ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMNETAL ENGINEERING

APPLICATION OF MULTI-CRITERIA DECISION-MAKING BASED ON COMBINED ANALYTIC HIERARCHY PROCESS AND LINEAR PROGRAMMING AS AN ALTERNATIVE FOR PROJECT SELECTION: THE CASE OF ETHIOPIAN ROAD AUTHROITY ROAD PROJECTS

A Thesis Submitted to The School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirement for The Degree of Master of Science in Civil Engineering (Construction Technology and Management)

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June 2022

Addis Ababa, Ethiopia

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STATEMENT OF DECLARATION

I hereby declare that this thesis entitled "*Application of Multi-Criteria Decision-Making Based on Combined Analytic Hierarchy Process and Linear Programming as an Alternative for Project Selection: The Case of Ethiopian Road Authority Road Projects*" is my original work. The work has not been presented for any other university and is not concurrently submitted in candidature of any other degree, that all sources of material used for the thesis have been duly acknowledged.

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ACKNOWLEDGMENTS

I would like to express my deep gratitude to my thesis advisor Dr. Abraham Assefa for his constructive advises in realizing this paper. Being his student throughout the graduate program, I have learnt so much from him and empowered to think differently on subject matter and other real world academic topics.

My gratitude also extends to the Addis Ababa Institute of Technology staffs for support given during the whole process of this study.

My gratitude also extends to the employees of Ethiopian Roads Authority, Ministry of Finance and Planning & Development Commission for their assistant and cooperation in providing the necessary data and information.

ABSTRACT

Resources are limited for pursuing and funding new projects hence the challenge is to prioritize, select and allocate optimally. Ethiopian public projects encountered challenges in selecting best projects, finishing in time and cost. The project selection methods commonly used are quantitative in nature and they lack to account for intangible factors which can affect the outcome of project appraisals. An integrated Analytic Hierarchy Process and Linear Programming model that considered both quantitative and qualitative factors in choosing capital project is presented. The combined model is applied in Ethiopian Roads Authority road projects with Planning and Development Commission and Ministry of Finance as prime stakeholders in project selections. Research surveys were conducted in those organizations and secondary documents were used for the analysis. The results indicated project characteristics, with 0.5 weight, were ranked higher than other criteria related to the firm characteristic and external factors with weights of 0.36 and 0.14 respectively. The most important project selection sub-criteria found to be profit, measure of worth, project risk, financial standing, and resources with the overall weight of 0.15, 0.13, 0.12, 0.10 and 0.09 respectively. Others are economic factors, experience, technical ability, size & complexity, duration, organization culture, environmental, location factors, social responsibility, and political factors with weights of 0.07, 0.07, 0.07, 0.06, 0.04, 0.03, 0.02, 0.02, 0.02, and 0.01 respectively. Four projects out of six total projects were selected to have the most use of resources under the available resource constraints. The study provides a simple framework that can be used by organizations to make these challenging decisions. The integrated model is recommended for its ability to capture all possible factors, optimality advantage and applicability in different situations with refining the selection criteria.

Key Words: Analytic Hierarchy Process, Linear Programming, Projects, Project Appraisal, Resource Constraint, Optimality

LIST OF ACRONYMS/ABBREVIATIONS

AADT : Average Annual Daily Traffic

AHP: Analytic Hierarchy Process

B-CR: Benefit-Cost Ratio

CBA: Cost Benefit Analysis

CEA: Cost-Effectiveness Approach

CI: Consistency Index

CR: Consistency Ratio

EIRR: Economic Internal Rate of Return

ENPV: Economic Net Present Value

ERA: Ethiopia Roads Authority

ETB: Ethiopian Birr

FIRR: Financial Internal Rate of Return

FNPV: Financial Net Present Value

FY: Fiscal Year

GC: Gregorian calendar

ILP: Integer Linear Programming

LP: Linear Programming

MCA: Multi-Criteria Analysis

MCDM: Multi-Criteria Decision Making

MoF: Ministry of Finance

PDC: Planning & Development Commission

R.I: Random Index

RRA: Regional Roads Authority

RSDP: Road Sector Development Program

WB: World Bank

WRO: Woreda Roads Authority

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CHAPTER ONE
INTRODUCTION

1.1. Background of the Study

Construction industry is an important sector in the economies of nations and plays a key role in their socio-economic growth. The Ethiopian construction industry accounts for 8.5% of the Gross Domestic Product [1]. Ethiopia is the second most populous countries in Africa with huge demand for construction products, including transportation infrastructures. In the context of Ethiopia, "road is the most important infrastructure that provides access to rural and urban areas in the country. Road plays crucial role to reduce transportation cost and support economic growth in the country" [2].

Construction projects are vital to economy in providing physical infrastructures, industries, housing needs of the society. Despite the construction industry's significant contribution to the economy of Ethiopia, its performance remains generally low. For instance, road construction projects are important components of the economy which have rippling effect in the production, manufacturing, and service sectors of the aggregate economy. In spite of their importance, Ethiopian road projects have been suffering from a serious drawback, which is partly due to improper project selection [2].

[2] stated the project management skill gap is among the basic reasons for projects to deviate from their intended quality, time, and cost. With increased demand for public work projects, there is a need to focus on efficiency of construction project services. During the last decades, various methods have been utilized to reduce construction projects under performances and its effects. Among the potential strategies to foster the sectors development is selecting the proper projects. One of the innovative approaches in this regard is to use multi-criteria decision-making method to select proper construction projects. Hence, proper selection of road projects helps the country to invest on highly prioritized works under serious resource constraint. Project selection, a crucial and challenging decision in many client organizations, is periodic activity involved in selecting a portfolio of projects, that meets an organization's stated objectives without exceeding available resources.

[3] Stated that roads in Ethiopia have been built and expanded; however, it is not always a success story, there are critics that challenge the success of those projects like constructing roads in low traffic volume areas. The public bodies might have some objectives to invest in those areas, but unless these investment projects have adequate economic return, their positive effects could not be sustainable. According to (Enea and Piazza, (2004), as cited in [4] the challenge in project selection attributed to the involvement of different goals (organization's objectives and priorities) and the large number of attributes to consider, financial benefits, intangible benefits, availability of resources and risk level of the projects.

Over the last decades, quantitative capital budgeting techniques that provide the highest return over a given period of time have been employed to select projects. Capital budgeting involves selecting the best project or projects that maximizes the investment criteria without exceeding the available limited budget. Typically project owners use optimization techniques using a measure of worth such as the Net Present Value (NPV) and the Internal Rate of Return (IRR). However, these methods lack to take into consideration of intangible factors that can affect the results of project assessments. Qualitative factors include organizational culture, experience, project location, political and economic environment [4]. Therefore, there is a need to develop a method for project selection for client organizations that can take into consideration both tangible and intangible factors. Multi-Criteria Decision Making (MCDM) techniques, such as the Analytic Hierarchy Process (AHP), have the ability to evaluate quantitative and qualitative criteria; researches showed that AHP results are simple, and suitable tool for project selection criteria prioritization and Linear Programming for optimizing resources. Therefore, a combined Analytic Hierarchy Process (AHP) and Linear Programming (LP) approach can be used to select and optimize projects to enhance the quality of capital budgeting.

The study focuses on selection of the road projects considering different qualitative and quantitative criteria that are well known in the scientific world. AHP decision making method is used to select and prioritize the proper projects selection criteria and LP is used to constrain against the limited resources in Capital Budgeting. Hence, the framework or technique undertaken in this study is helpful to transform the objectives of selecting better projects into

reality as a set of rules or systematic methodologies which are known in making significant impact on the organizational goals.

1.2. Problem Statement

Construction industry plays a key role in socio-economic growth of Ethiopia. In today's world, any sector has a competition to its areas of business. Hence, in order to survive, improving effectiveness and efficiency is the better way, partly by appropriate projects selection. Researches/studies including [3] showed construction projects in Ethiopia are not much competitive to meet owner's and citizens expectation which partly requires an examination of alternative techniques for best possible project selections.

In Ethiopia, significant finance allotted for the roads sub-sector, the 2020 Ministry of Finance (MoF) Medium Term Expenditure Framework (MTEF) showed, the capital budget for the ERA as; 38.2 billion ETB from treasury, 279 million ETB from grant and 7.86 billion ETB from loans. But Ethiopian Roads Authority 23 years RSDP report stated that "most areas in the country were isolated from economic centers, market and basic social services. The existing road network is largely in deteriorated condition". [3] Stated "some federal roads in Ethiopia are constructed in the remote areas where the traffic volumes are far below the minimum average. Some of the road projects with higher Annual Average Daily Traffic (AADT) are not given priority for investment and some of the roads are constructed with low standard. These projects could not generate sufficient additional revenues for the government, nor could they cover their running and maintenance cost. On the other hand, the government has no financial capacity and is not allocating sufficient funds for maintenance and operation. In view of that, it is envisaged important to evaluate and research for the road projects investment prioritization methods and to study better techniques". Therefore, the size, complexity, resource requirements, and impacts of those development projects underline the need to choose projects wisely.

[5] study showed that ERA has its own road projects investment prioritization and selection criteria. However, there is no weighting for each criterion to evaluate all projects in equal ground. She forwarded recommendation "as mitigation and intervention measures, that the roads authorities should develop new selection and prioritization of road projects investment".

The selection of proper construction projects can be defined as a Multi-Criteria Decision Making (MCDM) problem as multi-criteria with different weights are used. Hence, in order to overcome the challenges, multi-criteria decision-making methods have been proposed to select the proper projects by ranking the alternatives and to use constrained linear optimization for available budgeting considering serious shortage of finance in developing countries like Ethiopia. Studies such as [6] showed that MCDM methods have been successfully applied to the infrastructure project selection problems.

AHP is a simple, and suitable tool for project selection which is mostly used in infrastructure management as studied by [6], can be used to prioritize and weight the project selection criteria and use it to the particular organizations' list of projects, finally, they can be linearly optimized against the budget ceiling. Therefore, this research discussed about project selection techniques to overcome selection problems and offer recommendation for improvements in project success. For that reason, the MCDM methods, which take into account multiple criteria and rank the alternatives analytically, are used to solve road construction project selection problems.

1.3. Research Objectives

1.3.1. General Objective

The overall objective is to study and recommend the use of multi-criteria decision making for projects selection through the analytic hierarchical scientific decision-making system and linear programming under limited resources.

1.3.2. Specific Objectives

- ☞ To apply the use of multi-criteria decision-making method through combined approaches of Analytic Hierarchy Process and Linear Programming in Ethiopian road construction industry for effective & efficient projects selection.
- ☞ To recommend projects selection decision making process by providing simple hierarchical prioritizing framework.

1.4. Research Questions

- How does the implementation of multi-criteria decision-making method through combined AHP and LP help in road construction project selection to meet objectives?

1.5. Methodology of the Study

The research involves the use of primary and secondary data. Primary data were collected through questionnaires from Planning and Development Commission of Ethiopia, Ministry of Finance, and Ethiopian Roads Authority. Through the desk study pertinent literature in the area of project selection was identified. The currently used project selection methods, the allotted budgets, the projects profile information were gathered from those three organizations.

A research approach known as combined Analytic Hierarchy process (AHP) and Linear Programming (LP) was applied in this thesis. AHP is a tool and technique for the mathematical treatment of decision problems, and it is recommended for stakeholder's decision-makers. LP is a mathematical tool and technique; "ways to formulate real-world problems in mathematical terms (models), techniques for solving the models, and engines for executing the steps of algorithms". The technique can be used for optimum allocation of scarce resources subject to a set of limitations or restrictions on the use of available resources.

The questionnaire of the survey on the data collection tool seek to compare project selection factors for AHP analysis. The results of AHP process are augmented with LP to optimize and select projects with the available resources.

1.6. Significance of the Study

The study provides information on methods and techniques for project selection using the scientific analytic hierarchy process and linear optimization systems. Studies on project selection, prioritization and optimization are core areas of research in the field of project portfolio management, for which this would be significant. This helps project clients, financiers, economic planners, and other stakeholders. The method enables project leaders, managers, and their project selection teams to exercise their knowledge, intuition, professional

judgment, and at the same time to address the context and specifies the selection of particular projects.

1.7. Limitations and Scope of the Study

The scope of this study is limited to use of combined AHP and LP techniques to facilitate and offer recommendations and overcome problems of road construction projects selection. The questionnaires from under study organization experts were used for prioritizing literature reviewed project selection criteria in AHP; then project selection criteria treated six previous road projects from MoF data base with different features which were used in LP analysis. It's being research in partial fulfillment of an academic qualification; it didn't consider all road projects. The technique, mathematical programming, does not replace the knowledge and experience of experts, but it gives insights for the decision-making system.

1.8. Organization of the Thesis

The thesis is organized with five chapters. The first chapter begins the basic research information as an introduction part of the research. The second chapter devoted to the review of related literatures and followed by the third chapter which covers research methodologies used in order to achieve the objectives of the study. The fourth chapter encompasses the presentation of results, analysis and interpretation of the findings, and discussions part. The last chapter comprises the conclusions made, and recommendations forwarded based on the major findings of the study.

CHAPTER TWO

LITERATURE REVIEW

Chapter one discussed the motivation behind the thesis, need statement, objectives, methodology, and the expected outcome. This chapter provides background and a literature review about project selections. It covers research that has been previously conducted on methods used by different researchers and organizations to improve effective and efficient project selections.

2.1. Introduction

2.1.1. Projects Definition

A project is a temporary endeavor undertaken to create a unique product, service or result. The temporary nature of projects indicates a definite beginning and end. The end is reached when the project's objectives have been achieved or when the project is terminated because its objectives will not or cannot met, or even the need for the project no longer exists. Temporary does not necessarily mean short in duration since most projects are undertaken to create a lasting outcome [6].

The proclamation No.1210/2020, [7] to provide for the federal government public projects administration and management system defines "project as investments carried out by the project implementing bodies for the acquisition or improvement of fixed assets, to accelerate economic growth, fill market failures, which is undertaken in limited resource, time and place or economic sectors".

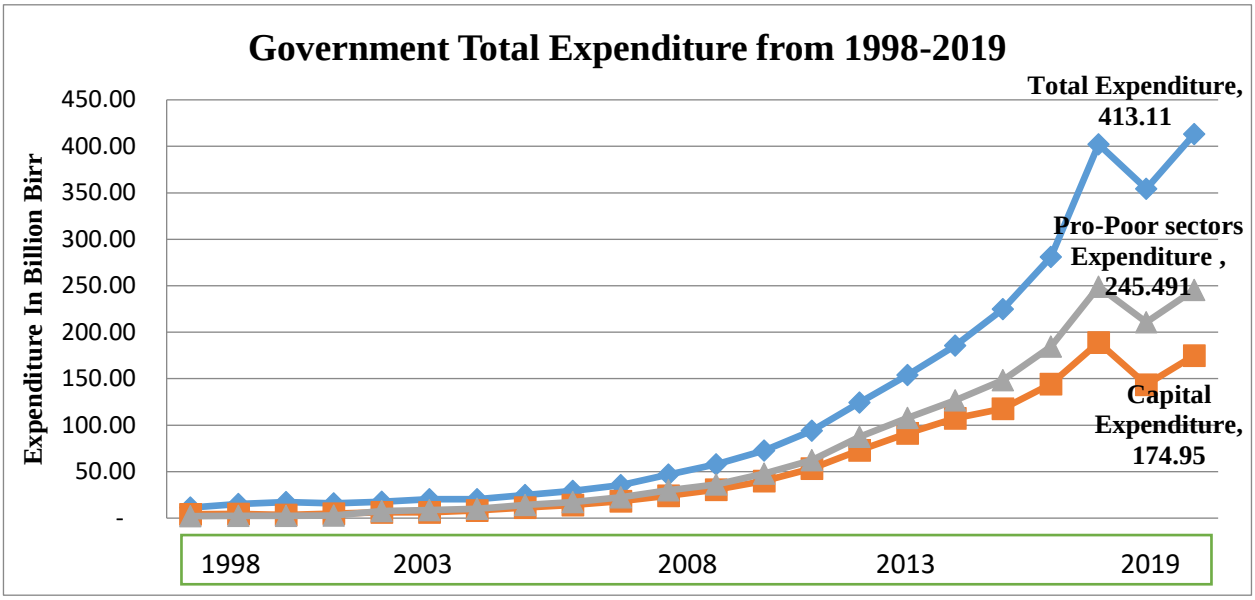
Projects in general are policy implementation tools using limited available resources (finance, work force and materials) for accomplishing development programs and plans. How to select, prepare, complete, operate and maintain the right projects are important issues to be considered for using a country's resource for development [3]. According to their study, some federal road projects have been implemented in areas of low traffic volume in which the government might have its own social and political objectives. Similarly housing development projects are implemented in different regions of the country that costs huge resource. According to their evaluation, some towns had completed apartments that did not attract end-

users, and the project implementation process was stopped before the project objectives were fulfilled. The financial recovery of the projects was not as expected and the contribution of the projects toward the strategic goal of the program was not significant. This in turn could affect the sustainability and long-term effects of the projects. Consequently, the size, environmental and social impacts of the investments underline the need to choose projects wisely, which is effective and efficient project identification, formulation, appraisal, selection and prioritization [3].

According to [6] project management is "the application of knowledge, skills and techniques to project activities to meet the project requirements". A project that meets requirements is a project which produces the expected results within the scope, budget and on the schedule. In addition, project must add the maximum value possible to the organization. Correspondingly, projects should add value at the national level as capital projects are change driving initiatives as opposed to the government day to day recurrent services. Underneath explains the Ethiopia government expenditure for capital projects across decades.

2.1.2. Ethiopia Expenditure for Capital Projects

In the past years, the Ethiopian government spent significant resources for capital projects to meet the demands of the public at large as shown in the following figure. The huge efforts undertaken so far to expand infrastructure has already begun to pay off in terms of economic growth and development. However, there are still infrastructure deficits that need to be bridged. Even though the government tried to meet the needs of the economy and the society, it is much inefficient and low level of road infrastructure facility that can carry the growing population and economy [1]. So, effective and efficient selection of projects for better use of the resources is mandatory to relive from debt pressure and to meet the society's socio-economic demand.



Source: From MoFC report, 2020

Figure 2-1: Ethiopian Federal Government total expenditure from 1998-2019

If we consider the road sector only, the data from [2] shows, physical works have been undertaken on a total of 159,218.4 km of roads excluding routine maintenance work and community roads. Over the past 23 years, 34.1 % of the total RSDP expenditure was on rehabilitation and upgrading roads, 32.2 % was on construction of link roads, 4.5 % was on construction of expressways, 4.2 % on maintenance of federal roads, 11.5 % on regional road construction and maintenance and 10.7 % on Woreda roads and 2.6 % was on institutional support projects and other activities at the federal level and 0.2 % for maintenance of urban roads. "Around 84 % of the RSDP financing cover the last twenty-three years came from internal sources, where the government of Ethiopia has financed 78 %, 5.9% from the office of the Road Fund and the community has contributed 1 % of the total finance of RSDP. The remaining 15.1% was pooled from the development partners" [2]. The basic motive of this research is considering the above fact that the government treasury finances most of the ERA road projects which needs effective and efficient road prioritization and selection methodologies to relive the encountered project challenges.

2.1.3. Project Selection

Projects are considered the building blocks in the planning and execution of organizational strategies. [6] stated projects originate from the strategic development of the nation or the

sector under study; they are tools to achieve the development objectives set out in the planning documents of the organizations. Since the capital available at any given time for new projects is limited, management must use capital budgeting techniques to decide which projects will yield the most return on investment over an applicable period. It is a process by which a business determines whether projects such as building a new plant or investing in a new product development is worth pursuing. [8]. Similar to any projects, road construction projects are subject of more demands today. Competition has forced firms to submit projects with minimal benefits in order to stay in business. In addition to their multi-stakeholder nature, projects are becoming more and more complex and risky.

In many cases, financial criteria are the only criteria considered in project selection decisions. Selection process based on qualitative and quantitative criteria have been used for decision making to justify capital investment and resource allocations. In others, the project selection decision-making process is based on the experience and feeling of the top management. Usually, the decision that results from these methodologies can be very debatable.[9] Projects can be grouped into programs and portfolios of programs. A program is defined as "a group of related projects managed in integration to control and obtain benefits not available from managing them individually". Programs allow companies to enhance the performance of related projects sharing resources and synchronizing efforts. In broader context, a portfolio is a "collection of projects or programs and other work that are grouped together to facilitate effective management of that work to meet strategic business objectives" [6]. Portfolio categorization, evaluation, prioritization and selection are essential processes for portfolio management and plays important roles in efforts to accomplish organizational strategic goals.

[10] stated the fundamental problem of decision theory such as project selection is how to derive weights for a set of activities according to importance of selection factors. Importance is usually judged by several criteria that may be shared by some or all of the activities. Weighting of activities with respect to importance is a process of multi-criterion decision making. So, in general, project selection is multi-criteria decision-making problem. There are many different multi-criteria decision methods found by researchers around the world. From these methods the following five are most widely used, weighted sum model, weighted product model, Analytic Hierarchy Process, elimination and choice translating reality and

techniques for order preference by similarity to ideal solutions. Therefore, projects require conceptual identification systems, rigorous appraisal, prioritization and selection to survive under such limited resource constraints.

2.1.4. Project Selection Using Multi-Criteria Decision Making

In a typical organization, projects compete for limited resources and hence the challenge is to prioritize projects in accordance with the strategic goals of the organization and then allocate optimally scare resources in a manner that will maximize the organization's wealth. The methods commonly used are quantitative in nature and they fail to take account for qualitative or intangible factors which are real factors that can affect the outcome of project appraisals. [8]. Popular traditional methods of capital budgeting that depend on quantitative measures include net present value (NPV), internal rate of return (IRR) using discounted cash flow (DCF), and payback period. These traditional allocation methods depend on quantified or tangible measures but fail to capture the intangible or qualitative measures such as risk of project, priorities between business units and subsidiaries, priorities within groups, discretionary versus required projects, statutory project (government requirement), social responsibility (community development) and other factors that lie within the strategic project portfolio. Besides, there are other projects like research and development (R&D) which are necessary for the long-term survival of companies but are simply difficult to assess or put into normal financial return model using the traditional methods. Additionally, their lack of managerial flexibility especially in a world of very dynamic business environment results in capital budgeting failures. Experience has shown that non-financial criteria should be included in project selection decision modeling.

