** | HORIZON Construction | CCC | 1,797,041,400 RWF | 26-Jul-11 | 8-Aug-11 | 6 | 16-Jan-12 | | 2 | The project has stopped | Development | 78% | **40%** | **Gregory RWAKIGARAMA** |
| **Kigali Urban Roads Updrading Project (36 km)** | The road is covered by Botuminous Concrete, constructuion of wallkways, construction of humps, street lighting, construction of drainage and rehabilitation of existing ones. | Paved | 36 | Single source | 450/UPPR/09 | **Ex-Im Bank of China** | CRBC | BE KIADY | USD 35917241.7 | 20-Aug-07 | Nov. 2009 | 24 | Nov. 2011 | | 0 | 17-Oct-11 | Development | 100% | **100%** | **UWITONZE Fr. Xavier** |
| **Rehabilitation of Ngororero-Mukamira** | The road is covered by a Bituminous Concrete, drainages were rehabilitated and other constructed, traitemet of weak sections by purging | Paved | 24.7 | None | 450/UPPR/09 | **Ex-Im Bank of China** | CRBC | STUDI Internationa l | 23,093,963,272 RWF | 29-Sep-08 | 2-Jul-09 | 18 | 2-Apr-11 | | 6 | 2-Jul-11 | Development | 100% | **96%** | **UWITONZE Fr. Xavier** |
| **Lot I: Ngororero-Kavumu** | Earth road, with drainage system of bridges was well as pipe culverts. The road is covered by marrum to strength the surface. | Improvement | 24.7 | None | 277/TRAVAUX ROUTIER/09 | **AfDB, GoR** | EUR | TECOS | 614,587,380 RWF | 1-Jul-09 | 1-Jul-09 | 7 | 31-Dec-09 | | 4 | 24-Jun-11 | Development | 100% | **94.1%** | **UWITONZE Fr. Xavier** |
| **Lot II: Kavumu-Rubaya-Kabaya** | Earth road, with drainage system of bridges was well as pipe culverts. The road is covered by marrum to strength the surface. | Improvement | 23 | None | 278/TRAVAUX ROUTIER/09 | **AfDB, GoR** | EUR | TECOS | 611,180,600 Rwf | 1-Jul-09 | 7-Jan-09 | 7 | 31-Dec-09 | | 4 | 24-Jun-11 | Development | 100% | **97%** | **UWITONZE Fr. Xavier** |
| **Crete Congo/Nil-Ntendezi** | (i)deforestation, scrub clearing, and scraping; (ii)fill and cut excavations and cleansing; (iii)construction of a 7 m large | rehabilitation | *30* | 008/W/2011-AIO/PLAN/RTDA-BAD | 449/TRAVAUX ROUTIERS/RTDA-CSEP/010 | **AfDB** | China Roads and bridges corporation | inframad | 10,633,467,514 RWF | **2-Aug-10** | 8-Oct-10 | 18 | 8-Apr-12 | | 3 | 8-Jul-12 | development | 97% | **98%** | **Jacqueline MANIRAGUHA** |
| ***BUTARE URBAN STONE ROADS Lot 2 & Lot 3 (of stone paved road and of drainage):stoned roads*** | Earth works -Base course of murram of 15cm thickness -Surfacing of paving stones -Sidewalk -Cleansings. | Construction of stoned roads | *5.286* | 5.286 | RMF/2010-2011/06 | **GoR** | ERGECO | SAFE Construction | 1 264 305 929 Rwf | 27-July-2010 | 16-Aug-10 | 6 | 16-Feb-11 | | 2 | **16-Apr-11** | development | 100% | **100%** | **Jacqueline MANIRAGUHA** |
| **BUTARE URBAN STONE ROADS lot 1** | Earth works -Base course of murram of 15cm thickness -Surfacing of paving stones -Sidewalk | Construction | 8.287 | | RMF.2010-2011/49 | **GoR,HUYE DISTRICT** | HORIZON Construction Ltd | SAFE Construction | 1 801 260 389 RWF | **2-Mar-11** | **24-Mar-11** | 6 | 24-Sep-11 | | 0.87 | **29-Mar-12** | development | 100% | **100%** | **Jacqueline MANIRAGUHA** |