[9] stated project selection is an essential process for portfolio management and plays an important role in accomplishing organizational goals. The study shows simple examples, which includes formulation and solution of the problem using 0-1 integer programming (one objective portfolio) and goal programming (multiple objectives portfolio) and finally concluded mathematical programming methods can improve the quality of the decision-making process reducing subjectivity and optimizing resource allocation in the projects that add more value to the organizations. Their study presents a literature review of the techniques used in project selection, numerical methods, and non-numeric methods.

Numeric methods include financial models, scoring, and optimization models in which this study focuses on the last one. The Numeric selection methods rank and rate the candidate projects according quantitative and qualitative normalized criteria. Criteria usually include financial benefits, productivity, reliability, environmental impact, and risks associated with each project alternative. According to [9] project selection process can be undertaken using mathematical programming models. The basic objective of linear programming is to maximize or minimize an objective function and meet some constraints at the same time. The formulation of the linear programming problem includes the definition of decision variables, objective function, and constraints.

Non-numeric Selection methods are also used in different industries because these methods are simple and take into consideration the experience and know-how of the decision makers. Some of these methods are sacred cow, operating or competitive necessity and comparative approaches. The sacred cow, it is high level executive based on her or his experience, knowledge and authority level decide that the organization must develop a specific project. This method is common in many kinds of business; however, decisions resulting might be questionable due to subjective assessment of the decision maker or poor technical and economic justification. The operating/competitive necessity selects the projects that are needed to keep the business running, under certain circumstances; an organization must undertake some projects to assure its sustainability in the long-term. On the other hand, the comparative approaches uses a pool of experts that rank a set of alternatives in a sequence taking into consideration quantitative and qualitative criteria produces a list of ranked projects according to the judgment of the members in the decision pool.

In infrastructure management, multi-criteria decision making (MCDM) has emerged as a decision support tool to integrate various technical information and stakeholder values [11]. Different MCDM techniques and tools have been developed. The study by [11] presents a comprehensive review on the application of MCDM literature in the field of infrastructure management. Approximately 300 published papers were identified that report MCDM literature applications in the field of infrastructure management areas including water resources, construction building technology, transport science technology, transportation infrastructure management, asset management, water distribution network, and pavement

management. The review was limited to articles published in referred journal and reputed conferences over the period of more than 30 years, the majority of the scholarly articles collected from the Web of science data base which accesses articles from over 10,000 journals worldwide, including journal of multi-criteria decision analysis and international journal of multi-criteria decision making which were searched separately since they publish important papers in the field.

The study by [11] focused on the following MCDM methods; Weighted Sum Model (WSM) and Weighted Product Model (WPM), Compromise Programming (CP), Analytic Hierarchy Process (AHP), ELimination Et Choix Traduisant la REalite (ELECTRE), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), The Preference Ranking Organization MEthod for Enrichment Evaluations (PROMETHEE), and VIKOR, Serbian name 'Vlse Kriterijumska Optmizacija Kompromisno Resenje'.

The study by [11] briefly explain the above methods as follows through reviewing different scholarly papers. Weighted sum method concept is searching for the weighted sums obtained from the performance ratings of each alternative on all criteria. It is necessary to process the normalization of the decision matrix into a scale comparable to all alternatives. The end result of the performance value is derived from the sum of the matrix elements of the normalized matrix element with the corresponding preference weight of the matrix column. Compromise Programming (CP) is a methodology that deals with problems of hierarchical nature which was developed by Zeleny later extended by others as composite programming. It is easy to use and well understandable when compared with more sophisticated methods but time consuming. ELECTRE used indirect method that ranks alternatives by means of pair-wise comparison, and due to complex computational procedure, it is time consuming without using specific software. The main strengths of the method are applicable even when there is missing information, incomparable alternatives, incorporation of uncertainties is required, and applicable for both quantitative and qualitative attributes. VIKOR is a method to solve MCDM problems with conflicting and non-commensurable (attributes with different units) criteria, assuming that compromise can be acceptable for conflict resolution, and when the decision-maker wants a solution that is the closest to the ideal solution, the alternatives can be evaluated according to all established criteria. The main strength of VIKOR is applicable even when

decision-maker is not able or does not know to express his/her preference at the beginning of system design, and algorithm can be performed without interactive participation of decision-makers. TOPSIS is introduced by Hwang and Yoon and its principle is the chosen alternative must have the closest distance from the ideal situation and furthest from the ideal solution from a geometric point of view using the Euclidean distance to determine the relative proximity of an alternative with the optimal solution. The positive ideal solution (A+) is defined as the sum of all the best alternative values for each attribute, while the ideal solution (A-) consists of all worst values achieved for each attribute. PROMETHEE is one of the methods of determining the order or priority in MCDM. The alleged predominance of criteria used is the use of value in outranking relationships. The use of promethea is to determine and produce decisions from several alternatives. The key issues are simplicity, clarity, and stability.

According to (Huang et al., 2011) as cited in [11] the above mentioned MCDM approaches share some common mathematical elements; values for alternatives are assigned for each criterion, and then multiplied by corresponding weights and finally combined to produce a total score. The approaches differ significantly in the details of how criteria values are assigned and combined. The processes have different information or knowledge requirements, and the calculated scores have different mathematical properties and, thus, slightly different values and meanings. The study sated the strength of AHP as it is applicable when exact and total parameters is collected, decision problems can be fragmented into smallest elements making evidence of each criterion applied, applicable for either single or multiple problems since it incorporates both qualitative and quantitative criteria, calculation of consistency ratio to assure decision makers. The limitation is as loss of information can occur due to potential compensation between good scores on some criteria and bad scores on other criteria.

The study results of [11] suggest that there is a significant growth in MCDM applications in infrastructure management and have been successfully used. The most commonly applied methods were AHP with 24 %, ELECTRE and PROMETHEE with 6.3 %, CP with 4.7%, TOPSIS with 5.3%, WSM with 3.3%, and VIKOR with 2 %. As the study reviewed wide range of related papers across decades, it is pertinent representative as far as MCDM methods comparison is considered.

Organizations now rely on projects as an important competitive factor for implementation strategies. According to (Shank, 1996) cited in [12] "areas of project selection decision that have been poorly covered in textbooks and receive only slightly improved attention in journals". The literatures focusing on financial consideration of projects, the yes and no decision assumed to flow logically from quantitative analysis has no detailed documentation in literature. Furthermore, the quantitative analysis of the incremental cash flows of projects received practically no attention in the formal literature, and that which examines the qualitative aspects of projects are ignored because it cannot be quantified. Studies dedicated to the project prioritization and selection problem with abundant methods, like the strategic intent in projects, factors in selecting projects and various qualitative and quantitative project selection models with the purpose of answering the question of whether organizations are doing the right projects.

2.1.4. Construction Projects Selection

The construction projects selection processes are well established in the literatures which clearly defines the procedures. Construction clients like Road Authorities face difficulty in selecting projects which offer attractive return on their investment. Additionally, they cannot undertake all projects concurrently due to limited resources and other constraints. Therefore, they must select the most feasible projects, which maximize positive results such as economic growth and development. and minimize any negative outcomes such as technical deficiency, environmental harm, etc. this increases the need for relying on a set of selection criteria for prioritizing projects. As stated in [5] in the developing world, the challenges in road infrastructure investment become even more daunting as manifested by the staggering size of infrastructure funding gap. It stated that project prioritization and selection in the public sector is in general a very complex and delicate problem due to huge investments, limited budget, conflicts between relevant criteria, influences of the state of politics and government. Effective prioritization of infrastructure projects is challenged by a series of constraints including institutionalized inefficiency, inadequate data obstructing decision-making, insufficient coordination among various stakeholders, lack of public consultation, lack of technical capacity for project evaluation and prioritization, and lack of consideration of possible alternatives in the infrastructure planning.

According to [4], the factors affecting project selection in the construction industry are grouped in three main categories: Project characteristic, owner (firm) characteristics and external factors. At some point, the categories seem to have conceptual overlaps such as project measure of worth and economic factor. However, measure of worth is directly looking for the project ability to return on its investment while the economic factor encompasses all economic factors/variables in national or regional unit undertaking that particular project. The project characteristics category is related to the project itself, the expected utility of the project and the strategic benefit of the project to the client organization. It consists of five criteria; profit, risk, measure of worth, size and complexity and duration. [13] Profit refers to the direct or indirect revenue/return to the society expected from the project as in the case of toll roads or the economic internal rate of return in other public roads. The risks are different criterions which are internal to the project which can arise from different perspectives from technical to social issues. Measure of worth is used to estimate the project feasibility based on quantifiable or tangible measures such as net present value (NPV), internal rate of return, payback period and benefit-cost ratio. The size and complexity criterion includes the need for coordination and management of the technological elements. The duration is the total time required to complete the project to meet its objectives.

The second category owner (firm) characteristics are related to the financial and non-financial strength and capability of the owner to handle projects. This category includes five criteria: organizational culture, experience, financial standing, technical ability, and available resources. The organization culture is how fit the project is for the organization goals and objectives. Experience is about the capability and past experience and the lessons gained from previous projects. The financial standing refers to the financial strength of the firm (owner) in terms of budget, and capital. [14]. The technical ability is the capability of the firm to handle the technological and innovation aspect of the project to complete successfully. The resources criterion refers to resource availability as of the project needs. The external factors category represents the interaction of the firm and its surroundings comprising five factors: environment, economic, location, political and social responsibilities. The environment factors are related to the wellbeing and overall impact of the project to the sustainability of the surrounding. The economic factors are the economic conditions, both macro and micro, in which the organization competes. The location criterion refers to the geographic location as it

affects the mobilization cost, accessibility and availability of electricity and water supply [13]. The political factors are related to government policies, laws and regulations, threat of power, etc. The social responsibility criterion includes the social impacts of the project. The following figure illustrates the project selection criteria used to prioritize by AHP and use them in linear optimization of limited resources for list of projects. Most of the project selection factors or variables studied in the literatures are included either in one way or the other in the following table studied by [4] as a source.

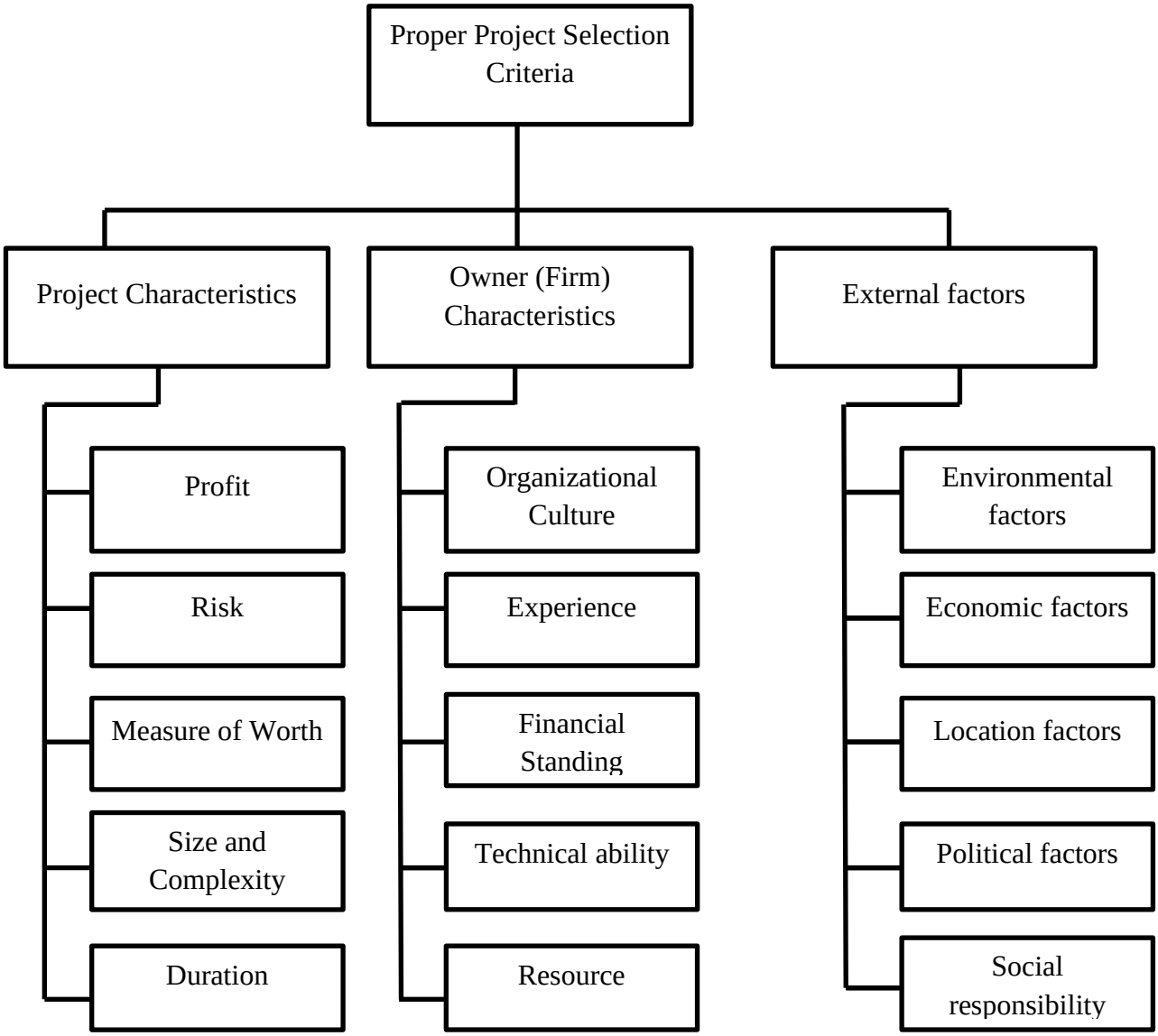


Figure 2-2: Factors affecting project selection

Raballand, 2013 cited in [15] stated the common professional mistake in project selection is to prioritize economic investment based on road deterioration and traffic demand. According to the study, "it was revealed that Zambian road project selection is mostly based on population density and poverty levels. Areas with low population density were prioritized between 2008 and 2011 and also areas with higher poverty rating were considered priority this led to low road infrastructure development in areas with higher economic activities such as cooper belt".

The study of [12] also identified different road project selection variables or factors from enormous literatures ranging from economic, political, community, organizational, technical, marketing, financial, administrative, personnel and others. The study listed project selection criterions for different project types including general project selection, rural road projects in Indonesia, road improvement by the central government, construction project selection in Nigeria, Research & Development project selection, BOT projects using AHP, infrastructure project selection, selection of construction project, R & D projects by other author, ministry of defense construction projects in Thailand, enterprise information system using Monte Carlo & Analytical Network Process (ANP), new product development project selection, regional road projects using ANP, management of change or IT projects, and public sector construction project selection. Underneath, the research area related to construction and road project types, including the World Bank project appraisal document, are taken as shown in the following table.

Table 2-1: Factors influencing different types of projects selection

Author(s)	Selection Criteria		Project Type
Mohanty (1992)	Intrinsic Criteria		General Project Type
	1. Project-Identification ability	4. managing attitudes	
	2. Resource requirements and availabilities	5. the time horizon of the project	
	3. Past experiences of the organization in managing projects		
	Extrinsic Criteria		
	1. The risk/return ratio	4.The socio-economic climate	
	2. The market environment	5. Legal & technological implications	
	3.Government policies and regulations		
Leinbach and Cromley (1983)	Road project selection variables		Rural road projects in Indonesia
	1. Total population	11. Road length	
	2. Threshold population	12. Bridge costs	
	3. Total agricultural land	13. Estate land	
	4. Potential agricultural land	14. Off season unemployment	
	5.Resource conversion equipment	15. Competing road	
	6. Higher order connection	16. Distance to surface materials	
	7. Internal access	17. Project total cost	

Author(s)	Selection Criteria		Project Type
	8. Integrated development scheme	18. Self-help level	
	9. Daily market distance	19. Project constructed	
	10. Facilities served		
Garret (1991)	Identified four influencing factors		Road investment by the central government
	1. Economic	3. Community	
	2. Political	4. Organizational	
	However, Garrett concludes that economics, social and organizational are the factors with the most significant impact on a selection of process		
Okpala (1991)	1. Availability of capital	6. Management	Construction project selection in Nigeria
	2. Economic situation	7. Competitive activities	
	3. Profitability	8. Viability	
	4. Political situation	9. Uncertainty & risk level	
	5. Benefit	10. Project competitiveness	
World Bank project appraisal document (2003)	1. Project development objective	6. Sustainability and risks	Infrastructure project selection
	2. Strategic context	7. Main conditions	
	3. Project description	8.Readiness for implementation	
	4. Project rationale	9.Compliance with bank policies	
	5. Project analysis		
Lin and Chen (2004)	1. Competence and capitals	4. Possibility of project continuation	

Author(s)	Selection Criteria		Project Type
	2.Reputation of the organization	5.Possibility of project continuation	Selection of construction project
	3. Undertaking of the organization	6. Danger and rivalry	
Putri (2011)	1. Condition of the road	4. Land use	Regional road projects using ANP
	2. Traffic volume	5. Policy	
	3. Economic		
Unuafe et al. (2016)	1. Security	10. Expected ROI	Public Sector Construction project selection
	2. Planning	11. Corruption	
	3. Geography & climate	12. Competitiveness	
	4. Administrative excess	13. Political reality	
	5. Availability of fund	14. Strategic fit	
	6. Availability of manpower	15. Project specific risk	
	7. Feasibility & viability	16. Leadership	
	8. Economic situation	17. Competence of selection	
	9. Technological ability		

Source: Adapted from Unuafe, 2018, (P,87)

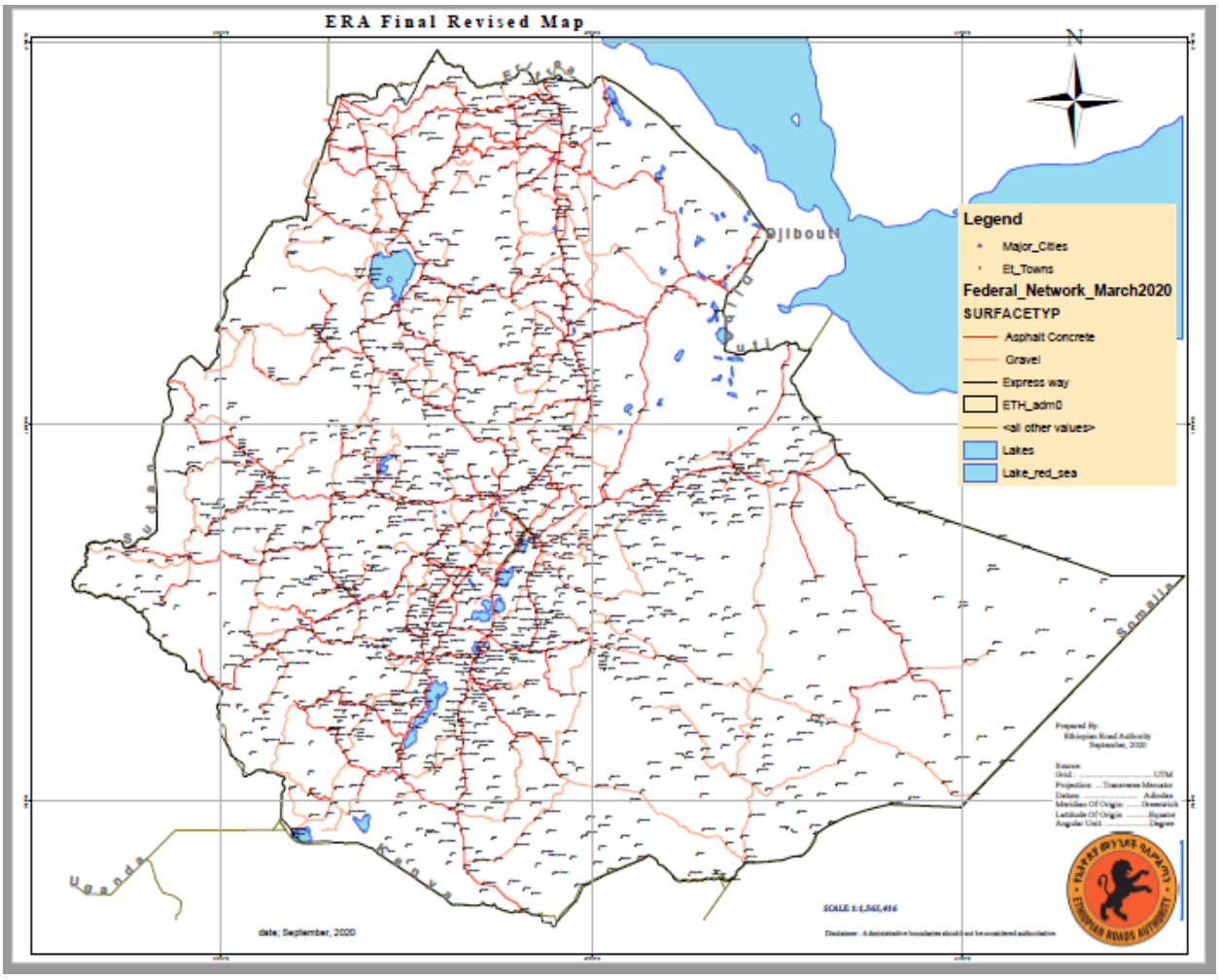
2.2. Road Transport Projects Prioritization and Selection

2.2.1. Road Transport Infrastructure

Road infrastructure has been considered as one of the most expensive and extensive infrastructure assets of the built environment globally. Road is one of the most important infrastructures that provides access to rural and urban areas in the country. Road plays crucial role to reduce transportation costs as well as physical exhaustion of the people and support economic growth in the country. According to researches, the provision of a new or improving an existing road mostly results in immediate effects such as employment opportunities in construction, reducing transport cost, and higher traffic. Often, with over a period of some years, the effects may produce more long-lasting and structural changes, or impacts. So, impacts are essentially from medium to long term changes i.e., over a 3–10-year period in agricultural production, non-road related employment, non-agricultural production, social pattern and some others. In Ethiopia, most areas were isolated from economic centers for years, market and basic social services. According to the RSDP of ERA, the existing road network was largely deteriorated and was in poor condition. Hence, the transportation sector was initially developed to contribute to Ethiopia's social and economic development and poverty reduction efforts by providing an efficient transport system, resulting in improved access, and movement of people and goods, improved agricultural production and marketing, a better access to social and economic facilities, and increased economic exploitation of the natural resources, amongst others [5].

The government of Ethiopia has recognized that limited road network coverage and poor condition of the existing road network have been an impediment to economic recovery and economic growth. Therefore, to address the problems in the road sector; the government has launched the Road Sector Development Program (RSDP) in 1997 with considerable support from the development partners. Since then, four phases of RSDP were implemented over the period of 1997-2015 and the fifth phase; RSDP V implemented from July 2015 to June 2020. [2]. In general, the objective of the RSDP was to expand the road transport infrastructure and to improve the existing network through upgrading and road maintenance as well as building domestic contracting capacity. The country's road network has increased from 26,550km in

1997 to 144,027km in 2020 (average growth of 7.5 %). Over the twenty-three years of RSDP, physical works consisting of rehabilitation and upgrading of trunk and link roads, construction of new link roads, rural roads & district roads and maintenance of federal and regional roads have been done by ERA, Regional Roads Authorities (RRA) and Woreda Road Offices (WRO) and the community and municipalities. Series of policy and institutional reforms have been implemented in the sector, which have enhanced implementation capacity of road projects and effectiveness of Road Asset Management. [16]. The following figure illustrates the Ethiopian federal road network as of March 2020; it shows the networks of asphalt concrete road, gravel, expressway across the geography of the entire nation [17].



Source: Adapted from (Ethiopian Roads Authority, 2020)

Figure 2-3: Ethiopian federal road network as of March 2020

The level of urbanization, motorization and deteriorating infrastructures in developing countries have been facing the enormous challenge of delivering sustainable forms of infrastructures with scare resources. Therefore, prioritizing projects based on transparent and evidence-based decision-making process has emerged as one of the most promising ways to bridge such enormous funding gaps especially for developing countries. Project prioritization is widely used globally as a tool to evaluate and rank projects; but the methods differ greatly across nations.

There are varying reasons for infrastructure planning and investments such as overstrained and congested existing systems; trying to sustain an acceptable level of service; national or development issues; promoting local economic growth; or safety and environmental objectives. According to (Preston, 1996) cited in [5] the decision and evaluation of infrastructure investments are influenced by three components. Those are to determine investment priorities, some mixture of operational/technical, strategic/political and socio-economic studies have to be conducted. Operational analysis addresses questions concerning technical effectiveness of the investment to find the technically most superior solution, strategic assessment determine the potential of long-term, entirely new and innovative technology investments on a political level, and socio-economic evaluation tries to measure impacts of the investment on society now and in the future; to evaluate and estimate the social worthiness/social welfare of the project; and to achieve an optimal allocation of scare resources. On the other hand (Hine et al. 2003) cited in [5] select five major categories of criteria. Those are economic, engineering, environmental, social, and risk/political categories.

According to (Mak, 1978) cited in [5] project prioritization process should be considered simply as a tool in decision-making, as a part of broader project programming process and is still subject to human bias. Priorities that are subjectively established run the risk of personal engineering bias, lack of comprehensiveness, and political bias. Furthermore, the increasing number and magnitude and complexity of the programs will make the subjective analysis unmanageable. First and foremost, there is the issue of rationality, one with clear steps and sequence is considered as rational procedures as of many literatures. This idea is critical as it differentiate between studied systematic methodologies that can be consistently replicated versus one without a well-defined structure. Underneath, the Ethiopian Roads Authority

(ERA) project prioritization and selection method and related literature reviews for different practices were reviewed.

2.2.2. Road Project Identification Process

[5] studied and evaluated the Ethiopian Federal Road projects investment prioritization practice. According to the study, main road projects in Ethiopia starts with identification of potential projects, which will best contribute to government objectives and development of economic sectors (such as: agriculture, mining, tourism, industry). The basis for identification might be as a result of economic development potential of the specific area, developing import-export corridor, improve accessibility, increased traffic level, improving road condition. Therefore, processes to meet the basic accesses and a participatory "bottom-up" and "top-down" planning approach are used.

According to [16], ERA uses three project identification processes. The first is projects identified by the regional road authorities and recommended to ERA for implementation. This is basically a bottom-up approach where the regional road authorities' study, consult with their local people according to their governing structure and identify the potential projects. The second is projects identified by the ERA, new roads for construction and existing roads for rehabilitation. In the case of new roads, ERA gives priorities to accessibility, location that needs an access road which does not have any road in that area and roads with traffic overflow where the existing road could not accommodate the existing traffic. On the other hand, in the case of road projects for upgrading/rehabilitation, the main factor for the identification of projects is traffic surveys on the existing road conditions expressed in terms of International Roughness Index. The third is, exceptional projects, exceptions can be made for some projects based on national policy programs such as food security, security problems, import-export corridor, industrial zones, and new infrastructure areas like dams or sugar factories. This is typical top-down approach of project identification as it cascades from the cross-sectorial integration or macro planning process. In addition, due to only working relationship (not having structural relationship) between ERA and regional road authorities, ERA would not verify that identified roads projects on regional/zonal level which were selected based on appropriate criteria, directly consult the community when/before selecting the projects and performs its own public needs assessment regarding road demands.

2.2.3. Road Project Prioritization and Selection Process

The considerable funding gaps for infrastructure projects needs prioritizing projects at a system level based on transparent and evidence-based decision-making process. The main concern of any prioritization systems is evaluating identified projects and ranks them in order of importance. The level of complexity of the project prioritization processes, though, varies greatly. The minimum condition for consideration as an acceptable methodology in project selections or in any application, first and foremost, there is the issue of rationality with clear steps and sequences as opposed to non-rational process which is open to the bias of the evaluator. The second is defensibility, as the one open to scrutiny with respect to the data used in the process and which resultant scores or rankings assigned to projects evaluated are related to the attributes of the proposed improvements.

Each prioritization system will be unique, although each will likely involve the following steps: starting from selecting criteria to evaluate projects, creating performance measures to compute project compliance to those criteria, combining scores for each performance measure in some way, and finally ranking the projects in order of importance.

According to [5] selection and priority setting methods for basic access road transport infrastructure consists of two broad types of methodologies which are usually applied in succession: screening and ranking. The first level, screening decreases the number of investment alternatives given budgetary constraints, by targeting poor or disadvantaged communities or eliminating low-priority links of the network. After screening methods have been applied to a set of investment choices, resources are still unlikely to be sufficient to finance the balance of the remaining desirable interventions, and hence a ranking or prioritization exercise is required. The Multi-Criteria Analysis (MCA), Cost-Effectiveness Analysis (CEA) and Cost-Benefit Analysis (CBA) are the main ranking methods in use. MCA is commonly used method in road transport infrastructure investments, a decision-making approach for situations in which a single-criterion approach is incapable of providing the required assessment framework due to usually conflicting criteria. The main phases of MCA are identification of criteria and preferences, criteria evaluation and weights generation, prioritization and ranking, then sensitivity analysis. Cost-Effectiveness Analysis compares the cost of interventions with their intended impacts, widely used to appraise investments in the

social sector, however rarely been used in the transport sector. This is mainly due to the belief that the impacts of transport interventions are mainly economic in nature and should be measured. But with the increased focus on the poverty and social impacts of transport investments, and their justification on these broader grounds, CEA has recently become more prominent. CBA is the most common approach for the economic evaluation of road investments which accounts for a comprehensive accounting of all the real costs and benefits associated with a road project. It uses producer surplus methods and consumer surplus method. The producer surplus method requires assumptions concerning the impact of transport investments on the productivity and output which are difficult to assess, overtime road transport infrastructure put more emphasis on social rather than economic objectives, the application and relevance of the producer surplus method has decreased in recent years. On the other hand, the consumer surplus methods attempt to take into account of uncertainty related to the input assumptions and an expanded treatment of user benefits, which is on the side of the consumer of the service.

According to [9] selection of projects had passed through different stages of preparation. The early stages of project selection and preliminary prioritization were based on a multi-criteria approach (MCA). Ethiopian Roads Authority (ERA) has its own criteria to prioritize road projects, 5 criteria for new roads and 5 criteria for rehabilitation/upgrading projects. After preliminary selection using the MCA approach, the project preparation moved to feasibility studies stage where a detailed economic and environmental analysis was carried out.

Preliminary selection of road upgrading projects: Five criteria were used for preliminary selection of road projects. These criteria with the respective weights are: Annul Average Daily Traffic (AADT) on the proposed road with 30 % weight in which roads with high traffic rate are given priority; network connectivity with 20 % weight in which roads which improve the efficiency of the road network connectivity are given priority; road condition with 20 % weight in which priority is given to roads or sections of road that were in a poor condition; investment potential with 10 % weight in which priority is given to roads connecting places with high investment potential, and import/export corridor and regional integration roads with 20 % weight in which priority is given to upgrading import/export and regional integration corridors [16].

Preliminary selection of new roads: Five criteria are applied for preliminary selection of new roads. These criteria with the respective weights are: roads to economic development potential with 20 % weight in which priority is given to the construction of new roads providing access to areas with unexploited natural resources; road to surplus food crops and cash crops growing areas with 20 % weight; missing links with 20 % weight in which costs and time of travelling could be reduced significantly by constructing link or short access roads between some towns in the country; new access population centers with 30 % weight in which priority is given to roads providing access to large isolated communities, and roads to government identified emerging regions or isolated areas with 10 % weight [16].

Final prioritization and selection: It is during the feasibility stage that final project selection was made on the basis of economic viability. Though the identified projects will not be properly analyzed and calculated based on the available weightings criteria, all criteria would be addressed and checked at the project feasibility study stage [16]. All new construction and upgrading projects are selected based on the conventional Producer Surplus approach or Highway Development and Management (HDM 4) tool analysis results, as found appropriate in order to compare the total discounted costs with the total benefits. Feasibility studies for most of the road's ear-marked for upgrading or new construction were underway or well advanced. Finalization of procurement for civil works and consultancy for those projects scheduled to start in the early years of the program was well advanced. The Roads Economic Decision Model (RED), developed by the World Bank, was used to improve the decision-making process for the development and maintenance of low-volume regional roads. The model performs an economic evaluation of road investment options using the consumer surplus approach and was customized to the characteristics and needs of low-volume roads. Hence, the final prioritization and selection criteria were addressed through respective feasibility study.

2.2.4. Effectiveness, Challenges and the Way Forward

Effective and efficient prioritization of infrastructure projects are hindered by a series of constraints, including inefficiency of institutional structures, lack of data to support decision-making, inadequate coordination among various stakeholders, lack of public consultation, lack of technical capacity for project programming, and lack of consideration of possible

alternatives in the infrastructure planning [18]. The major challenges of setting priorities for infrastructure development in developing countries are lack of: systematic approach to deal with competing objectives among social, economic and environmental issues, integration of involved stakeholders, public participation in consultation and monitoring in the transport planning process, consistency of project prioritization strategies in decision-making process, and risk management to ensure the potential costs and benefits are equitably allocated. So, according to, [19] transport project evaluation has become a very complex task due to "incomplete information on, for example, the environmental impact of certain investments, uncertainty of exact traffic evaluation and pay-offs, an increasing set of regulations and regulatory bodies and controversy on the methodology to be used for the valuation of environmental and social impacts."

According to [5] ERA would not perform project's post-evaluation studies on government-financed projects due to different reasons; hence, there is no means to verify the constructed project's effectiveness and whether they are giving the desired benefits. In addition, feedback assessment would not be carried out from the public and its own road asset management department on the constructed roads. So, ex-post evaluations are not done in detail (since the establishment of prioritization criteria within ERA), evaluation and or revision of such criteria have not been performed. Therfore, the main purpose of ex-post evaluation of project is to learn lessons for future prioritization and selection of projects, if not done, it will be among the challenges to be addressed in the future. In general, the challenges of ERA's Road prioritization and selection process are, budget limitations, rapid rate of traffic growth, regional competition, excessive public demand, local consultants and contractor's capacity problem, lack of integration with other infrastructure development institutions, decision makers' interest, poor maintenance practice and lack of sufficient data. Even though such challenges, the study puts the overall performance as good for the last two decades in improving the country's road networks and road conditions even if it indicate the necessity of better systematic tool for project prioritization and selection [5].

The related literatures puts the following recommendations to improve the current ERA's road projects selection and prioritization practice; institutions should have qualified experts and leaders to enhance their project implementation, monitoring and evaluation capacity, improve

their maintenance management practices, the road project selection and the routes selection should consider the environmental sustainability, safety, compensation, and ensure to have sufficient data on the assets to use them on systematic project selection methodologies. Finally, researcher such as [5], who studied the evaluation of road projects investment prioritization method in Ethiopia, recommends ERA to establish multi-criteria decision model/s for infrastructure development in which this paper partly tries to study on it.

2.2.5. Experiences of Some Developing Countries

In the above, short summery of the practice of road projects selection and prioritization practice is presented for better insight of Ethiopian practice. “In a developing country like Nigeria, various government development plans in the past have been formulated towards overcoming the shortage in infrastructure supply capacity. However, despite these past efforts to support the expanding populace, access to adequate infrastructure by citizens remains a mirage. In Sub-Saharan Africa which is lagging behind the rest of the world in its level of infrastructure development, thereby blocking the quick movement of goods and people on the continent and increasing transport costs to as much as twice that of any typical Asian country” [12]. Therefore, it is crucial to identify and select projects that will enable the nation pursue its strategic objectives since the provision of infrastructures like roads has been acknowledged as the major source of a more productive and competitive national economy.

The research done in developing country such as Gabon pre-evaluation and selection of road projects showed “classical economic criteria alone cannot reflect the entire economic and social reality of the road. Consequently, other criteria should be added, highlighting such factors as the specificity of production made possible, its commercialization level, its impact on the objective of integrating population within the national community and the administrative and social needs met. The inevitable multiplicity of road projects filing for public financing and the generally implicit existence of financial limitations force the government of Gabon to be selective as of the preliminary project identification phase.” [20]. Hence, the research showed how road project selection is difficult and multi-criteria decision-making problem under constrained resources. It recommends government should have a road project pre-evaluation and selection method that adapts to the specific conditions of Gabon

and eliminates the problems inherent in improvisation. Below, different tools and techniques to be used for project prioritization and selection are discussed.

As in (KPMG, 2014) cited in [15], "the most common problem today for Africa's Infrastructure development decision makers is that making 'yes or no' choices with incomplete and/or inadequate information. This is as a result of poor initial research and studies into potential construction projects and highlights the need to involve the right people in infrastructure development from both public and private sectors." As (Oppong, 2014) cited in [15], the study on infrastructure development in Africa concluded that most governments do not set the right priorities in project section and state that most projects were ad-hoc and misplaced. Good project planning efforts entail that selected projects meet intended objectives and expectations of the general public rather than being white elephants.

[15] studied road construction planning practice in Zambia. The study identified some of the problems like non-adherence to strategic plans, political interference, poor project prioritization, uncoordinated contract procurement, procuring contracts before confirmation of funds availability, government bureaucracy, inconsideration of vendor past performance during tendering and inappropriate project designs. The study identified that road sector government implemented works proceeded to tendering and procuring works without proper planning, scope definition, cost estimates and designs. These challenges were among the critical reasons for the Zambian government to "announce the suspension of procurement of roads and other infrastructure development projects in 2016. This was in an effort to enable the government clear the outstanding debt on the running projects as well as to minimize further stress on the national treasury which was already experiencing difficulties in meeting its obligations towards vendors." Hence, the above government intervention is a clear indicator of the dangerous impacts of improper project selections.

[21] puts, in developing countries like Ethiopia, an effective and efficient methodology has not been employed adequately and the selection and prioritization of projects lacks systematic quantification of road project attributes as per standards. Decision making bodies who are responsible for maintenance of immense lengths of roadways and associated facilities, transportation agencies frequently have to decide which sections of highways, from the road network, need immediate attention and which can be deferred. A variety of factors influence

this decision, the pavement condition is one of these important factors. Economic, political, and a host of other factors must be evaluated integrated with pavement condition before project selection may be made. The study by [21] used nine criteria influencing decision making in pavement maintenance management system which are average annual daily traffic, vehicle composition, type of distress, severity, extent, project cost, accident rate, drainage condition and land use.

The study of [12] indicated that despite the development of various frameworks to assist in the appraisal and selection of government projects, failures are still being recorded with government projects. In developing countries, where frameworks are rarely used, the problems are encountered. The study aimed at investigating the practice of construction project selection process within the Nigerian public sector in order to inform theories of decision making from the perspective of developing nations and project management practice. While there is vast empirical literature on project selection focusing on the development of selection models such as sensitivity analysis, economic models, cluster analysis, decision theory, simulation, analytic hierarchy process, pair-wise comparison for information system (IS) projects, research and development (R&D) projects, and contractor selection in the developed countries, surprisingly much less attention has been given regarding the empirical analysis of public construction project selection mechanisms in Nigeria. In the Nigerian context, the focus has been on causes and effects of abandoned projects [14].

Despite the considerable research and commentary into the causes of capital project failure and the wide applicability of project selection models, in the developed world projects are still facing. In the Nigerian context where frameworks are rarely used, the problems are compounded. [12]. Its findings revealed that with the increase in population, incidence of infrastructure shortage has continued to increase in Nigeria, causing a severe challenge, especially to the Nigerian government. The finding of the study revealed that a visible theoretical project selection framework to support public sector decision makers in making project decisions is still lacking. The significance and complications surrounding project selection within the Nigeria context, call for the development of a systematic approach that can aid decision makers in the evaluation and selection of projects. The study concludes the importance of a systematic project selection framework by proposing a selection framework

and guidelines/protocols that will aid decision makers to be consistent in assessing and selecting construction projects within the Nigeria public sector.

The identified a number of factors as influencing the project selection process within the public sector and these have been grouped under six categories: technical factors, stakeholders' expectation factors, financial feasibility factors, social factors, strategic alignment factors and external factors. According to (Olusegun and Michael, 2011) in [12] the causes and effects of abandonment of construction projects in Nigeria concludes that not only projects are not selected based on selection criteria or models but also influenced by other factors. The authors in that study identified factors such as: inadequate project fund and planning, inflation, bankruptcy of contractor, variation of project scope, political factor, death of client, incompetent project manager, incorrect estimate, inadequate cost control, faulty design, and delayed payment responsible for the high rate of abandoned projects in Nigeria. In the following table, comparative analysis of different project selection methods is presented from the [12] study.

Table 2-2: Comparative analysis of different project selection method

Selection Methods	Advantages	Disadvantages
Financial Investment Analysis: NPV, ROI, DCFs, payback period	Considers time value of money in the context of the project alongside the firm itself	It should be incorrect because it does not consider strategic benefit
	Easy to make decisions and control and prevent waste and loss and get the most beneficial projects	Pays no attention to resource limitation problem
		The focus is on short-term goals
Multi-Attribute Decision Model (MADM)	MADM assists in the event where selection factors cannot be quantified. It facilitates base for manipulating further complex scientific models	Trends to sacrifice some factors for others whenever there are conflicting factors
	Mathematical models condense resolution time and aids in attaining best decision. In comparison with other optimization methods, linear programming is more flexible and considered the most appropriate method for solving complex problems. Maximal optimal utilization of factors of production. It provides an organization with a database through information of	It is possible that no single decision may be reached due to unrealistic assumptions. It is difficult to apply due to its complexity and lengthy calculations involved. Linear programming lacks operational flexibility in the sense that it is difficult to alter or change the system once the objective function and the constraint equations have been applied to the problem.