| **ACCESS - ROAD N° 3 & ROAD C (Kigali Special Economic Zone)** | The project is located within Kigali City to the North-East of Kigali International Airport. The site is at the end of the KIMIRONKO road up to the road 1, the | Emergency | 3 | None | 293/RTDA/2011 | **GoR** | NPD-COTRACO | INFRAMAD | 5 369 880 982 RWF | **15-Apr-11** | **15-Apr-11** | 6 | 1-Aug-11 | | 16 | **17-Dec-12** | development | 48% | **74.60%** | **Jacqueline MANIRAGUHA** |
| **ACCESS - ROAD N° 1 PAVED ROAD CONSTRUCTION (Kigali Special Economic Zone)** | The project is located within Kigali City to the North-East of Kigali International Airport. The site is approximately 3km from the main road to Nyagatare off the | Emergency | 2 | () | 943/RTDA/010 | **GoR** | NPD-COTRACO | INFRAMAD | 1 801 260 389 RWF | **6-Dec-10** | 10-Aug-10 | 6 | 10-Feb-11 | | 12 | 17-Dec-12 | development | 74% | **76%** | **Jacqueline MANIRAGUHA** |
| **MUDASOMWA-GISOVU EARTH ROAD + AMENDMENTS: ACCESS ROAD TO MUSHUBI TEA FACTORY +RUKARARA HYDROPOWER PLANT ACCESS ROAD** | The main works are: □ Installation and withdraw of site; □ Topographic Surveys; □ Clearing of undergrowth and cleaning of the road reserve; □ Earthwork out of cut and fill; □ compaction Preparation and completion of subgrade; | Periodic maintenance | 65.2 | 133/T/2009-I/MININFRA/RPPA | RMF/2009-2010/33 | **RMF** | NPD-COTRACO | **GE&SS** | 3,662,012,295 RWF | 19-Feb-12 | 10-Mar-10 | 12 | 10-Mar-11 | | 31-Aug-11 | 12-Apr-12 | **Maintenance** | 100% | **100%** | **MUHOZA Albert** |
| **CYAKABIRI-NYABIKENKE-MASIZI BRIDGE Lot 1** | The main works are: □ Installation and withdraw of site; □ Topographic Surveys; □ Clearing of undergrowth and cleaning of the road reserve; | Periodic Maintenance | 51.25 | 118/T/2009-I/MININFRA/RPPA | RMF/2009-2010/56 | **RMF** | Entreprise Mubiligi Paul (EMP) | **TECOS** | 3,118,997,587 RWF | 17-May-10 | 14-Jun-10 | 12 | 14-Jun-11 | | 2 | 14-Aug-11 | **Maintenance** | 100% | **100%** | **MUHOZA Albert** |
| **PERIODIC MAINTENANCE WORKS OF BUTARE - KIBEHO - MUSE** | The main works are: □ Installation and withdraw of site; □ Topographic Surveys; □ Clearing of undergrowth and cleaning of the road reserve; □ Earthwork out of cut and fill; | Periodic Maintenace | 53 | None | RMF/2009-2010/06 | **RMF** | GM&CEC | CETROING | 2,291,852,404 RWf | 30-Jul-09 | 7-Sep-2009 | 9 | 7-Jun-10 | | 4 | 8-Oct-10 | **Maintenance** | 100% | **100%** | **MUHOZA Albert** |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **REHABILITATION OF SASHWARA-KABATWA ROAD** | The main works are:<br>- Installation and withdraw of site;<br>- Topographic Surveys;<br>- Clearing of undergrowth and cleaning of the road reserve;<br>- Earthwork out of cut and fill;<br>- compaction Preparation and completion of subgrade;<br>- Implementation of lateritic wearing course;<br>- Work of drainage of rain water: side ditches out of ground or masonry, culverts… | Rehabilitation and Periodic maintenance | 9.8 | 011/T/2012-N/PLAN/RTDA | | **EWSA** | ERGECO LTD | NG'ANDU CONSULTING RWANDA | 521,366,100 Rwf | 11-May-12 | 6-Sep-12 | 5 | 6-Feb-13 | | 0 | 6-Feb-13 | **Maintenance** | 100% | **2%** | **MUHOZA Albert** |