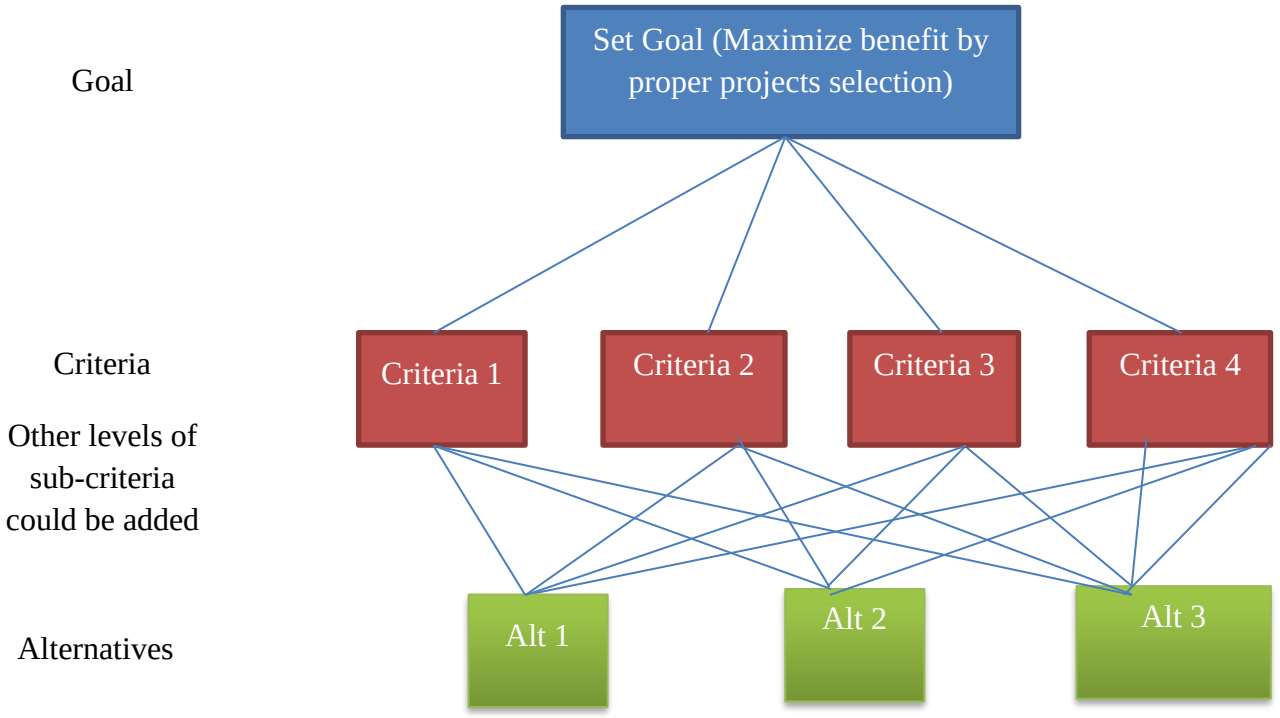
Selection Methods	Advantages	Disadvantages
Linear and Integer Programming	various alternatives generated which in turn helps in judicious allocation of resources.	Linear programming only provides a solution to a single objective; hence in situations where an organization has conflicting multiple objectives, linear programming is never the best method to employ.
Zero-1 Goal Programming	Has the ability to reconcile contradictory tangible criteria from diverse stakeholders into go, no-go decision.	Qualitative factors, risk and uncertainty are outside its coverage
		Not suitable for solving large problems
Fuzzy Logic	Integrates the amount of confidence of decision makers that may momentously impact on decision making	Over reliant on concise mathematical scrutiny.
Analytic Hierarchy Process (AHP)	Easy to use Permits the lively involvement of decision makers in attaining consensus AHP helps to elicit the complex judgments of different experts in a common platform It also ensures accuracy in the sense that it has an in-built method to check the inconsistency of judgments. Tangible and intangible individual principles as well as collective principles can be incorporated.	Not appropriate in deprecatory resource restriction conditions

Selection Methods	Advantages	Disadvantages
Analytic Network Process (ANP)	Provides healthier solution for interdependent standards	Using ANP to compare other options is complicated
Scoring & Ranking	Takes into account a wide variety of criteria from financial and tactical fields subject to organizational need	Simple to apply but does not guarantee resource practicability
Research and Development Method (R &D)	For small-scale testing	The affirmative relations between small-scale result and large-scale prospect cannot be surely assumed. The riskiness of real projects remains higher than beta testing
Strategic bucket	Creates a resilient relationship among allotting funds and strategy of organization. Permits the application of diverse criteria for different strategic sets of projects	Requires top management time and commitment Apportionment of resources to tactical groups does not guarantee focus on a particular project with highest financial return
Strategic Index	Projects selected are aligned with the organization's strategy. Stimulates better administrative participation into the project selection process	Unsuccessful in delivering the most financially beneficial set of projects Does not take risk into consideration while selecting projects

Source: Adapted from (Unuafe, 2018), (P, 69)

2.3. Analytic Hierarchy Process (AHP) and Linear Programming (LP)

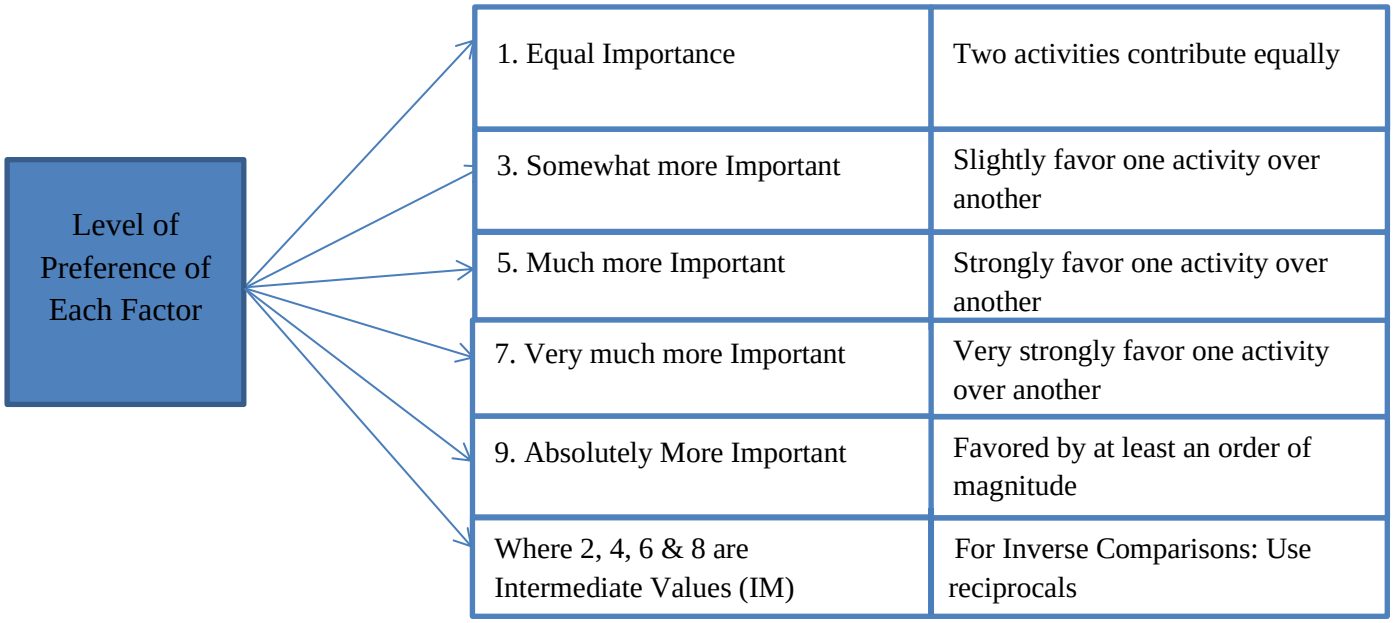
There are different methods to be used in prioritization and selection of projects; the methods used often depend on the nature of the problem. The Analytical Hierarchy Process (AHP) is one of the methods which offer a systematic way of evaluating complex problems, is easy to use, and integrates the opinion of experts. AHP separates complex decision-making problems into elements within a simplified hierarchical system. By using AHP, the study determines a goal, identifies and categorizes selection criteria and take actions by applying the appropriate techniques. Mostly, this technique considers the following steps: Identify the basic criteria associated with the construction project process from literatures, specify them in certain categories, structure the decision factors in a hierarchy, conduct survey of construction industry professionals and analyze the data and discuss the results. Finally, those prioritized project selection criteria treat projects under constrained resource when combined with other optimization techniques.



Source: Own drawing

Figure 2-4: Example of the hierarchy structure

The above figure demonstrates the decision-making problem as a hierarchy of criteria and alternatives. On top is the goal that each level works toward reaching in the project objective. Therefore, the criteria levels and sub-levels will illustrate the categories of criteria and the last level will show where implementation of different alternatives will be considered for improving the achievement of the project goal. So, a pair-wise comparison scale for comparing selection criteria for AHP preference will be as follows:

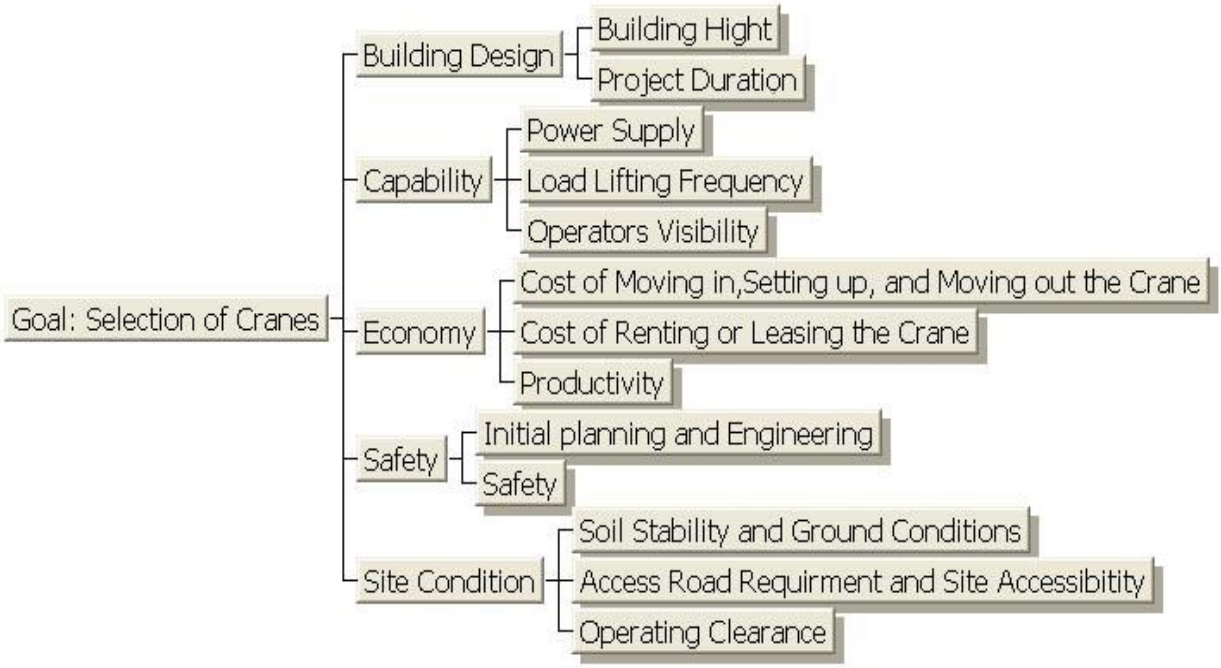


Source: Adapted from (T.L. Satty, 1990)

Figure 2-5: Pair-wise comparison scale for AHP preferences

The AHP is also used in other aspects of the construction industry. For instance, study in the selection of construction equipment, cranes using AHP studied by [22] stated, it is "due to the central role of cranes in construction operations, specialists in the construction industries have cooperated in the development of structured methods and software to help select the best crane type in construction sites. Crane selection is a time-consuming process which needs extensive data collection. The process of crane selection is a multi-criteria decision-making problem with conflicting and diverse objectives". In [22], a systematic methodology is presented under the consideration of multiple factors and objectives that are witnessed to be crucial to the construction process. The model includes building an analytic hierarchy structure with a tree of hierarchical criteria and alternatives, AHP, to ease the decision making. Three alternative crane types were considered, namely, Tower, Derrick and mobile cranes. Their result

indicated that the judgment was consistent, precise and justifiable. Study presented hierarchical model to select the best crane that will serve the construction process in a fairly optimized manner. This is performed through matching the effect of the tree of sub-goals according to their weights of importance. The following criteria are considered, building design, capability, economy, safety, and site condition. So, the following figure shows the developed hierarchical structure of the problem in which the first level has the goal of selecting the optimal crane type. The second level consists of five criteria, under which there are further sub-criteria. The last level of the hierarchy comprises of the three alternatives of the available crane types. In general, they used the following AHP crane selection criteria.

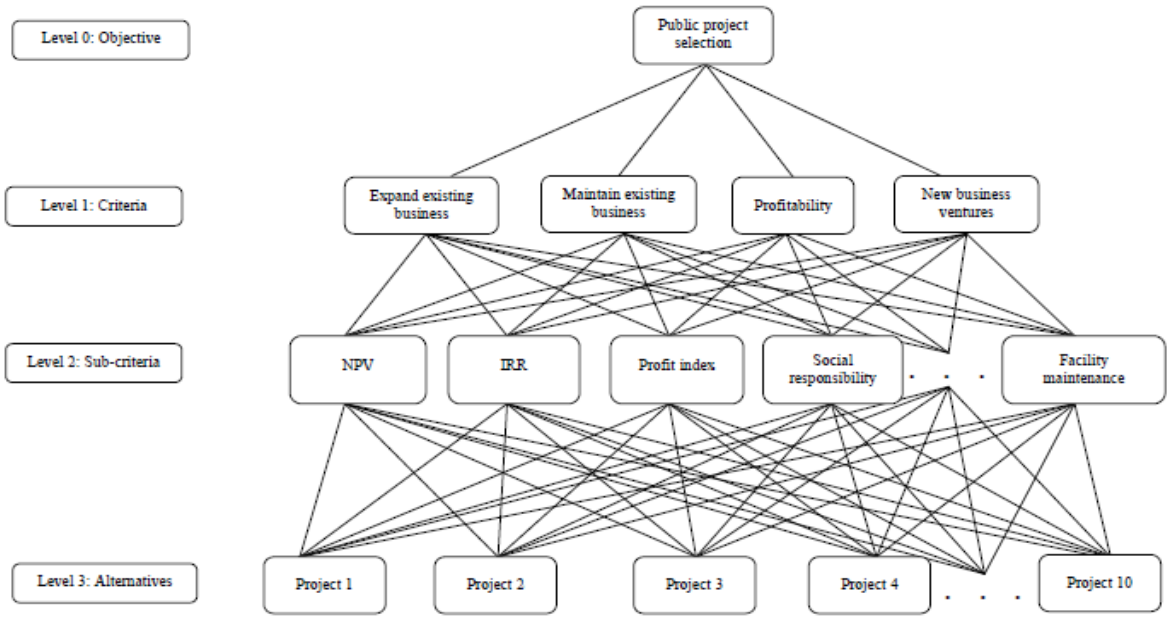


Source: Adapted from D. Dalalah,F, AL-Oqla & M. Hayajneh,2010

Figure 2-6: Example: AHP crane selection hierarchy

As shown in the figure, after establishing the decision hierarchy, set of pair-wise comparison matrices are developed for all levels of the hierarchy. An element in the higher level is assumed to be the governing element for those in the lower level of the hierarchy. The elements in the lower level are compared with respect to each other according to their effect on the governing element above. This yields a square matrix of judgments; the pair-wise comparison is performed on the basis of how an element dominates the other.

According to [8] traditional methods like NPV and IRR are used to estimate project profitability, but these methods do not capture all the factors that influence the budgeting process. Moreover, these financial methods lack the flexibility and ease for modifying the budget in future times. They put; the weightings (rankings) obtained from analysis provide more realistic estimates of the weights needed in the mathematical programming models. In the study, created reliable framework for project prioritization and selection decision that ensures a formal linkage between capital budgeting decision and organization objectives, developed a project selection model that is capable of capturing both tangible (quantitative) and intangible (qualitative) factors in determining project profitability and made project selection process efficient and effective which is flexible and easily modifiable to accommodate change. Based on top management judgment, they generally agreed that capital projects selections will be principally based on the four major factors: expansion of existing business, maintenance of existing business, profit making and new business ventures. As in the following figure, their model has a three-tier hierarchical structure whose main goal is the effective and efficient selection of capital projects in the public sector arena.



Source: Adapted from I.Ehie, E.Oyatoye & I. Joseph, 2016

Figure 2-7: The hierarchical structure of the AHP model

Linear Mathematical Optimization Problem:

It is an optimization problem in which we minimize (or maximizes) a linear function. The function that we minimize (or maximize) and constraints can be described by linear functions. The linear optimization (LO) is the technique that studies these problems, it is also known by the name of linear programming, a term introduced by George Dantzig to 1947, but this name tends to be abandoned because of possible confusion with the concept of computer programming. LP use for solving real world problems: According to [23], Linear Programming is part of a great revolutionary development which has given mankind the ability to state general goals and to lay out a path of detailed decisions to take in order to "best" achieve its goals when faced with practical situations of great complexity. The tools for doing this are "ways to formulate real-world problems in detailed mathematical terms (models), techniques for solving the models (algorithms), and engines for executing the steps of algorithms (computers and software)".

According to [24] mathematical optimization methods can be used in project selection decision process, the study presents the reviews on optimization methods and a practical use case in portfolio management area using the objectives of maximizing the organizational benefits, minimize cost and consider the constraints and strategic objectives. So, project portfolio selection can be used using several techniques, numeric and non-numeric methods, and linear and nonlinear optimization methods for mono-objective and multi-objective problems. The study considers the application of integer linear programming method to select one of the eight projects, those that will maximize its financial profit (profit, in terms of monetary value less the cost of capital) under the constraints of the available budget and the interrelationship in between those candidate projects. Finally, it concludes the advantages of the method remains the objectivity and accuracy of the results they present to decision makers. Optimization techniques consider relationships between projects and other factors that other methods do not consider. They allow the user to explore scenarios through sensitivity analysis for each factor in the objective function and the constraints. Mathematical programming and optimization technique rely on the availability and quality of the information about the candidate projects. The more knowledge on the candidate projects to be prioritized and selected, the more accurate the evaluation and selection process.

[25] stated project selection involves decision making and it plays a crucial role in any organization. Therefore, selecting not just the right projects but also the right mix of projects for the portfolio is considered as one of the most important tasks for organizations to ensure the achievement of the corporate strategy within limited resources and capabilities of the organization. Prioritizing and selecting optimal project portfolio can be very challenging especially with a large number of projects with multiple constraints and interdependencies.

The study puts "an integer linear programming model for project selection was developed and applied in a selected organization in Nigeria. The model seeks to optimize the mix of the projects to be undertaken while keeping the total cost and project interdependency as constraints. The study recommends "the model can also be used to plan an optimal mix of project portfolio for a future date within the limitations of a given set of constraints and interdependence".

The following points shows the procedures of the [25] study on an Integer Linear Programming Model (ILP) for project portfolio selection. An integer linear program deals with the optimization of function of variables, that is, objective function, subject to a set of linear inequalities known as constraints. It made the following assumptions in model formulations:

- The objective function and the constraints equations are linear
- All coefficients in the objective function and constraint equations are defined with certainty
- The decision variables are considered to be integer
- The budget is fixed. That is, the total fund available to carry out the selected projects is known and fixed
- Project interdependencies exist. That is, projects could be mutually exclusive, complementary, or non-dependent

The general ILP: In canonical form, the integer linear programming problem may be stated as [25];

Optimize $Z(X)$

Subject to *g(X)*

Where;

X is the binary decision variable which is a zero-one decision vector

Z(X) is the objective function

g(X) is the matrix of constraints

Decision Variables: The decision variables are defined by:

$X_i = \begin{cases} 1. \text{ If project } i \text{ is selected or included in the portfolio} \\ 0, \text{ if otherwise} \end{cases}$

Where $i = 1 \ldots N$

And *N* is the total number of projects being considered. X_i is the binary decision variable. It is a 'yes' or 'no' decision on each project.

Objective Function: the objective function is expressed thus:

Max Z= $= \sum_{i=1}^{N} a_i X_i$

Where;

Z is the value function to be optimized (maximized)

*X*i is 1 or 0 depending in weather project *i* is selected or not

a_i is the priority level of each project, i.e., all projects are considered not to be of the same importance.

Constraints: the objective function is subject to the following constraints

$$\sum_{i=1}^{N} C_i \leq AF$$

Where:

N = the total number of projects being included

C*i*= cost of each project

AF= budget or finance available for all the projects

The rest are the project relationship constraints: such as mutual exclusiveness, complementary relationship and mandatory projects which were expressed mathematically. The mandatory and mutual exclusiveness relationship was used in this study.

The objective function seeks to maximize the total number of projects to be incorporated in the portfolio and subject to a set of constraints. From the above model, the constraints include resource constraints such as finance, or budget, mutual exclusiveness, mandatory and interdependency among projects.

Appling the model gives the following where the coefficients are priority levels of each project, and Xi are projects.

Maximize $Z= 6X_1+2X_2+4X_3+5X_4+5X_5+6X_6+X_7+2X_8+3X_9+4X_{10}+5X_{11}+3X_{12}+3X_{13}$

$5X_{14}+4X_{15}+2X_{16}$, where the coefficients are priority levels of the project (1-6).

Subject to:

$6300X_1+950X_2+1600X_3+1200X_4+890X_5+9000X_6+8300X_7+10500X_8+18400X_9+850X_{10}+14100X_{11}+980X_{12}+19000X_{13}+1850X_{14}+2000X_{15}+1000X_{16}\leq$ 100,000 (total budget), where the coefficients are the cost of each project.

Finally, the model has not only prioritized the projects, but it has also given an optimum project mix based on the weights, mutual exclusiveness, complementarities, and interdependencies. The model can also be used to plan project portfolio for a future date within the limitations of a given set of constraints.

Using the integer linear programming, only the projects with higher priority in AHP calculation and falling within the budgetary constraint were selected. Therefore, some projects of higher priority were selected, and the budget was not exceeded. Other remaining projects that were not selected could be represented during a subsequent plan period for consideration. The analysis of the study results showed that “a total of 11 projects out of 16 were eligible for selection in the period under review”. The total cost of the selected project was 90 % of the total budget. Generally, apart from not prioritizing and obtaining an optimal project mix, the community would have spread its entire resources on the 16 projects with some of them being

abandoned later. Hence, with 90% usage of the total budget, it was good to implement only the 11 projects rather than starting the whole 16 projects getting in difficult situation at the end. In conclusion, the study shows that the model may be successfully applied to existing organizations to select optimum project portfolio and handle project interdependency, provides a good project mix within budgetary constraints and project interdependency, and may also be used to plan project portfolio for a future date within the limitations of a given set of constraints.

2.3.1. Combined use of AHP and LP

The combined AHP and LP research approach is a method to prioritize construction Projects selection criteria under some constraints. [26] Research indicated that the approach, integrated AHP with LP can definitely make a more realistic and promising decision than stand-alone AHP only, the review shows more focus has been confined to the integrated AHPs. It can be integrated with other techniques, for instance, mathematical programming in order to consider not only both qualitative and quantitative factors, but also some resource limitations. The research not only provides evidence that the integrated AHPs are better than the stand-alone AHP, but also aids the researchers and decision makers in applying the integrated AHPs effectively. Among 66 journal articles reviewed and reported by [27], 33 papers (50%) integrated the AHP with the mathematical programming techniques, including integer linear programming (ILP), mixed integer linear programming (MILP) and goal programming (GP). The Analytic Hierarchy Process (AHP) and Linear Programming (LP) techniques have been used in project selection; however, their combined use is rather limited. The overall goal is to choose the best projects that maximize the overall benefit for the owner. [27] studied the application of the multi-criteria decision-making methods for project selection, it provided decision methods for project managers in construction companies. It integrated the AHP with other two, Delphi method and technique for order preference by similarity to ideal solution. As a result, the criteria for selection are determined by expert opinions, and then assign the weight of criteria by AHP. Finally, the other methods were used to evaluate alternatives which are found prioritized by weight for project. So, the study recommends the integrated use of AHP with other techniques to prioritize and select projects as it is helpful to find the priority weights of each selection criteria and constrain projects with the available resource.

[8] study on a comparison between the integrated model and the capital budgeting technique shows that the integrated model outperformed the common capital budgeting method in choosing the projects that best meet the organization's overall goal. They used an integrated analytic hierarchy process (AHP) and linear programming (LP) model that considered both quantitative and qualitative factors in choosing the best capital project options from a list of present competing projects. Their integrated model was applied in a developing country within the Nigerian National Petroleum Corporation (NNPC), the national oil and Gas Company engaged in adding value in the nation's hydrocarbon resources, in selecting capital projects that meet the organization's strategic goals. In their methodology, the prioritized weights (ratios) of the individual projects obtained from AHP were used as the pre-emptive weights of the decision variables of the resulting LP model that examines the profitability of the organization.