| **Periodic Maintenance of Byimana- Buhanda-Kaduha** | Installation, cutting, pose of wearing course, drainage system and environment protection | Rehabilitation | 49 | N° 032/T/2010-NR/MININFRA/RPPA | RMF/2009-2010/55 | **RMF** | SAM Consruct | **HYCOGEC CONSULTANT** | 2603957932 Rwf | 3-May-10 | 3-Jun-10 | 16 | 2-Oct-11 | | 4 | 8-Nov-11 | Maintenance | 100% | **98.76%** | **Dieudonné GARUKA** |
| **Urgent Maintenance Works of Gitarama-Huye-Akanyaru and Huye-Kitabi Roads.** | Urgent Repair Works | Emergency | 186.4 | 022/S2012-IO/PLAN/RTDA | RMF/2011-2012/02 | **RMF** | Horizon Construction | RTDA | **548, 945, 602.20 RWF** | 29-Jul-11 | 14-Apr-11 | 4 | 14-Aug-12 | | 6.1 | 13-Feb-12 | **Maintenance** | Stopped at 45% | **36%** | **Dieudonné GARUKA** |
| **Rehabilitation and periodic maintenance Rwamagana - Zaza road** | | Periodic Maintenance works | 28 | 001/T/2011-N/RTDA | RMF/2011-2012/64 | **RMF** | ENC JV Buildafrica | Bureau d'Etude HYCOGEC | 1,849,378,800 RWF | 29-Jun-12 | 9-Aug-12 | 10 | 9-Jun-13 | | 5 | Not yet | **Maintenance** | 62% | **45%** | **Garuka Dieudonne** |
| **Slope failure at Kiizi, Gakomeye spot in HUYE - KITABI road PK 21+00** | Slope failure occurred due to a stream that dug deep under the paved road at PK21+00. This stream has been deviated and maintenance works are at 55% at this spot. | Emergency | 0.035 | None | RMF/ 2012 - 2013/ 08 | **RMF** | Engineering Regiment | **Major Rukeratabaro** | 90,410,000 RWF | | 17-May-12 | 5 | 17-Oct-12 | | 0 | 17-Oct-12 | Maintenance | 100% | **95%** | **Rutera Rose** |
| **Rehabilitation and Periodic maintenance of Nyakinama-Vunga-Satinsyi unpaved road** | Periodic Maintenance | Rehabilitation and Periodic Maintenance | 21 | 106/T/2010-N/MININFRA/RPPA | RMF/2010-2011/66 | **RMF** | ERGECO | **ATLANTIS CONSULT** | 2,049,915,779 RWF | 28-Jun-11 | 14-May-12 | 9 | 14-Feb-13 | | 6.5 | 31-Aug-13 | **Maintenance** | 32% | **10%** | **Ndahayo Faustin** |
| **Emergency works for repair of unpaved road Nyagatovu - Ntebe** | Emergency works for repair of unpaved road Nyagatovu -Ntebe | Emergency | 6.2 | None | RMF/2012-2013/10 | **RMF** | NPD COTRACO | | 172,355,369 RWF | | 21-Jun-12 | 3 | 21-Sep-12 | | 0 | 18-Apr-13 | Maintenance | 100%. | **100%** | **Perpetue** |
| **Emergency for removal of landslides on Ngororero-Mukamira Asphalt road** | Landslide Removal, Paving Road with Asphalt | Emergency | PK 92+200 and PK51+500) | SINGLE SOURCE | | **RMF** | Engineering regiment | **RTDA** | 462,602,150 RWF | not yet | 21-Sep-12 | 3 | 21-Oct-12 | | Not specified | Not specified | Maintenance | 23% | **44.42%** | **UWANJYE Yvette** |
| **Nyabarongo River bank protection on Ngororero Mukamira road** | Nyabarongo River bank protection on Ngororero Mukamira road | Emergency | PK 33+100 | None | N°RMF/2011 – 2012 / 32 | **RMF** | ENGINEERING REGIMENT | **RTDA** | 166,770,714 | 21-Feb-12 | 15-Dec-12 | 2 | 9-Feb-12 | | 3 | 9-Feb-12 | Maintenance | 100% | **17.73%** | **UWANJYE Yvette** |
| **EMERGENCY WORKS FOR PREVENTION OF INFILTRATION AT GISWI – UWINTEKO ROAD SECTION, RETAINING WALL AT NYARUSHISHI SECTOR AND ROAD DEVIATION AT MUNINI SECTOR** | EMERGENCY WORKS FOR PREVENTION OF INFILTRATION AT GISWI – UWINTEKO ROAD SECTION, RETAINING WALL AT NYARUSHISHI SECTOR AND ROAD DEVIATION AT MUNINI SECTOR | Emergency | | None | N°RMF/2012 – 2013 / 05 | **RMF** | ENGINEERING REGIMENT | **RTDA** | 92,877,950 RWF | 24-Jul-12 | 2-May-12 | 3 | 2-Aug-12 | | 3 | Not specified | Maintenance | 48% | **86%** | **UWANJYE Yvette** |
| **Supply and Installation of Urgent Road Traffic Signs on Bazilette and Rwaza Black spots in Rubavu District & Painting three humps on Huye road at the entrance of National University of Rwanda.** | Supply and Installation of Urgent Road Traffic Signs on Bazilette and Rwaza Black spots in Rubavu District & Painting three humps on Huye road at the entrance of National University of Rwanda. | Supply and Installation | | None | 147/RTDA/011 | GOR | CLUBA ALFIO | **RTDA** | 2,325,644 | 11-Jan-11 | 11-Jan-11 | 1 | 12-Jan-11 | | 0 | 12-Jan-11 | planning | 100% | **100%** | **Verjus Hadelin** |
| **Supply and Installation of road traffic signs on Muhanga-Karongi and Huye-Nyamagabe National roads & Overhead gantry sign boards at 12 Borders.** | Supply and Installation of road traffic signs on Muhanga-Karongi and Huye-Nyamagabe National roads & Overhead gantry sign boards at 12 Borders. | Supply and Installation | 152 | 007/F/2012-NO/PLAN/RTDA | 013/RTDA/012 | GOR | K CRéA LTD | **RTDA** | 556,074,885 Rwf | 30-Mar-12 | 30-Mar-12 | 3 | 30-Jun-12 | | 1 | 31-Aug-12 | planning | 95% | **100%** | **Verjus Hadelin** |
| **Supply and Installation of road traffic signs on Kigali-Akanyaru road and Kigali-Kayonza road.** | Supply and Installation of road traffic signs on Kigali-Akanyaru road and Kigali-Kayonza road. | Supply and Installation | 157 | 003/F/2011-N/RTDA | 101012 | GOR | SIGNBOARD DEVELOPMENT LTD | **RTDA** | 344,835,884 RWF | 3-Jan-12 | 3-Jan-12 | 3 | 6-Jan-12 | | 1 | 17-Jan-12 | planning | 100% | **100%** | **Verjus Hadelin** |
| **Painting 3 humps on Musanze road at the entrance of Hospital and 5 humps on Rubavu Urban road & 16 road markings on these roads.** | Painting 3 humps on Musanze road at the entrance of Hospital and 5 humps on Rubavu Urban road & 16 road markings on these roads. | Painting Humps | | None | None | GOR | SIGNBOARD DEVELOPMENT LTD | **RTDA** | Not yet | ***5-Mar-12*** | ***5-Mar-12*** | 0.5 | ***19-Mar-12*** | | 0 | ***19-Mar-12*** | planning | 100% | **100%** | **Verjus Hadelin** |
| **Construction of the road to Tumba College of Technology** | Construction of the road to Tumba College of Technology | Rehabilitation and Upgrading | 9.5 | 020/W/2012-N/PLAN/RTDA | 007/CRP//RTDA/2013 | JAICA , GOR | FAIR CONSTRUCTION | **RTDA** | 2,949,726,240 Rwf | 22-Feb-13 | 8-Jul-13 | 5 | Not yet | | 0 | Not yet | Planning | 0% | **0%** | **Marcel MASENGO** |