2.4. Summary

Different researches/studies on project prioritization and selection using multi-criteria decision making analysis are done and recommended using MCDM as in the combination of Analytical Hierarchy Process and Linear Programming helps practitioners and academicians in making complex decisions. Those approaches are common to use in construction industry through equipment selection, contractor selection, risk assessment and others uses. But there is limitation of relevant study done in Ethiopian construction sector on how it will help to overcome the present challenges of construction projects selections and prioritization to meet project objectives under constrained resource envelope. According to [5] "regarding the overall application of ERA road projects prioritization criteria under the current criteria, the criteria specified for prioritization of road projects would be verified through feasibility study of the road projects. However, the literature reviews revealed that the feasibility studies of the projects only show the viability of those specific projects without giving scores, and hence comparison/ranking would not be performed between projects based on the said prioritization criteria weighting." This is the basic gaps on this study area which needs research intervention for alternative project selection framework as partial contribution for future improvements.

The project selection methods are used often depending on the nature of the problem. The Analytical Hierarchy Process (AHP), mathematical programming and optimization

techniques are among the different methodologies used in project selection. The complexity of mathematical programming can be reduced for the end-user with the development of a decision support system, which assists the decision maker in choosing the set of projects that adds more value to the organization. Some of the advantages of optimization models are they lead to optimal project selection without bias and subjectivity. Optimization techniques consider relationship between projects and other factors that other methods do not consider. Their potential is based on their capacity to customization according to the needs of the decision-making team. The objectivity and robustness of the project selection process is improved setting the objective function and constraints that best reflect a particular situation.

In this study the researcher chosen to use the AHP method as an alternative to the existing project system, which offers a systematic way of evaluating complex problems, is easy to use, and integrates the opinion of experts. AHP separates complex decision-making problems into elements within a simplified hierarchical system, and it is convenient to integrate with other tools like Linear Programming.

CHAPTER THREE

RESEARCH METHODOLOGY

Chapter 2 provided backgrounds and literature review covering several aspects of the thesis objective. This chapter presents the research methodology, which includes the research design, method, approach, and survey used in this thesis.

3.1. Research Design

The overall objective of the research is to study the combined Analytical Hierarchy Process (AHP) and Linear Programming (LP) techniques for decision making on prioritization and selection of road construction projects to meet objectives. The fundamental problem of making decision is how to derive weights for asset of activities according to importance which is usually judged by several criteria that may be shared by some or all the activities. Weighting of criteria regarding their importance is a process of multi-criterion decision making. The following diagram shows the conceptual flow of the research design.

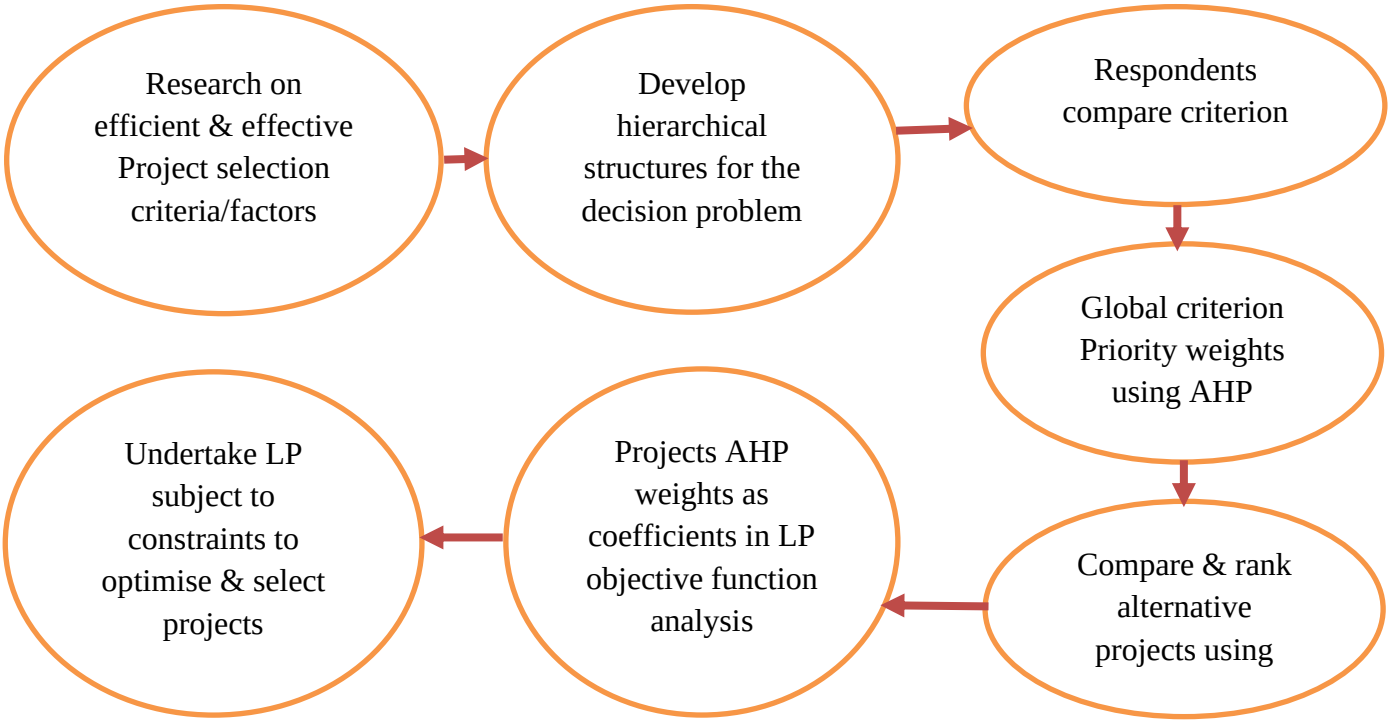


Figure 3-1: Research design combined AHP & LP Approach

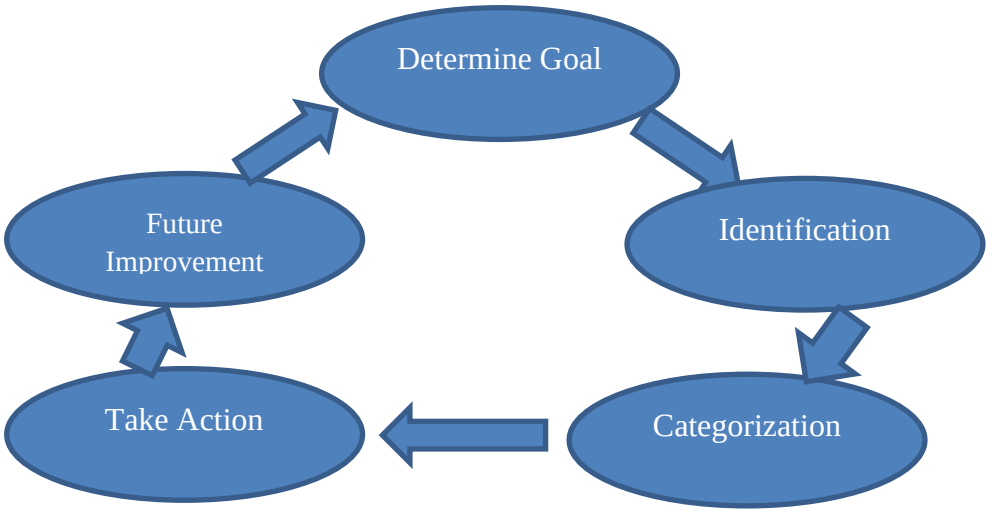
A research approach by integrating AHP and LP was applied in this study. AHP is a method for the mathematical handling of decision problems, and it is recommended for stakeholders' decision makers. Linear programming is a technique for optimum allocation of scarce resources subject to a set of limitations or restrictions on the use of available resources. They had been successfully used in different fields and disciplines. AHP's ability to handle both qualitative and quantitative data makes it an ideal methodology for some prioritization problems. [28] stated AHP should be a science of scaling based on mathematics, philosophy, and psychology. The objective of this approach is to use the weights, also known as priorities, to simply implement the most important activities by rank. The problem then, is to find the strength or priority of criteria and then compose the results to obtain a single overall priority for all alternatives projects.

The research identified a group of project selection criteria, by adapting and extending presented by literatures. After searching the project selection criteria in the literatures, for the validation purpose, the researcher discussed with different department experts and mangers on those criteria based on values, strategic direction, and available resources. The participants were from the three public organizations used in this study as described in the tools/instruments below. Three main criteria and fifteen sub-criteria were identified from related research reviews and all of the discussants replied that these criteria and sub-criteria were necessary for the ranking of road projects. List of those fifteen projects selections criteria is within the categories related to project characteristics, firm (owner) characteristics and external factors. Finally, the contents and descriptions of the criteria in the questionnaire were modified by incorporating comments. Then for the gathering of data on the application of construction projects selection techniques, the decision factors were put in a hierarchy and survey was sent to respondents. AHP process was then applied to analyze and prioritize these techniques in each level of the process in order to examine the relationship between projects selection and its objective. Finally, those prioritized project selection criteria features were treated with the projects under study and constrained optimization was done with the available capital budgeting. From medium-term expenditure framework (MTEF) of MoF, the road sectors annual allocated budget was found, which serve as resource constraint in linear optimization. Similarly, with regard to validity, piloting the questionnaires, Cronbach's alpha calculation and consistency analysis was done, and the results are discussed in chapter four.

Diverse selection methods have been developed to assist decision makers in making decisions, some are not extensively employed either on the basis that they are complex and difficult for decision makers to understand, or they address only a few of the highlighted concerns. In studies, quantitative issues widely analyzed, qualitative issues also certainly affect the outcome of project decisions although they are more often not well comprehended and normally given adequate attention. To this end, the methodology of this research studies a simple hierarchical framework to select proper projects using the combined advantages of each technique i.e., Analytic Hierarchy Process and Linear Programming.

3.1.1. Research Process

1. Projects selection criteria survey was sent to the organizations under study for AHP analysis. The basic approach or steps of for studying selection methods are;
    a. Define the goal of the decision- What do the study want to decide, for what purpose, and what are the alternatives?
    b. Structure the decision problem in a hierarchy-what are the categories and criteria that figure into decision?
    c. Pair comparison of criteria in each category- Which do the study prefer, and how much does the study prefer one or the other?
    d. Calculate the priorities and consistency index-were the comparisons logical and consistent?
    e. Evaluate alternatives according to the priorities identified-what alternative optimum solution is there to the decision problem?
2. Linear Optimization with resource constraints (from allocated capital budgeting): the AHP prioritized project selection criteria from the respondents of the target organizations treated six demonstratives anonymous road projects. The priority ratios (weights) obtained from the AHP were used as the coefficients of the decision variables in the linear programming.



Source: Own drawing

Figure 3-2: AHP for decision making

3.1.2. Tools/Instruments

The research data was collected from primary and secondary sources. The primary data was collected by using cross-sectional questionnaire surveys. Detailed information was collected from those who are involved in the road construction projects as project evaluator, supervisors, project implementation specialists and other experienced professionals. The survey objective is to quantify relative priorities for a set of factors and alternatives on a ratio scale, based on the responses of the professionals' experience. Transforming the decision-making problem into hierarchy of criteria and alternatives was proposed from literatures i.e., the categorizations comply with a set of different project selection criterion, and the criteria are then prioritized for decision making. Then a pair wise comparison matrix was constructed for all elements.

The secondary data were collected from ERA plan, capital projects status report, projects approved for expenditure, thesis works, electronic retrieval, journals, and relevant books. After identifying key selection criteria, the second step was to assess the weights of these criterions through the pair-wise comparison questionnaires in AHP based on the response of professionals from:

- Ethiopian Roads Authority (ERA): responsible for road construction projects initiation, implementation, operation, and maintenance.

- Planning and Development Commission (PDC): responsible for appraisal, selection, monitoring, and evaluation of public development projects.
- Ministry of Finance (MoF): responsible for public development projects budgeting and monitoring.

A questionnaire was prepared to inquire the respondents experience and designed to enable pair-wise comparisons using the AHP methodology. The questionnaire designed in such a way that it is clear, short and in line with specific and general objectives in light of getting a high response rate from the participants. Furthermore, to collect comprehensive and demonstrative data, since respondents may be from different professional disciplines and organizational views, definitions and explanations were written in the questionnaire. Pre-testing the questionnaire before mass distribution was undertaken to check reliability, validity, and to check the appropriateness of data collection instruments. The respondents answered the questions consistently and responded that the parameters in the question can measure the objectives of the study. The next step was computing the priority (weight) for each main category and criterion by using Microsoft-Excel as per the procedures shown in chapter four. Using a prioritization matrix is a proven technique for making tough decisions in an objective way. It is a simple tool that provides a way to sort a diverse set of items into an order of prioritization matrix importance by deriving a numerical value. So, creating and using a prioritization matrix involves five simple steps: determining the criteria and rating scale; establishing criteria weight; creating the matrix; work to score projects; and discussing results and prioritize the list.

Next, the third step, the priority weights obtained from the AHP used as the coefficients of the decision variables in the linear programming for optimal allocation of the budgets for those six selected anonymous road projects which are from MoF data base. As some of the projects for this study might have conflict of interests, it was decided not to mention the names of the projects and hence, projects are identified with sequential numbers as shown in chapter four. It being research in partial fulfillment of an academic qualification, it didn’t look at all the projects but some upon which reasonable conclusions can be deduced.

3.1.3. Sampling Technique

For the purpose of collecting data, the study conducted a survey on professionals working in Ethiopian Roads Authority (ERA), Planning and Development Commission (PDC) and Ministry of Finance (MoF) which are prime stakeholders in public road projects selection. The survey was sent to project management professionals who are actively engaged in road projects, targeting decision makers, project development specialists, Engineers, and related disciplines. At the second stage, purposive sampling was used to select employees and managers who are very familiar with the practices and challenges of the project selections. So, the target experienced professionals from those organizations who have hands-on experience on the project evaluation, selection and prioritization was the target respondents. Hence, purposive sampling method was used, first judgmental/ criteria-based sampling (the criteria were targeting employees with hands on experience and duty on road development projects), then snowball/networking techniques were used. The total sample size is one hundred respondents (considering 3 organizations and number of directly involved departments in project selection); since responding the questionnaire requires a high level of competence and expertise and for the purpose of identifying the target population, the researcher was assisted by employees of the respective institution. The networking was done, first contacting the development projects workstream staffs and coordinators, second contacting other project implementing, and budgeting work streams assisted by the first respondents. The following figure illustrates sampling and data collection processes.

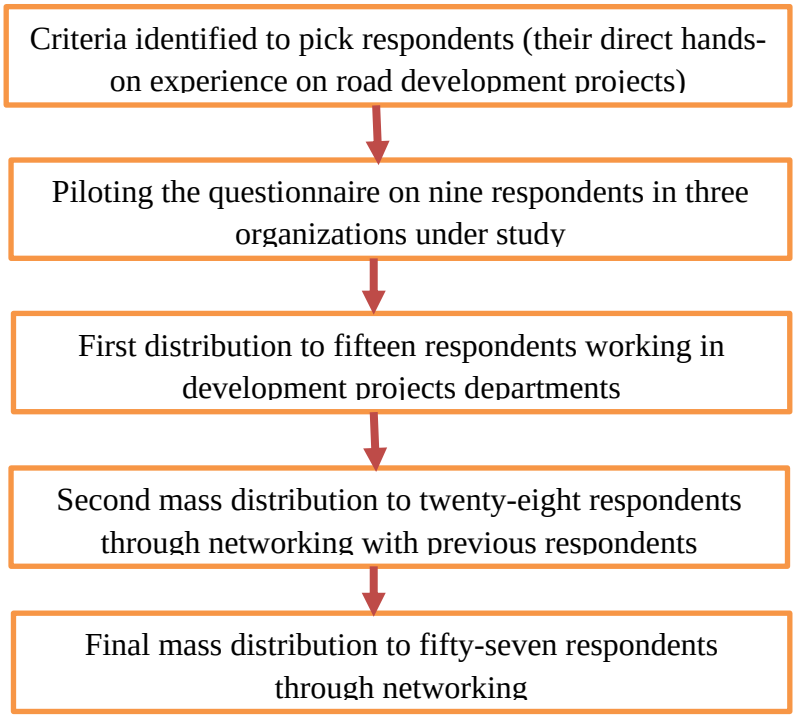


Figure 3-3: Sampling and data collection process

3.2. Method of Data Analysis

According to [29] data analysis refers to the process of evaluating data using analytical and logical reasoning to examine each component of the provided data. Absolute and relative measurements were used for the determination of the score of the criteria. In relative measurements, the pair-wise comparison is developed for each alternative in the scale of 1 to 9. The level of preference of one criteria/factor over another getting more importance across 1 to 9. The relative score of each criterion is determined by eigenvector found with normalized matrix using AHP. In absolute measurement, as shown in chapter four, projects were compared each other based on the absolute nature/profiles of projects found in their feasibility studies after identifying highest project selection criteria from AHP analysis.

According to [10], the Analytical Hierarchy Process is a decision-aiding method aimed at quantifying relative priorities for a set of alternatives on a ratio scale, based on the subjective judgment of the decision maker. It is a philosophy based on the intention to provide a comprehensive and rational framework for structuring a decision problem, for representing

and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

The first task was developing the AHP hierarchy structure for the decision problem. The criteria were selected, and alternatives were identified. The data was collected from respondents of the three organizations, Ethiopian Roads Authority, Planning and Development Commission, and Ministry of Finance. The respondents compared the criteria against each other. Then, the data was encoded in MS-Excel and data analysis techniques in multi-criteria decision making were done. Preference analysis, preference weighting, comparison matrix, computation of priorities, percent ratio of priorities and results for each level and method validations, Cronbach's alpha calculations, consistency analysis, consistency measure, consistency Index (C.I), Random Index (R.I), Consistency Ratio (C.R) and consistency results were analyzed. It is good to measure the level of consistency among all the respondents regarding the weight of selection criteria. The consistency measures lie on reason behind AHPs subjective base on scaling based on mathematics, philosophy, and psychology.

The score (weight) of each project was found by multiplying the score of projects for each criterion by its global weight and then adding them to find the overall score of each project. This was done by MS-Excel. Finally, those prioritized project section criteria's features from AHP analysis treated the randomly selected six projects characteristics under study and linearly constrained them with the available capital budgeting, a process of Linear Programming (LP).

The global priority weights of criteria for project selection were determined from AHP analysis, then the projects were compared each other to obtain the local priorities of each project. After the projects have been prioritized using AHP, the weights of each project were used as the coefficients of the decision variable in the objective function of a linear programming. The weights of projects actually show the contribution of each project towards meeting the organization objectives, efficient and effective project selection. Thus, maximizing these weights can be translated to maximizing benefit for the organization in terms of selection factors. Finally, the projects were selected and linearly optimized subject to constraints using MS-Excel solver.

CHAPTER FOUR
DATA ANALYIS AND RESULTS

Chapter 3 discussed the research methodology, approach and survey used in this thesis. This chapter demonstrates data collection process, analysis, validation, the results obtained. It also explains utilization of AHP and LP method and presents the results.

4.1 Data Collection

4.1.1 Work Experience of Survey Respondents

The questionnaire was distributed through personal delivery method followed with immediate collection of completed questionnaire. The data of respondents of the survey was analyzed according to the participants' level of experience and organization as illustrated in figure 4.1 and 4.2 respectively.

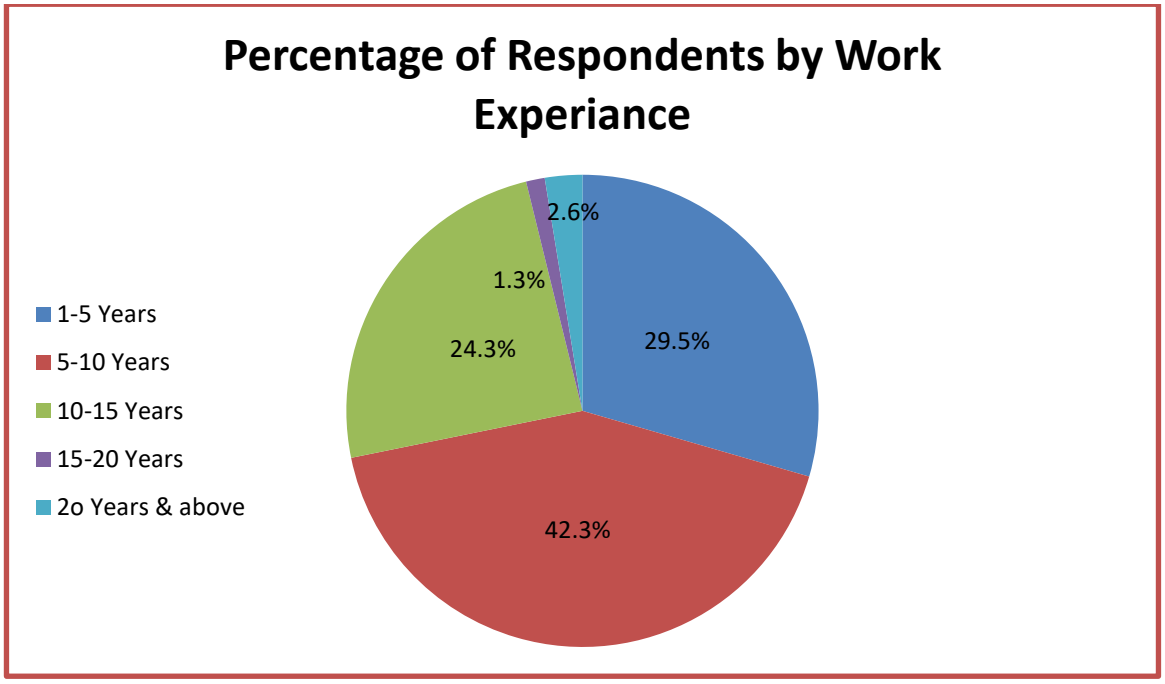


Figure 4-1: Distribution of survey respondents by level of experience

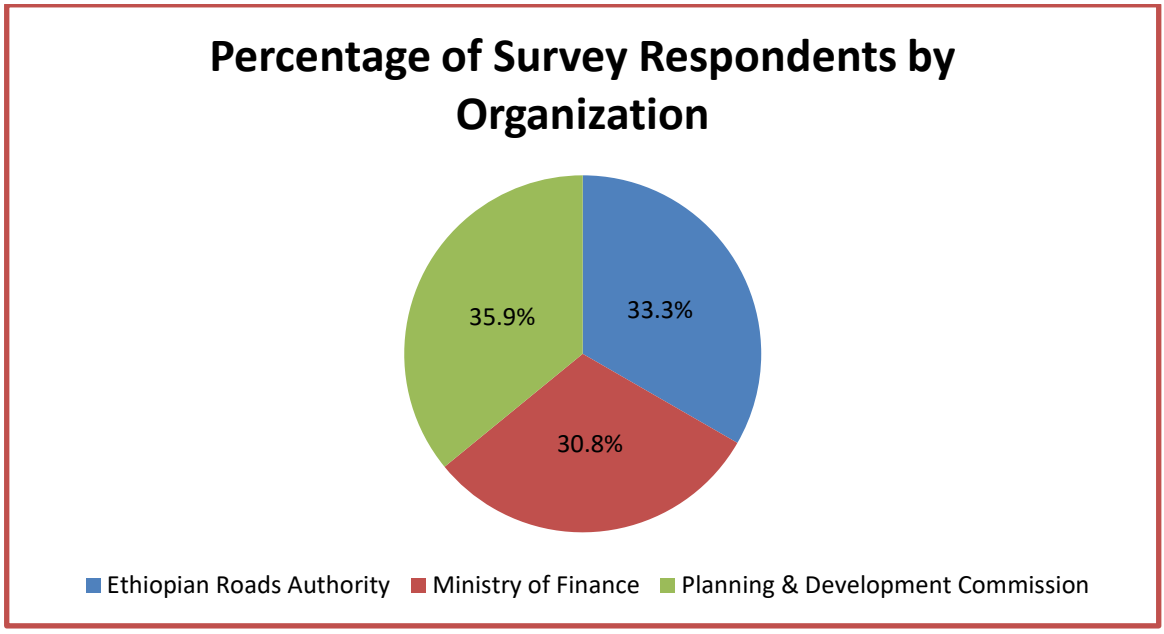


Figure 4-2: Distribution of survey respondents by organizations

4.1.2 Respondents responses

There were 100 questionnaires included in the survey with the response rate of 88 % despite the questionnaire requires high level of expertise and commitment. Among them 10 were rejected due to failure to fill the questionnaire completely. Hence, 78 surveys are used for the analysis.

4.2 Data Analysis

4.2.1 Analytic Hierarchy Process Analysis

In this study, a decision hierarchy structured and AHP was applied in order to examine the relationship between road construction projects selection criteria and their importance to meet objectives. The model used has a three-tier analytical hierarchical structure whose main goal is providing alternative technique for selection of road projects in the public sector arena, the case of Ethiopian Roads Authority.

4.2.1.1 Preference Analysis and Preference Weighting

Evaluating the pair-wise comparison questions judged by all targeted project management professionals experience was done. According to [28] “the fundamental scale of the AHP is a scale of absolute numbers used to answer the basic question in all pair-wise comparisons: how

many times more dominant is one element than the other?" Based on this principle, to obtain the set of overall priorities for a decision problem, synthesizing the judgment was made in the pair-wise comparison. The data is weighted and added in order to give a single number to indicate the priority of each element on a scale of 1 to 9 as per the definition of weights given below.

Table 4-1: Pair-wise comparison scale

Weight	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent scale values	When compromise is needed
Reciprocals	For Inverse comparisons	A reasonable assumption

Source: From T.L.Satty, 1990

4.2.1.2 Comparison Matrix

To evaluate the pair-wise comparison, a comparison matrix was created for all criterions. The following figure illustrates (shows) the result matrix of criterions from all respondents as an example, where the coding and the remaining matrixes, calculations, analysis for the survey, and respondents' responses is illustrated in the Appendix B.

Table 4-2: Comparison matrix

Pairwise Comparision Matrix															
Parameter	Profit	Risk	Measure of Worth	Financial Standing	Resource	Economic Factors	Experience	Technical Ability	Size and Complexity	Duration	Organizational Culture	Environmental Factors	Location Factors	Social Responsibility	Political Factors
Profit	1.00	3.58	2.47	3.04	3.91	4.68	4.45	3.45	3.74	4.73	5.79	6.24	5.68	5.85	6.65
Risk	0.28	1.00	2.40	2.84	2.82	4.36	3.98	3.46	3.85	4.41	5.47	6.21	5.74	5.49	6.45
Measure of Worth	0.41	0.42	1.00	3.10	4.18	4.86	4.49	3.30	3.73	4.91	5.76	6.22	5.67	5.95	6.68
Financial Standing	0.33	0.35	0.32	1.00	3.41	4.29	3.91	3.09	3.59	4.58	5.72	6.40	5.67	5.60	6.40
Resource	0.26	0.36	0.24	0.29	1.00	3.90	3.34	3.02	3.27	4.26	5.51	6.27	5.97	5.64	6.45
Economic Factors	0.21	0.23	0.21	0.23	0.26	1.00	2.99	2.62	2.93	3.77	5.51	5.72	5.51	5.31	5.97
Experience	0.22	0.25	0.22	0.26	0.30	0.33	1.00	2.98	3.02	3.65	5.16	5.60	4.92	5.42	5.90
Technical Ability	0.29	0.29	0.30	0.32	0.33	0.38	0.34	1.00	3.53	4.40	5.51	5.90	5.41	5.38	6.12
Size and Complexity	0.27	0.26	0.27	0.28	0.31	0.34	0.33	0.28	1.00	3.71	5.27	5.41	4.81	5.25	5.86
Duration	0.21	0.23	0.20	0.22	0.23	0.27	0.27	0.23	0.27	1.00	4.60	5.29	5.23	5.05	6.17
Organizational Culture	0.17	0.18	0.17	0.17	0.18	0.18	0.19	0.18	0.19	0.22	1.00	3.78	3.46	3.65	5.00
Environmental Factors	0.16	0.16	0.16	0.16	0.16	0.17	0.18	0.17	0.18	0.19	0.26	1.00	3.48	3.09	4.17
Location Factors	0.18	0.17	0.18	0.18	0.17	0.18	0.20	0.18	0.21	0.19	0.29	0.29	1.00	3.11	3.78
Social Responsibility	0.17	0.18	0.17	0.18	0.18	0.19	0.18	0.19	0.19	0.20	0.27	0.32	0.32	1.00	3.79
Political Factors	0.15	0.16	0.15	0.16	0.16	0.17	0.17	0.16	0.17	0.16	0.20	0.24	0.26	0.26	1.00
Total	4.31	7.81	8.47	12.42	17.58	25.32	26.03	24.31	29.86	40.37	56.34	64.89	63.15	66.05	80.39

The matrix was established by making rows and columns to have the same parameters. For example, if the second row is risk, the second column is also risk; if the third row is measure of worth, the third column is also measure of worth. The matrix was arranged and a score range of 1 to 9 was selected and allocated, where increasing score implies the increasing row importance than column. The diagonal of the matrix was allocated a score of 1 since it compares one element with itself. Each element is compared in the corresponding level and calibrated on a numerical scale. This requires n (n-1)/2 comparisons, where n is the number of elements with considerations that diagonal elements are equal to one and other elements are simply the reciprocals of earlier comparisons.

4.2.1.3 Internal Consistency Check Using Cronbach's Alpha

Research based on measurement must be concerned with the accuracy, dependability or reliability of measurement. A reliability coefficient demonstrates whether the test designer was correct in expecting a certain collection of items to yield interpretable statements about individual differences. [30].

Cronbach's alpha, also known as coefficient alpha, is a measure used to assess the reliability, or specifically internal consistency, of a set of scale or test (e.g., questionnaires). In other words, the reliability of any measurement refers to the extent to which it is a consistent measure of a concept, and Cronbach's alpha is one way of measuring the strength of that consistency.

Cronbach's alpha is computed by correlating the score for each scale item with the total score for each observation (usually individual survey respondents or test takers), and then comparing that to the variance for all individual item scores:

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{K} \sigma_{Y_i}^2}{\sigma_X^2}\right)$$

Where: K refers to the number/quantity of components/items or questions

$\sigma_{Y_i}^2$ refers to the variance associated with item *i*

σ_X^2 refers to the variance associated with the observed total scores

Using the above formula in MS-Excel, the results are:

K =105

$\sum\sigma_{Y_i}^2$ = 601.87

σ_X^2 = 9735.23, and

The Cronbach's alpha (α) was calculated as 0.95.

Cronbach's alpha typically ranges from 0 to 1. Interpretation of Cronbach's alpha is with a lack of agreement regarding the appropriate range of acceptability. Values closer to 1.0 indicate a greater internal consistency of the variables in the scale. In other words, higher

Cronbach's alpha values shows greater scale reliability. A frequently specified acceptable range is a value of 0.70 or above. According to Nunnally, (1967) as stated in [31], recommended 0.50 to 0.60 for the early stages of research, 0.8 for basic research tools, and 0.9 and above for minimally tolerable estimates. To this end, the alpha of this research is acceptable since it is above the cutoff, as per the recommendations for all types of research.

4.2.1.4 Computation of Priorities

The following steps show the overall procedures of calculating the priorities starting from developing the model.

Step 1: Develop a model

The chart with goal, selection criteria to prioritize from is presented below. The basic project selection decision factors are categorized in to three where different features are included within each category.

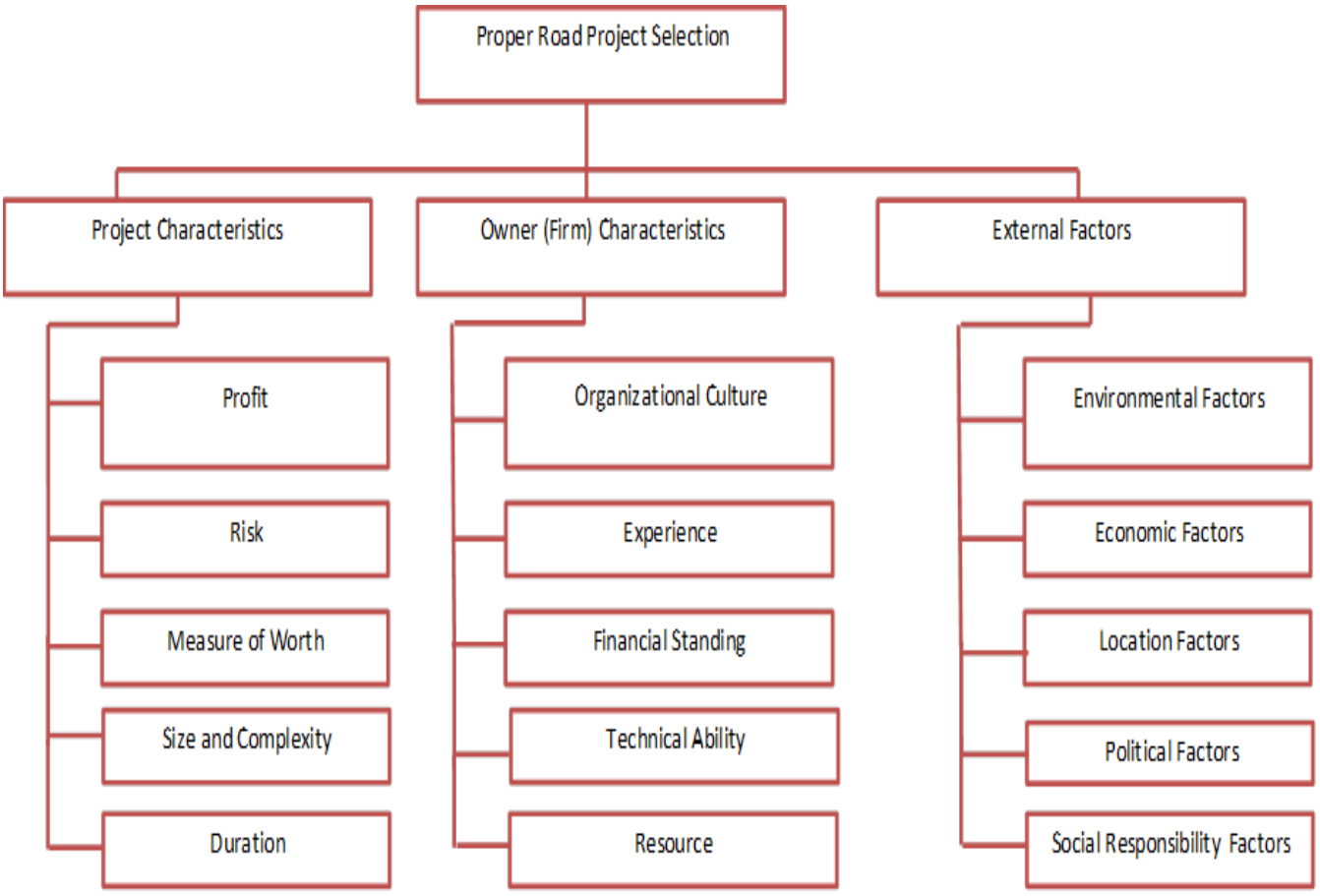


Figure 4-3: Factors affecting project selection

Step 2: Derive priorities (weights) for the criteria

To compute the priorities, scores were normalized first. This step is to normalize the matrix by totaling the numbers in each column. Each entry in the column is then divided by the column sum to yield its normalized score. The sum of each column is one. The mathematical normalizations steps can be summarized as follows:

For the matrix of pair-wise elements:

$$\begin{bmatrix} C11 & C12 & C13 \\ C21 & C22 & C23 \\ C31 & C32 & C33 \end{bmatrix}$$

a) Sum the values in each column of the pair-wise matrix

$$C_{ij} = \sum_{i=1}^{n} C_{ij}$$

b) Divide each element in the matrix by its column total to generate a normalized pair-wise matrix

$$X_{ij} = \frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}} = \begin{bmatrix} W_{11} & W_{12} & W_{13} \\ W_{21} & W_{22} & W_{23} \\ W_{31} & W_{32} & W_{33} \end{bmatrix}$$

c) Divide the sum of the normalized column of matrix by the number of criteria used (n) to generate weighted matrix.

$$W_{ij} = \frac{\sum_{i=1}^{n} W_{ij}}{n} = \begin{bmatrix} W_{11} \\ W_{21} \\ W_{31} \end{bmatrix}$$

The table below illustrates an example for normalization and priorities calculations.

Table 4-3: Normalization and priority calculations

Normalization and priority calculation

Parameter	Profit	Risk	Measure of Worth	Financial Standing	Resource	Economic Factors	Experience	Technical Ability	Size & Complexity	Duration	Organizational Culture	Environmental Factors	Location Fctors	Social Responsibility	Political Factors	Total (Sum of Rows)	Priority (criterion weights)
Profit	0.23	0.46	0.29	0.24	0.22	0.18	0.17	0.14	0.13	0.12	0.10	0.10	0.09	0.09	0.08	2.65	0.18
Risk	0.06	0.13	0.28	0.23	0.16	0.17	0.15	0.14	0.13	0.11	0.10	0.10	0.09	0.08	0.08	2.02	0.13
Measure of Worth	0.09	0.05	0.12	0.25	0.24	0.19	0.17	0.14	0.12	0.12	0.10	0.10	0.09	0.09	0.08	1.96	0.13
Financial Standing	0.08	0.05	0.04	0.08	0.19	0.17	0.15	0.13	0.12	0.11	0.10	0.10	0.09	0.08	0.08	1.57	0.10
Resource	0.06	0.05	0.03	0.02	0.06	0.15	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	1.29	0.09
Economic Factors	0.05	0.03	0.02	0.02	0.01	0.04	0.11	0.11	0.10	0.09	0.10	0.09	0.09	0.08	0.07	1.02	0.07
Experience	0.05	0.03	0.03	0.02	0.02	0.01	0.04	0.12	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.93	0.06
Technical Ability	0.07	0.04	0.04	0.03	0.02	0.02	0.01	0.04	0.12	0.11	0.10	0.09	0.09	0.08	0.08	0.91	0.06
Size and Complexity	0.06	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.03	0.09	0.09	0.08	0.08	0.08	0.07	0.74	0.05
Duration	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.08	0.08	0.08	0.08	0.08	0.60	0.04
Organizational Culture	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.06	0.05	0.06	0.06	0.39	0.03
Environmental Factors	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.02	0.06	0.05	0.05	0.30	0.02
Location Factors	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.02	0.05	0.05	0.26	0.02
Social Responsibility	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.05	0.22	0.01
Political Factors	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.15	0.01
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	Total	1.00

4.2.1.5 Percent Ratio of Priorities and Results

Through computation of all matrix scores prioritization was achieved. The matrix below shows the relative priorities of each decision factors.

Project Profit……..	0.15
Project Risk……	0.12
Measure of Worth……..	0.13
Financial Standing…….	0.10
Resource…….	0.09
Economic Factors……...	0.07
Experience……..	0.07
Technical Ability……	0.07
Size and Complexity……..	0.06
Duration……..	0.04
Organizational Culture…...	0.03
Environmental Factors……	0.02
Location Factors…….	0.02
Social Responsibility…….	0.02
Political Factors…….	0.01

Hence, through AHP calculation procedures as shown in the above table and in the appendix B in detail, among the three basic categorical factors related to project characteristics are weighted 0.50 with profit (0.15), risk (0.12), measure of worth (0.13), size and complexity (0.06), and duration (0.04); related to owner (firm) characteristics are 0.36 with organizational culture (0.03), experience (0.07), financial standing (0.10), technical ability (0.07), and resource(0.09), and related to external factors are weighted only 0.14 with environmental factors (0.02), economic factors (0.07), location factors (0.02), political factors (0.01), and social responsibility (0.02).

Table 4-4: Priority weights for categories and each decision factors

Decision Factors Category	Selection Criterion/Decision Factors	Percentage	Rank
Project Characteristics	Profit	15%	1st
	Measure of Worth	13%	2nd
	Risk	12%	3rd
	Size and Complexity	6%	9th
	Duration	4%	10th
	Sub-Total	**50%**	
	Financial Standing	10%	4th
	Resource	9%	5th
	Experience	7%	6th
	Technical Ability	7%	6th
	Organizational Culture	3%	11th
	Sub-Total	**36%**	
	Economic Factors	7%	6th
	Environmental Factors	2%	12th
	Location Factors	2%	12th
	Social Responsibility	2%	12th
	Political Factors	1%	15th
	Sub-Total	**14%**	
Total		**100%**	

The following bar chart illustrates the priority weights of the three broad categories and the fifteen criterions for better presentation.

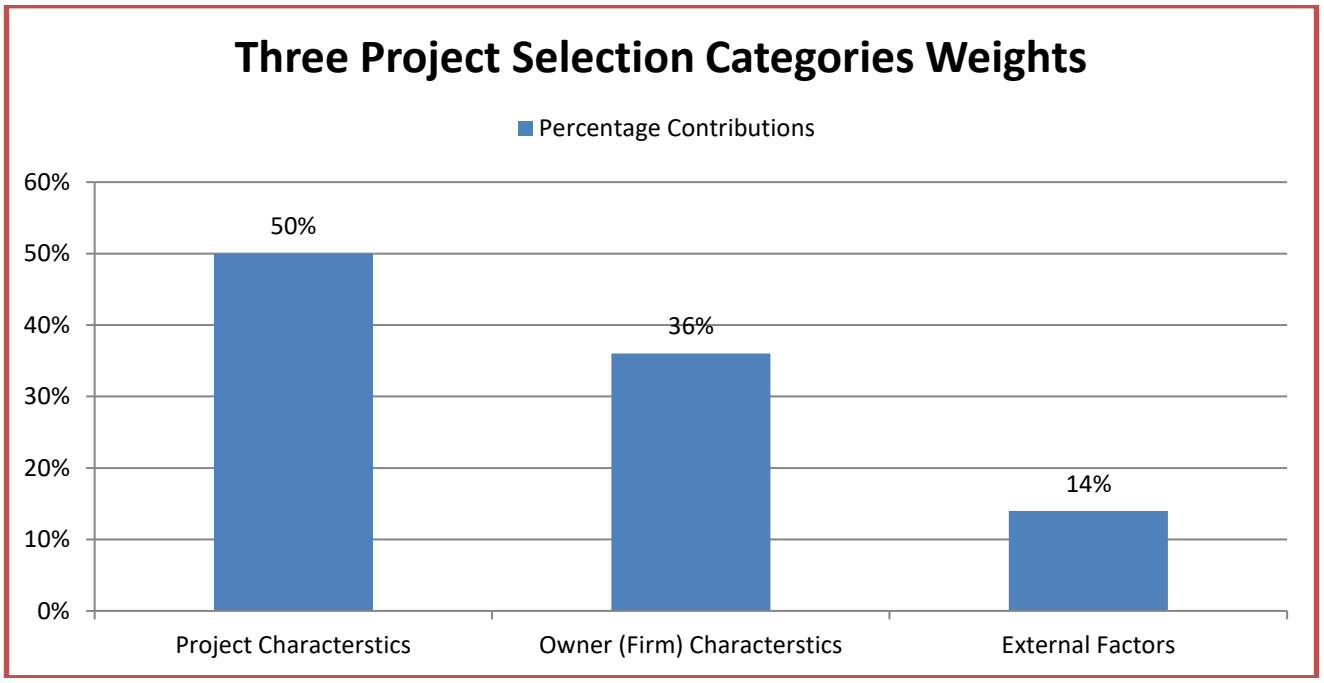


Figure 4-4: Three broad categorical project selection factors percentage contributions

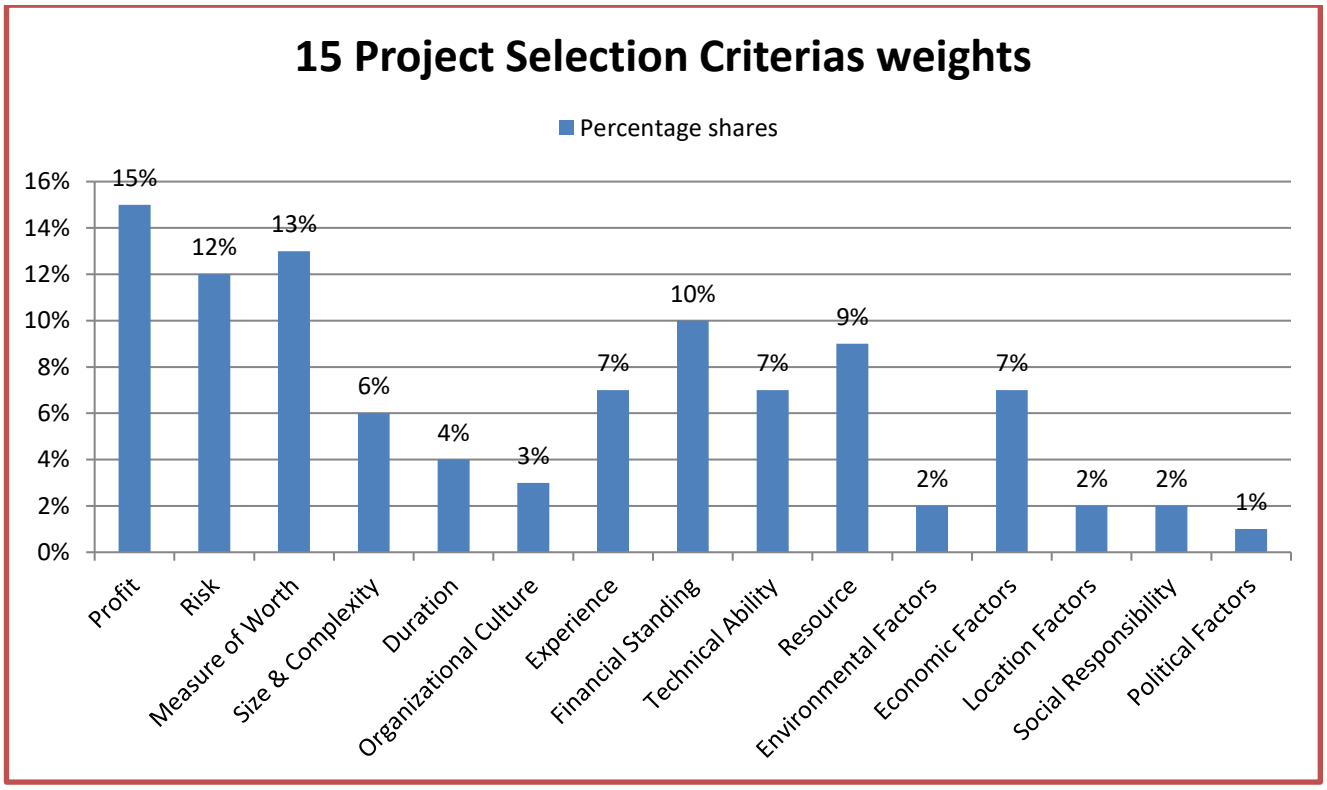


Figure 4-5: The fifteen project selection criteria percentage contributions

4.2.1.6 Method Validation

Reliability and validity are ensured in this section. To validate the results and methods used in these decision-making problems, it is important to know how good its consistency is. The importance of this step is to not base the decision on judgments that have such low consistency that they appear to be random.