| **Detailed studies for roads of access to tea Gatare and Kivu Muganza tea factories.** | Detailed studies for roads of access to tea Gatare and Kivu-Muganza tea factories. | Rehabilitation Periodic | 38.63 | None | RMF/2010-2011/34 | GOR/RMF | MULTI CONSTRUCT | **None** | 28,000,000 RWF | 26-Nov-10 | 12-Jun-10 | 3 | 3-Jun-11 | | 0 | 3-Jun-11 | Planning | 100% | **100%** | **Marcel MASENGO** |
| **Emergency Works of Rehabilitation of Musanze - Kinigi asphalt road** | Patching of potholes on Musanze - Kinigi asphalt road, Construction of the retaining wall on Musanze - Rubavu asphalt roand and well as the construction of the storm water drainage. | Emergency | 15 | Short List | RMF/2012-2013/09 | RMF | ECOAT | **RTDA** | 308,342,626 | 30-Jul-12 | 31-May-12 | 2 | 30-Jul-12 | | 0 | 30-Jul-12 | Maintenance | 100% | **95.87%** | **MUNYANEZA Thaddee** |
| **Emergency Maintenance of construction of the retaining wall on Rubengera - Pfunda earth road at Kivumu and on Brasserie - Nymwenda - Nkora earth road at Cyimbiri** | Contruction of the retaining wall on both roads | Emergency | 2 | N/A single source | RMF/2012-2013/11 | RMF | Engineering regiment | **RTDA** | 50,250,000 RWF | 10-Aug-12 | 4-Jun-12 | 3 | 3-Sep-12 | | 0 | 3-Sep-12 | Maintenance | 100% | **100%** | **MUNYANEZA Thaddee** |
| **Emergency Maintenance repair Works for repair of damaged section on Kabarondo - Hotel Akagera earth road at Kadiridimba** | Embarkment repair (elevation) | Emergency | 2 | N/A single source | RMF/2012-2013/13 | RMF | Engineering regiment | **RTDA** | 125,906,500 RWF | 10-Aug-12 | 4-Jun-12 | 3 | 3-Sep-12 | | 0 | 3-Sep-12 | Maintenance | 100% | **100%** | **MUNYANEZA Thaddee** |
| **Emergency Maintenance repair Works for Karongi - Rusizi road** | Construction of the retaining wall and patching of potholes | Emergency | 5 | N/A single source | RMF/2012-2013/12 | RMF | Engineering regiment | **RTDA** | 104,979,500 RWF | 10-Aug-12 | 21-May-12 | 3 | 20-Aug-12 | | 2 | 20-Oct-12 | Maintenance | 100% | **100%** | **MUNYANEZA Thaddee** |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RWESERO DAM REPAIR WORKS** | RWESERO DAM REPAIR WORKS | Emergency | | None | 1315/CORP/012 | RMF | EGECOR | | 74,026,828 RWF | | 16-Jun-12 | 4 | 16-Oct-12 | | 3 | 6-May-13 | Maintenance | 100% | 70% | **KAGABA Remy** |
| **Routine maintenance of Ruhengeri-Nyakinama-Cyanika** | routine maintenance | routine maintenance | 34 | None | RMF/2011-2012/24 | RMF | ECOBE | RTDA | 14,664,000 RWF | 29-Dec-11 | 1-Dec-12 | 10 | 11-Dec-12 | | 0 | 11-Dec-12 | Maintenance | 100% | 100% | **MWISENEZA Maxime** |
| **Jomba-Shyira** | Rehabilitation and periodic maintenance | Rehabilitation | 15.3 | Short List | 11.07.029/983/12/ LTU-DIR/YM/jps | EWSA+ RTDA | ECOTIBAT | C.C.C | 3,212,743,200 RWF | 19-Mar-12 | 31-Jan-12 | 9 | 31-Oct-12 | | 2.67 | 31-Oct-12 | Maintenance | 68% | 32% | **MWISENEZA Maxime** |