Piloting the Questionnaires: It was done before mass distributions. Pre-testing a survey is the way to make sure that it is going to deliver the data that were expected to receive, in terms of validity and reliability. It is designed to make sure that people understand the questions and to indicate that something may be wrong with the survey. So, it helps to determine the strengths and weaknesses concerning question format, wording and order, question variation, meaning, task difficulty, respondent's interest, and attention. To be reliable, a survey question must be answered the same way each time. It was assessed by comparing the responses gave in one pretest with answers in another pretest. The survey question's validity is determined by how well it measures the concepts it is intended to measure. The comments given on the questionnaire design and the overall aspects were incorporated. The pre-test survey shows the respondents answered the survey questionnaires consistently the same way since the questions are brief marking in one of the levels of preference. The respondents answered during discussion that the questions can measure the intended objectives of the study. In the pre-testing the questionnaire, the priority weights or percentages across the project selection criteria were as follows; project characteristics (0.6) with profit (0.17), measure of worth (0.14), risk (0.13), size and complexity (0.09), and duration (0.07); owner (firm) characteristics (0.32) with financial standing (0.09), experience (0.06), technical ability (0.06), resource (0.06), and organization culture (0.05); external factors (0.08) with economic factors (0.03), environmental factors (0.02), 0.01 for location, political and social responsibility factors. The result from the pilot questionnaires had structural similarity with the results of the mass distributions even though some factors ranking difference occurs.

Consistency Analysis

As per [10], consistency means that "when we have a basic amount of row data, all other data can be logically deduced from it. In doing pair-wise comparison to relate *n* activities so that each one is represented in the data at least once, we do n-1 pair-wise comparison judgments.

From them all other judgments can be deduced simply by using the following kind of relation." It could be computed by calculating the consistency measure, consistency index, and consistency ratio.

Consistency Measure

Decision accuracy refers to the extent to which classifications based on test scores match those that would have been made if the scores did not contain any measurement error. Accuracy must be estimated because errorless test scores do not exist. According to [10], "to get a crude estimate of consistency, multiply the matrix of comparisons on the right by the estimated solution vector obtaining a new vector. If divide the first components of this vector by the first component of the estimated solution vector, the second component of the new vector by the second component of the estimated solution vector and so on, we obtain another vector. If we take the sum of the components of this vector and divide by the number of components, we have an approximation to a number lambda maximum to use in estimating as reflected in the proportionality of preferences." The following steps illustrate the estimation process:

1) Consistency vector was calculated by multiplying the pair-wise matrix by the weights vector

$$\begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix} \quad x \quad \begin{bmatrix} W_{11} \\ W_{22} \\ W_{31} \end{bmatrix} \quad = \quad \begin{bmatrix} C_v\,11 \\ C_v 21 \\ C_v 31 \end{bmatrix}$$

2) Then it was accomplished by dividing the weighted sum vector with criterion weights

$$C_v 11 = \frac{1}{W11}\ \left[C11W11 + C12W21 + C13W31\right]$$

$$C_v 21 = \frac{1}{W21}\ \left[C21W11 + C22W21 + C23W31\right]$$

$$C_v 31 = \frac{1}{W31}\ \left[C31W11 + C32W21 + C33W31\right]$$

3) λ_{Max} was calculated by averaging the value of the consistency vector

$\lambda_{Max} = \frac{\sum_{i=1}^{n} C_v ij}{n}$, the following table illustrates the calculations for the above steps.

Table 4-5: Consistency Ratio & Consistency Index calculations

Consistency Calculations

	Profit	Risk	Measure of Worth	Financial Standing	Resource	Economic Factors	Experience	Technical Ability	Size and Complexity	Duration	Organizational Culture	Environmental Factors	Location Factors	Social Responsibility	Political Factors	Weighted sum value	Criterion Weights	Lambda (λ_i=Weighted sum/criterion weights
Weights	0.18	0.13	0.13	0.10	0.09	0.07	0.06	0.06	0.05	0.04	0.03	0.02	0.02	0.01	0.01			
Profit	1.00	3.58	2.47	3.04	3.91	4.68	4.45	3.45	3.74	4.73	5.79	6.24	5.68	5.85	6.65	3.34	0.18	19
Risk	0.28	1.00	2.40	2.84	2.82	4.36	3.98	3.46	3.85	4.41	5.47	6.21	5.74	5.49	6.45	2.67	0.13	20
Measure of Worth	0.41	0.42	1.00	3.10	4.18	4.86	4.49	3.30	3.73	4.91	5.76	6.22	5.67	5.95	6.68	2.67	0.13	20
Financial Standing	0.33	0.35	0.32	1.00	3.41	4.29	3.91	3.09	3.59	4.58	5.72	6.40	5.67	5.60	6.40	2.17	0.10	21
Resource	0.26	0.36	0.24	0.29	1.00	3.90	3.34	3.02	3.27	4.26	5.51	6.27	5.97	5.64	6.45	1.76	0.09	20
Economic Factors	0.21	0.23	0.21	0.23	0.26	1.00	2.99	2.62	2.93	3.77	5.51	5.72	5.51	5.31	5.97	1.35	0.07	20
Experience	0.22	0.25	0.22	0.26	0.30	0.33	1.00	2.98	3.02	3.65	5.16	5.60	4.92	5.42	5.90	1.19	0.06	19
Technical Ability	0.29	0.29	0.30	0.32	0.33	0.38	0.34	1.00	3.53	4.40	5.51	5.90	5.41	5.38	6.12	1.16	0.06	19
Size and Complexity	0.27	0.26	0.27	0.28	0.31	0.34	0.33	0.28	1.00	3.71	5.27	5.41	4.81	5.25	5.86	0.90	0.05	18
Duration	0.21	0.23	0.20	0.22	0.23	0.27	0.27	0.23	0.27	1.00	4.60	5.29	5.23	5.05	6.17	0.70	0.04	18
Organizational Culture	0.17	0.18	0.17	0.17	0.18	0.18	0.19	0.18	0.19	0.22	1.00	3.78	3.46	3.65	5.00	0.43	0.03	16
Environmental Factors	0.16	0.16	0.16	0.16	0.16	0.17	0.18	0.17	0.18	0.19	0.26	1.00	3.48	3.09	4.17	0.32	0.02	16
Location Factors	0.18	0.17	0.18	0.18	0.17	0.18	0.20	0.18	0.21	0.19	0.29	0.29	1.00	3.11	3.78	0.27	0.02	15
Social Responsibility	0.17	0.18	0.17	0.18	0.18	0.19	0.18	0.19	0.19	0.20	0.27	0.32	0.32	1.00	3.79	0.23	0.01	16
Political Factors	0.15	0.16	0.15	0.16	0.16	0.17	0.17	0.16	0.17	0.16	0.20	0.24	0.26	0.26	1.00	0.17	0.01	17
																	λ (Sum)	275
																	λmax=Average of Lambda	18
																	C.I= (λmax-n)/(n-1)	0.214
																	R.I (for n=15)	1.59
																	C.R = C.I/R.I	0.1348

Consistency Index (C.I)

Deviation from consistency is called consistency index and can be calculated using the following steps:

1) Multiply each column of the pair-wise comparison matrix by the corresponding weight

2) Divide sum of rows entries by the corresponding weight

3) Compute the average of the values from step 2, denote it by λ_{max}

4) The approximate CI is:

$CI = \frac{\lambda_{max} - n}{n-1}$, Where n is the number of criteria,

Then $CI = \frac{18-15}{15-1}$ = 0.214

Random Index (R.I)

The consistency index of a randomly generated reciprocal matrix from the scale of 1 to 9 with reciprocal forced called Random Index (R.I) [10]. The following table gives an average of R.I. for matrixes of order 1-15. The first row is an order of the matrix (number of attributes or criteria), and the second row is the average R.I. Hence, for 15 criteria, the R.I is 1.59.

Table 4-6: Random Index Scale

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Consistency Ratio (C.R)

According to [10], "the AHP measures the overall consistency of judgments by means of Consistency Ratio. It was calculated by taking the ratio of C.I to the average R.I for the same order matrix." The value of the consistency ratio should be 0.1 or less. For practical purpose, even a CR which is above 0.1 percent with few figures is considered. If it is much higher than 0.1, the judgment may be somewhat random and should be adjusted. During pre-testing this study questionnaire with only 10 respondents in those three organizations, the CR was calculated as 0.085. It is expected that upon mass distribution with such high expertise

questionnaires in higher number of respondents with different subjective response may differ slightly.

Consistency ratio $CR = \frac{Consistency\ Index}{Random\ Index}$

CR= 0.214/1.59 =0.1348

Consistency Adjustment

The accuracy of the AHP model is dependent on the quality of the decision (the pair-wise comparisons) of the participants which is subjective in nature. The consistency check was reassuring, as humans are by their nature inconsistent, and being encouraged to be consistent added a degree of rigor to the comparisons procedure. [28] puts "AHP should be a science of scaling based on mathematics, philosophy, and psychology". As a clarification of inconsistency ration, [32] stated that "usually we cannot be so certain of our judgments that we would insist on forcing consistency in the pair-wise comparison matrix. Rather, we guess our filling or judgments in all the positions except the diagonals (which are always one), so we may not be perfectly consistent, but that is the way we tend to work." He suggested that one way to improve consistency is to rank the activities by a simple order based on the weights obtained in the first run. A second pair-wise comparison matrix is then developed with this knowledge of ranking in mind". Then, the consistency generally is better. So, the second pair-wise comparison matrix was developed by simple ordering based on the weights obtained in the first run. In the Appendix B, the simple ordering ranks, the adjusted pair-wise comparison matrixes, the adjusted normalization and priority calculations, the adjusted consistency measurement calculations are presented. The table below shows the consistency ratio, and consistency index calculations.

Table 4-7: Adjusted consistency index and consistency ratio calculations

Adjusted Consistency Calculations

	Profit	Risk	Measure of Worth	Financial Standing	Resource	Economic Factors	Experience	Technical Ability	Size and Complexity	Duration	Organizational Culture	Environmental Factors	Location Factors	Social Responsibility	Political Factors	Weighted Sum Value	Criterion Weights	Lambda (l)=Weighted sum/Criterion weights
Weights	0.15	0.12	0.13	0.10	0.09	0.07	0.07	0.07	0.06	0.04	0.03	0.02	0.02	0.02	0.01			
Profit	1.00	2.00	1.50	2.00	3.00	3.00	3.00	2.00	3.00	4.00	5.00	5.00	4.00	5.00	5.00	2.44	0.15	16.60
Risk	0.50	1.00	1.50	2.00	2.00	3.00	3.00	2.00	3.00	3.00	4.00	5.00	5.00	4.00	5.00	2.08	0.12	16.80
Measure of Worth	0.66	0.66	1.00	2.00	3.00	4.00	3.00	2.00	3.00	4.00	5.00	5.00	4.00	5.00	5.00	2.23	0.13	17.16
Financial Standing	0.50	0.50	0.50	1.00	2.00	3.00	3.00	2.00	2.00	3.00	5.00	5.00	4.00	4.00	5.00	1.74	0.10	17.19
Resource	0.33	0.50	0.33	0.50	1.00	3.00	2.00	2.00	2.00	3.00	4.00	5.00	5.00	4.00	5.00	1.47	0.09	17.03
Economic Factors	0.33	0.33	0.25	0.33	0.33	1.00	2.00	1.50	2.00	3.00	4.00	5.00	4.00	4.00	5.00	1.17	0.07	16.70
Experience	0.33	0.33	0.33	0.33	0.50	0.50	1.00	2.00	2.00	2.00	4.00	4.00	4.00	4.00	5.00	1.07	0.07	16.37
Technical Ability	0.50	0.50	0.50	0.50	0.50	0.66	0.50	1.00	2.00	3.00	4.00	5.00	4.00	4.00	5.00	1.12	0.07	16.10
Size and Complexity	0.33	0.33	0.33	0.50	0.50	0.50	0.50	0.50	1.00	3.00	4.00	4.00	4.00	4.00	5.00	0.92	0.06	16.05
Duration	0.25	0.33	0.25	0.33	0.33	0.33	0.50	0.33	0.33	1.00	3.00	4.00	4.00	4.00	5.00	0.69	0.04	15.50
Organizational Culture	0.20	0.25	0.20	0.20	0.25	0.25	0.25	0.25	0.25	0.33	1.00	3.00	2.00	2.00	4.00	0.42	0.03	15.05
Environmental Factors	0.20	0.20	0.20	0.20	0.20	0.20	0.25	0.20	0.25	0.25	0.33	1.00	2.00	2.00	3.00	0.33	0.02	14.89
Location Factors	0.25	0.20	0.25	0.25	0.20	0.25	0.25	0.25	0.25	0.25	0.50	0.50	1.00	2.00	3.00	0.33	0.02	14.99
Social Responsibility	0.20	0.25	0.20	0.25	0.25	0.25	0.25	0.25	0.22	0.25	0.50	0.50	0.50	1.00	3.00	0.29	0.02	15.09
Political Factors	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.25	0.33	0.33	0.33	1.00	0.22	0.01	15.55
																λ(Sum)		241.06
																λmax=Average of Lambda		16.07
																C.I= (λmax-n)/(n-1)		0.08
																R.I (for n=15)		1.59
															CR < 0.1 (Acceptable)	C.R = C.I/R.I		0.048

The survey results previously described helps in gaining an insight into the way how prioritization is made in project selection criteria to meet project objectives for stakeholder's decision making. The overall analysis of results of priorities could be illustrated as shown in the following figure using the AHP hierarchical chart used in the data collections.

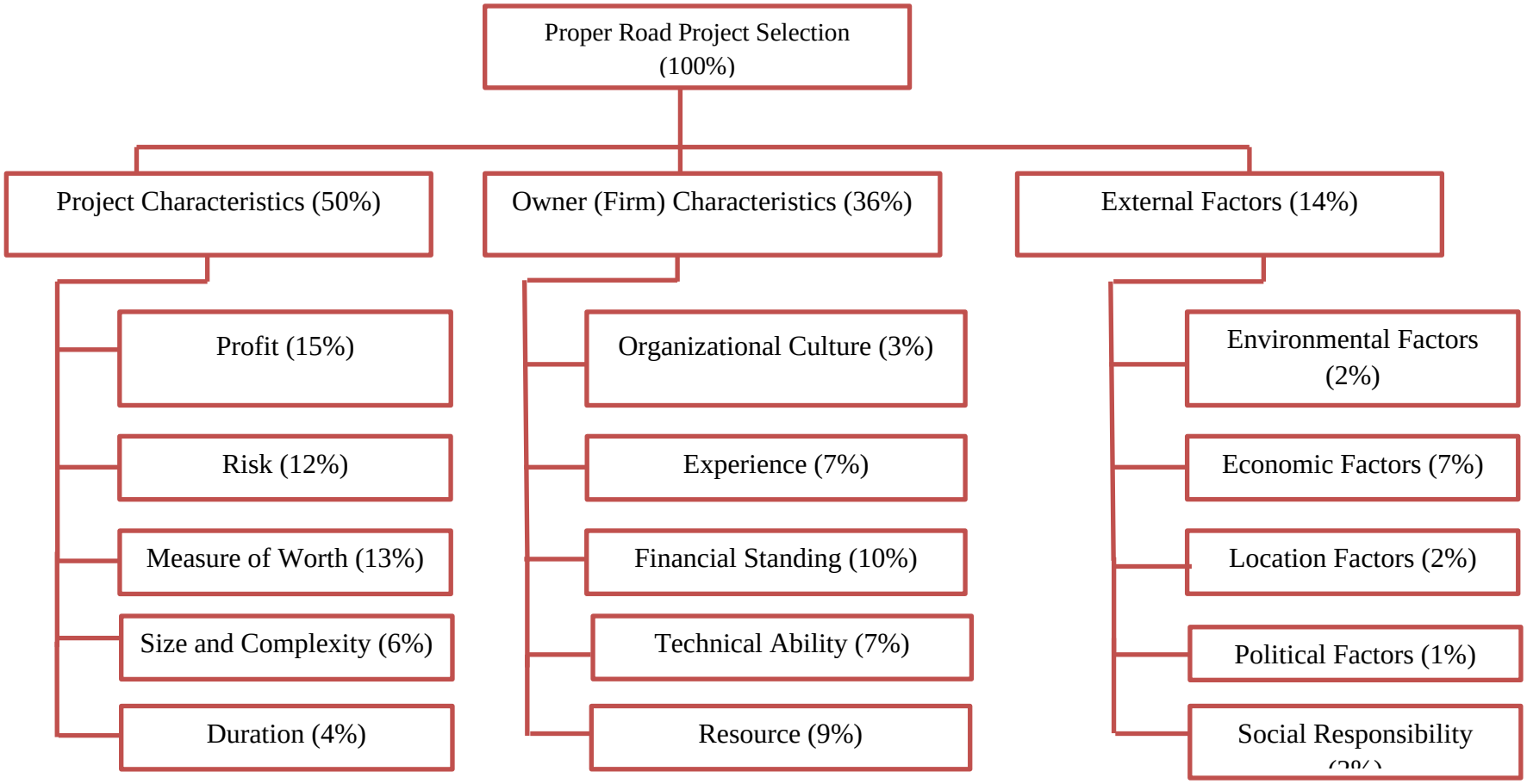


Figure 4-6: Weights assigned for factors affecting project selection

4.2.1.7 Derive Overall Priorities (Model Synthesis)

For this study, the available investing options for the organization are considered as six road projects started in 2020/21 G.C. To simplify calculations, reduce the time for pair-wise comparisons of alternatives against each selection factor and to accelerate work, the top five factors are selected for pair-wise comparison purposes. These five criteria are profit, measure of worth, project risk, financial standings, and resource.

Finally, the overall priorities (model synthesis) derived and final decision was made. The global weights (priorities) calculated by AHP process as in the previous steps. Then, local priorities (preference) of the alternative projects were obtained by comparing each other with respect to selected top five criterions. The alternative projects were compared using the objective features of the projects i.e., by maximizing or minimizing with respective of best features in that particular criterion. Finally, the score (weight) of each project is then calculated.

The project selection criteria are divided into three broad categories: Project Characteristics, Firm Characteristics, and External Factors. Each category includes a set of five criteria. The lowest level of the hierarchy is the set of alternatives (projects). Once the criteria are selected and alternatives are identified, the decision maker compared the projects against each other in terms of meeting each section criterion. The score (weight) of each project is then calculated. The decomposition of the problem into a hierarchy is presented in the following figure.