| **Construction of a Retaining wall at Gisiza and deviation of Koko river at pk 27+600 Rubengera -Rugerero road** | Construction of a Retaining wall at Gisiza and deviation of Koko river at pk 27+600 Rubengera -Rugerero road | EMERGENCY | | Short List | RMF/2010-2011/40 | RMF | EUR | BE KIADY | 202,722,702 RWF | 12-Jan-11 | 12-Jan-11 | 4 | 15-Aug-11 | | 3 | 26-Jul-12 | Maintenance | 100% | 100% | **MWISENEZA Maxime** |
| **PERIODIC MAINTENANCE WORKS OF PINDURA-BWEYEYE** | routine maintenance | routine maintenance | 32 | 017/S/2011-IO/MNT/RTDA | RMF/2012-2013/01 | RMF | EMP/C.P.A | | 16,516,000 RWF | 7-Oct-12 | 15-Jul-12 | 2 | 15-Sep-12 | | 0 | 15-Sep-12 | Maintenance | 100% | 100% | **MUNYANEZA George** |
| **Cyakabiri Nyabikenke Ndusu lot 2** | Subgrade reshaping, layer of a new murram layer thick of 20 cm and provide an effective road drainage | Improvement works | 34.558 | NO 118/T/2009-I/MININFRA/RPPA | RMF/2009-2010/53 | RMF | SOBETRA UGANDA LTD | TECOS | 3,020,371,003 | 7-May-10 | 21-Jun-10 | 10 | 21-Apr-11 | | 5 | 21-Sep-12 | MAINTENANCE | 100% | **86.07%** | **NSHIMIYIMANA Albert Jackson** |
| **Kazabe Rutsiro Gashubi** | Subgrade reshaping, layer of a new murram layer thick of 20 cm and provide an effective road drainage and rehabilitation of bridges | Improvement works | 55.322 | no 042/T/2010-N/MININFRA/RPPA | RMF/2010-2011/08 | RMF | ENTREPRISE USENGIMANA RICHARD | TECOS | 3,392,802,054 RWF | 1-Sep-10 | 15-Sep-10 | 14 | 15-Oct-11 | | 3 | Not yet | MAINTENANCE | 82% | 60% | **NSHIMIYIMANA Albert Jackson** |
| **Acees road to karongi tea Factory( Karongi Gasenyi and Rugabano Gasenyi)** | Subgrade reshaping, layer of a new murram layer thick of 20 cm and provide an effective road drainage | Improvement works | 28.6 | 003/i/2011-N/RTDA | | GOR | FIECO | TECOS | 1,228,910,469 RWF | 28-Nov-12 | 6-Dec-12 | 7 | 6-Jul-13 | | 1 | Not yet | MAINTENANCE | 58,3% | 25% | **NSHIMIYIMANA Albert Jackson** |
| **Rehabilitation of Kigali-Gatuna road** | Rehabilitation of Kigali-Gatuna road | Rehabilitation | 77.8 | EuropeAid/130264/ D/WKS/RW | 2011/001/UE/MT | EU | STRABAG | TR-ENGINEERING | 32,982,999.50 Eur | 15-Nov-11 | 2-Jan-12 | 30 | 2-Dec-14 | | not yet | Not yet | Development | 50% | 47% | **Pasteur Kayiisire** |
| **Brasserie-Nyamwenda-Nkora** | Rehabilitation and periodic maintenance | Rehabilitation | 27 | Single Source | | RMF | SAM Consruct | SOGIS | 1,424,635,000 | | 9-Dec-09 | 9 | 9-Aug-10 | 279,645,500 Rwf | 3 | 9-Nov-10 | Maintenance | 100% | 99% | Ezechehiel |
| **Maintenance works of Gakoma-Rukarara access road to Rukarara Hydropower plant** | Subgrade reshaping, layer of a new murram layer thick of 20 cm and provide an effective road drainage and rehabilitation of bridges | Improvement works | 8.6 | | | RMF | FAIR CONSTRUCTION | GE&SS | 429,480,258 RWF | 25/05/2011 | | | | | | | MAINTENANCE | 100% | | PETER MUGABO |
| **Emergency works on Ruhengeri-Cyanika Road (2+700 chainage)** | wearing course and construction of box culvert | Emergency | 0.2 | | 15/RMF/2009-2010 | RMF | EMP | NA | 101,902,402 RWF | | 26-Jul-10 | 2 | 26-Sep-10 | | 0.5 | 10-Sep-10 | Maintenance | 100% | 99% | UMUGWANEZA Providence | |