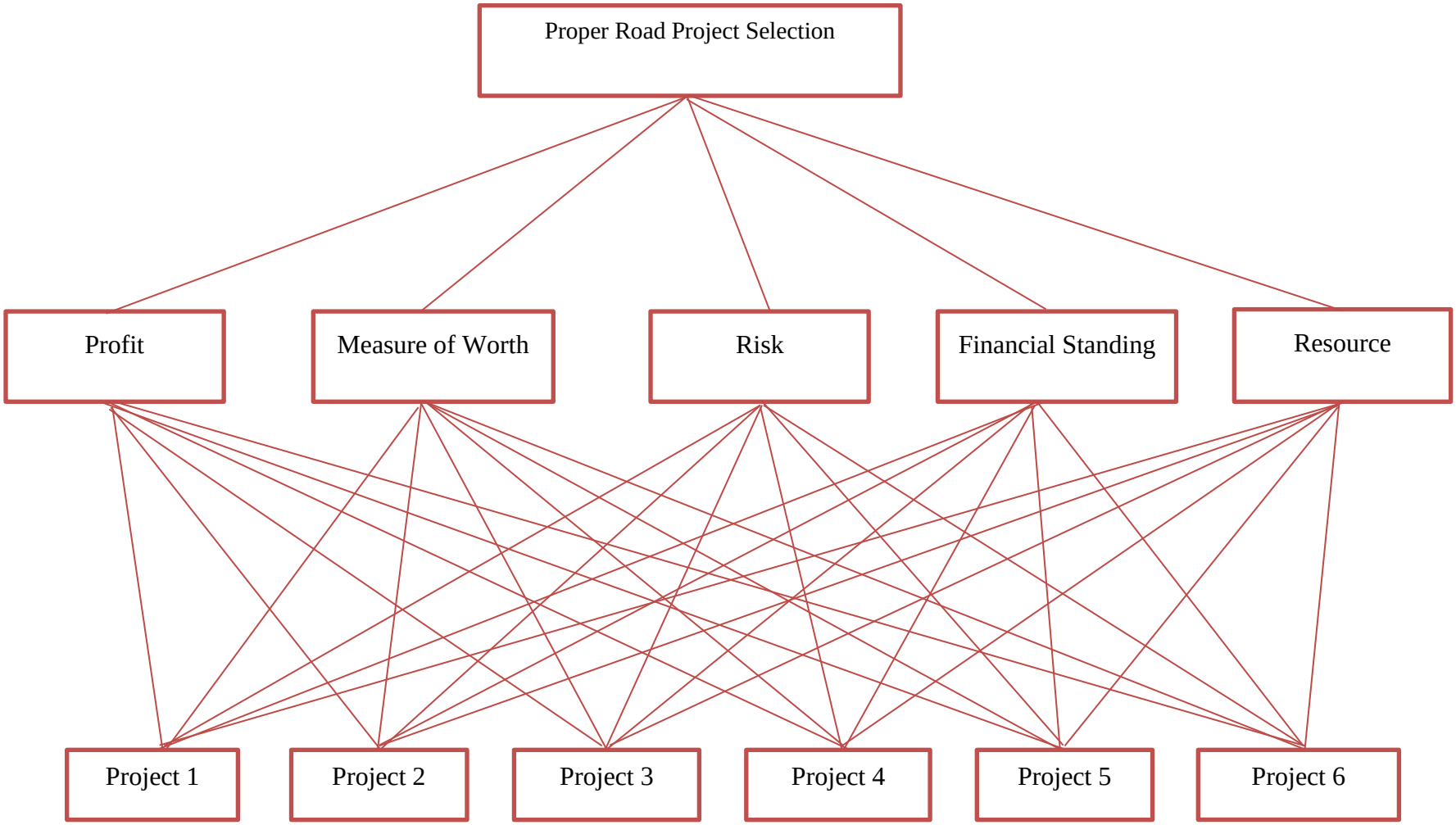


Figure 4-7: Decomposition of the problem into a hierarchy

Capital Projects Profile

The project profile of the six anonymous projects is presented which are alternatives in AHP priority and linear optimization calculations. As some of the projects for this study might have conflict of interests, it was decided not to mention the names of the projects and hence, projects are identified with sequential numbers. However, all the required data has been gathered and included in the study.

Project 1 (P1): The project is in central Ethiopia with 100 km length with the total cost of 1,306,509, 000 ETB. The project document indicates, the project road, an existing gravel road connects three woreda in the regional state. It has a variable carriage width ranging from 6m to 8m, with very poor to medium riding quality, and was built with (Design Standard) DS5. In general, it has rough gravel wearing course surfacing (with complete gravel loss at some sections), can be rated as road in fair to poor condition. The existing average travel speed on the road is about 40km/h with sections having running speed as low as 35km/h and it passes through mainly rolling to mountainous terrain. The project road will be designed for DS-5 standard with improvement to asphalt concrete.

The project was started at 2020/21 GC budget year. Its length is 100km with road functional classification of main access road. The project area climate classification is temperate with minimum and maximum elevation of 1570-2170m respectively. The forecasted traffic volume is 1,420 at 2038. The transport demand in the immediate influence area includes the proximity to major towns. The EIRR is 25.5 %, the NPV is 4,003.23 million ETB and B/C ratio of 3.7.

Project 2 (P2): The project road is located in the southeast part of Ethiopia. The total project length is 140km with functional classifications of link road. It was started in 2020/21 GC budget year with expected future traffic of 679 forecasted in 2038. The climate classification of the project area is hot-arid climate zone with the mean annual rainfall less than 450mm. The project cost is 2,878,405,998.33 ETB. The road improvement project to asphalt concrete has NPV of 2,438 million ETB, 1.98 benefit-cost ratio, and 19.33 % EIRR.

Project 3 (P3): The project was started at 2020/21 G.C budget year. Its cost is 9.240 billion ETB with the total length of 308 km running from the center of the country to the south. It was started in 2020/21 GC budget year.

The project feasibility undertaken by consultants of ERA shows, the project corridor width is 7.3m carriageway standards and 3.0 m shoulders in rural areas and additional 3.5m parking lanes and 2.5 m sidewalks in urban areas. The project's functional classification is link road with climatic classification of cold and temperate at an elevation from 1,800-3000m. The road traffic volume classification, Annual Average Daily Traffic (AADT) is from 3,000-10,000. The project AADT forecasted to be 13,693 at 2038. The project has EIRR is 43.8 %, benefit –cost ratio of 5.02, and the NPV calculated at 10.23 % is 25,425.11 million ETB.

Project 4 (P4): The project length is 90 km to be built in northern Ethiopia 580km from Addis Ababa with total project cost of 3.5284 billion ETB. The project construction period is 4 years aimed at upgrading to the paved road standard. It is started at 2020/2021 G.C budget year.

The project Annual Average Daily Traffic (AADT) is 152 in 2020 and it is projected to be 875 in 2038. The economic indicators done at 10.23 % discount rate are EIRR of 11.9 % and NPV of 196 million ETB.

Project 5 (P5): The project is 103.9km running in western Ethiopia with project cost of 2.072 billion ETB started in 2020/21 GC budget year. The road functional classification is link road with minimum and maximum elevation of 492.06m and 1002.4m above sea level with arid climate. It is classified as DC-5 as per ERA geometric design manual. The project traffic is 460 at 2023 and forecasted to be 1592 in 2038.

ERA's consultant had done the economic analysis and the NPV is 987.07 million ETB, the B/C ratio is 2.129 with EIRR of 17.3%.

Project 6 (P6): The project is located in the northern Ethiopia 650 km from Addis Ababa. The project length is 72 km started in 2020/21 G.C budget year. The project road functional classification is DC-5 with temperate climate classification. The traffic on the project road is estimated at about 330 AADT in the year of opening (2024). The project traffic road in 2038 is projected to be 1107.

The project EIRR is 18.2 % and NPV of 2,372,000.9 ETB calculated at 10.23 % discount rate. The project cost is 1.79 billion ETB. Construction period has been scheduled for four years, and it started in 2020/21 GC budget year.

The results of each project, which is grasped from the projects profile, for those five criteria are presented in the following tables.

Table 4-8: Project Profiles

	Benefit-Cost Ratio (B/C)	EIRR	Project Cost (ETB)	Road Length KM)	AADT @ 2038 G.C	Functional Classifications
P(1)	3.7	25.5%	2.29 billion	100	1420	Main access road
P(2)	1.98	19.33%	2.89 billion	140	679	Link Road
P(3)	5.02	43.8%	9.240 billion	308	16,693	Link Road
P(4)	4.9	11.9%	3.53 billion	90	875	Link Road
P(5)	1.858	17.3%	2.072 billion	103.9	1592	Link Road
P(6)	2.517	18.2%	1.79 billion	72	1107	Link Road

The Economic Internal Rate of Return (EIRR) is considered as profit indicator, Benefit-Cost ratio (B/C) as measure of worth indicator, and the project cost as resource indicator. Profit in this case is the direct (as in the case of toll roads) or indirect revenue/return the society and the government benefits in investing in public road infrastructures. The financial standing which is the firm characteristics is considered equal for all projects since they are executed by the same firm in the public sector arena. Had it been in private sector, it may vary depending on the type of the project since the orientation and goal of the private and public firms differ. The project risks are categorized based on the discounted cash flow rate of return (DCFROR) considering high risks are taken expecting high returns naturally. [8, p. 275] Therefore, low risk (DCFROR; 10%to 20 %), medium risk (DCFROR; 21% to 35 %), and high-risk (DCFROR; above 35 %). Hence, corresponding with the EIRR of each project as in the above threshold, on the scale of 1-5; low risk is assigned as 1, medium risk as 3, and high-risk as 5.

Table 4-9: Project profiles with selection factors

	Profit	Measure of Worth	Project Risk	Financial Standing	Resource
Project 1	25.5%	3.7	3	1	2.29 billion
Project 2	19.33%	1.98	1	1	2.89 billion
Project 3	43.8%	5.02	5	1	9.240 billion
Project 4	11.9%	4.9	1	1	3.53 billion
Project 5	17.3%	1.858	1	1	2.072 billion
Project 6	18.2%	2.517	1	1	1.79 billion

The comparison of each of those projects against the listed five criterions is presented below. The comparison is made by preferring whether to increase or decrease the criteria characteristics and benchmarking one of the projects to evaluate it with the other ones. The normalization of the matrixes, the local priority calculations, the consistency index, and constituency ratio calculations are presented in the Appendix B part.

Then, the overall priority weight for each project is calculated by multiplying the score of each project for each criterion by its global weights (by taking only the top five criterions), and then adding them to find out the overall score of each project.

Table 4-10: Comparison matrices and local priorities for each project

Profit	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**Priority Vector**	**Measure of Worth**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**Priority Vector**
P1	1	1.32	0.58	2.14	1.47	1.4	**0.19**	P1	1	1.86	0.74	0.76	2	1.47	**0.19**
P2	0.75	1	0.44	1.62	1.11	1.06	**0.14**	P2	0.54	1	0.39	0.4	1.06	0.79	**0.10**
P3	1.72	2.27	1	3.7	2.56	2.38	**0.32**	P3	1.35	2.56	1	1.02	2.7	2	**0.25**
P4	0.46	0.62	0.27	1	0.68	0.65	**0.09**	P4	1.32	2.5	0.98	1	2.63	1.95	**0.25**
P5	0.68	0.9	0.39	1.47	1	0.95	**0.13**	P5	0.5	0.63	0.37	0.38	1	0.74	**0.09**
P6	0.71	0.94	0.42	1.53	1.05	1	**0.13**	P6	0.68	1.27	0.5	0.51	1.35	1	**0.13**
λmax=6.01		CI=0.00227423			CR=0.001834			λmax=6.02		CI=0.03871524			CR:0.003122197		

Risk	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**Priority Vector**	**Financial Standing**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**Priority Vector**
P1	1	0.33	1.66	0.33	0.33	0.33	**0.07**	**P1**	1	1	1	1	1	1	**0.17**
P2	3	1	5	1	1	1	**0.22**	**P2**	1	1	1	1	1	1	**0.17**
P3	0.6	0.2	1	0.2	0.2	0.2	**0.04**	**P3**	1	1	1	1	1	1	**0.17**
P4	3	1	5	1	1	1	**0.22**	**P4**	1	1	1	1	1	1	**0.17**
P5	3	1	5	1	1	1	**0.22**	**P5**	1	1	1	1	1	1	**0.17**
P6	3	1	5	1	1	1	**0.22**	**P6**	1	1	1	1	1	1	**0.17**
λmax=5.84			CI=-0.03		CR=-0.02504181			λmax=6			CI=0		CR=0		

Resource	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**Priority Vector**
P1	1	1.26	4	1.54	0.9	0.79	**0.20**
P2	0.79	1	3.2	1.22	0.72	0.62	**0.16**
P3	0.25	0.31	1	0.38	0.22	0.19	**0.05**
P4	0.65	0.82	2.63	1	0.58	0.51	**0.13**
P5	1.1	1.39	4.54	1.72	1	0.87	**0.22**
P6	1.27	1.61	5.1	1.97	1.15	1	**0.25**
λmax=6.08		CI=0.015251337			CR=0.01229946		

Table 4-11: Local and global priorities for each project

	Profit (0.254)	Measure of Worth (0.221)	Project Risk (0.203)	Financial Standing (0.169)	Resource (0.153)	
Project 1	**0.19**	**0.19**	**0.07**	**0.17**	**0.20**	**0.163**
Project 2	**0.14**	**0.10**	**0.22**	**0.17**	**0.16**	**0.155**
Project 3	**0.32**	**0.25**	**0.04**	**0.17**	**0.05**	**0.18**
Project 4	**0.09**	**0.25**	**0.22**	**0.17**	**0.13**	**0.17**
Project 5	**0.13**	**0.09**	**0.22**	**0.17**	**0.22**	**0.159**
Project 6	**0.13**	**0.13**	**0.22**	**0.17**	**0.25**	**0.173**

The matrix presentation of the above table is as follows:

	Profit	Measure of Worth	Project Risk	Financial Standing	Resource		
P1 =	0.19	0.19	0.07	0.17	0.2		
P2=	0.14	0.1	0.22	0.17	0.16		
P3=	0.32	0.25	0.04	0.17	0.05	X	
P4=	0.09	0.25	0.22	0.17	0.13		
P5=	0.13	0.09	0.22	0.17	0.22		
P6=	0.13	0.13	0.22	0.17	0.25		

0.254
0.221
0.203
0.169
0.153

In order to found out the overall priority, the score (weight) for each project is calculated by multiplying the score of each project for each criterion by its global weight and then adding them to find out the overall score of each project. Then, the overall priorities of each project and the ranks are presented below:

Table 4-12: Alternatives/projects weighting and ranking

Alternatives	Overall Priority Weights	Ranks
Project 1	0.163	4th
Project 2	0.155	6th
Project 3	0.18	1st
Project 4	0.17	3rd
Project 5	0.159	5th
Project 6	0.173	2nd

Then, the overall priorities (weights) of each project are used as the coefficients in linear programming while selecting the projects based on the resource constraint.

4.2.2 Linear Programming (LP) Analysis

Linear Programming is a mathematical tool; "ways to formulate real-world problems in mathematical terms (models), techniques for solving the models, and engines for executing the steps of algorithms". Linear programming (0 & 1 integer programming) is used for budget constraints after selecting six road projects from database and analyzing using the topmost prioritized five criterions from AHP analysis.

Organizations are challenged in selecting projects which contributes most for their objectives. Additionally, they cannot undertake all projects concurrently due to limited resources and other constraints. Therefore, they must select the most feasible projects, which maximizes positive results such as profits, reputation, etc. and minimize any negative outcomes such as technical deficiency, environmental harm, etc.

Many road projects were up under the Ethiopian federal government for 2020/21 G.C budget year. According to Ministry of Finance (MoF) 2020/21 federal government capital budget, the annual budget available for the road sector was 58,080,201,000 ETB (around 58 billion ETB) as shown in the budget code of 15/00/000/273. According to the budget code, among this budget, 50 billion (86%) is from treasury, 7,821,731,000 (13.56%) is from loan and 258,470,000 (0.44%) is from foreign assistance. This capital budget is including ongoing

projects, road rehabilitation, upgrading, maintenance works, bridge constructions, projects feasibility studies as well as new road construction projects. The number of new road projects already entered into budget are 151 with 18,894,705,000 ETB (more than 18 billion ETB) free fiscal space in the capital budget assigned for new projects having 32.53 percent of the total assigned capital budget for all types of works. The above calculations are done by the researcher by having the 2020/21 allotted capital budget for Ethiopian roads Authority and the federal government's annual capital budgets for all government sectors. It is revealed that upon discussions with experts, the portfolio management in the budgeting process is still to be strengthened as it is difficult to explore the free fiscal space by subtracting the new projects expenditure from the total allotted capital budget for all works. This is basically the main challenges of government budgeting due to a number of stakeholders with different roles and interests. The document showing the 2020/21 allotted capital budgets for ERA is around 34 pages for all ongoing projects, road rehabilitation, upgrading, maintenance works, bridge constructions, projects feasibility studies and new projects. For better illustration, the researcher own tabulation showing the new projects first year expenditures, the budget codes, and sources of finance are presented in appendix C.

The researcher selected six anonymous projects which started in 2020/21 budget year, considering those sample projects financed by the government, availability of enough data about the project, and functional classification similarity of the roads. Then the average annual allotted expenditure was divided into the number of newly entered road projects to find the expenditure of one project at specified year. Hence, the average budget ceiling for six projects is 750,783,000, then those six projects were constrained against this available financial resource.

The following calculations show the use of binary integer linear programming in project selection. This study uses ERA's six candidate projects and investigated which projects increase the overall benefits. Maximizing the AHP priority weights actually shows the contribution of each projects towards meeting the organization objective of selecting proper projects. The available budget, the first-year expenditure of projects, and the AHP priority weights associated for each project are shown in table below.

Table 4-13: Linear optimization table

Project Information	**Project 1**	**Project 2**	**Project 3**	**Project 4**	**Project 5**	**Project 6**	**Constraint (ETB)**
Priority Weights	0.163	0.155	0.18	0.17	0.159	0.173	
Annual Budget (in Million ETB)	52.5	205	335	88.5	176.5	90	750,783,000

The notations are defined as follows:

X_1=1 if project 1 is selected, 0 otherwise

X_2=1 if project 2 is selected, 0 otherwise

Or

X_j: Binary decision variable for project *j*, j=1 (if project j is selected, 0 otherwise)

n: Number of projects

J: Project number, j=1 to n

Z=Total Benefits

C_j: Overall benefit on the ranking of project *j* from the score of AHP analysis

a_{ij}: Amount of capital *i* required by project *j*

D_i: Total capital available

The weights of projects actually show the contribution of each project towards meeting the organization objectives. Thus, maximizing these weights can be translated to maximizing benefit for the owner in terms of selection factors. So, the objective function of the resulting LP model is to maximize the benefit of the organization is stated as follows.

$$Z_{max} = \sum_{j=1}^{n} C_j X_j \ \forall_j$$

$$Z_{max} = 0.163X_1 + 0.155X_2 + 0.18X_3 + 0.17X_4 + 0.159X_5 + 0.173X_6$$

The decision variables, represented as X_j are the selection of project *j* for *j*= 1, 2…. n. The value of X_j is one if the project is accepted and zero if it is rejected.

Subject to the following constraint:

a. Availability of capital

$$\sum a_{ij} X_j \leq D_i \ \forall_{i,j}$$

$$52.5X_1 + 205X_2 + 335X_3 + 88.5X_4 + 176X_5 + 90X_6 \leq 750.783$$

b. If a case when there are two projects that are disjointed, since the two projects are in the same geographic regions, that is, if for example project *j* is selected, then project *i* cannot be selected. The case is described by the following constraint:

$$X_4 + X_6 \leq 1$$

c. At most five out of six projects constraints; maximum of only five out of six projects can be executed due to the implementation capability of the organization; with available capital base on individual project requirements, hence we have:

$$X_1 + X_2 + \cdots + X_6 \leq 5$$

d. $X_j \geq 0 \ \forall_{i,j}$ or X_j=0-1 (binary decision variable)

Then following table from excel-solver resulted which projects are selected with quantification of the coefficient of decision variables.

Table 4-14: Excel-solver linear optimization calculations

Linear Optimization Using Excel-Solver				
Variables				
Project 1(X1)	1			
Project 2(X2)	0			
Project 3(X3)	1			
Project 4(X4)	1			
Project 5(X5)	1			
Project (6X6)	0			
Objective Function				
Maximize	0.68			
Constraints	LHS	Inequality	RHS	LHS Left Hand Side RHS Right Hand Side
Constraint 1	652	<=	751	
Constraint 2	1	<=	1	
Constraint 3	4	<=	5	
Constraint 4	X1	Binary		
Constraint 5	X2	Binary		
Constraint 6	X3	Binary		
Constraint 7	X4	Binary		
Constraint 8	X5	Binary		
Constraint 9	X6	Binary		
Maximum value for the objective function is 0.679 with X1=1, X2=0, X3=1, X4=1, X5=1, and X6=0				

The optimal solution is found to be Projects 1, 3, 4, and 5 with a combined benefit of 0.679. This infers the organization should invest in project 1, 3, 4, and 5 in order to maximize their benefit. It also means that by investing in those projects, the organization gets 67.9 percent of benefit in terms of the five decision factors. Hence, if the organization invests in all projects, it may get loaded during the implementation period either due to finance or implementation capability which hampers the successful completion of projects within time and cost. Of the 750,783,000 ETB budgeted, 652 million ETB will be finally allocated to the four projects selected.

4.3 Discussion of Results

The capital project selection decisions are crucial to the achievement of organizational objectives that in turn will ensure the benefit and long-term survival. To this end, it is essential that organizations capital project selection process be effective and efficient so that decision makers and planners should make conscious efforts in reviewing and seeking better models for choosing among competing capital projects. The AHP model was used to compare the relative importance of the main project selection factors.

The result revealed that participants agreed that project related characteristics was far more important and should be the major focus taking the highest priority. The owner or firm related characteristics ranked second indicating that after projects natures had been enhanced professionals preferred going into execution agencies characteristics. External factors are the third important, an indication that inside-out strategy that professionals want to be more proactive by enhancing what is intrinsic to them and face the external factors.

Among the three basic categorical factors related to project characteristics are weighted 0.50 with profit (0.15), risk (0.12), measure of worth (0.13), size and complexity (0.06), and duration (0.04); related to owner (firm) characteristics are 0.36 with organizational culture (0.03), experience (0.07), financial standing (0.10), technical ability (0.07), and resource(0.09), and related to external factors are weighted only 0.14 with environmental factors (0.02), economic factors (0.07), location factors (0.02), political factors (0.01), and social responsibility (0.02). Based on the integrated AHP-LP model, Projects *P*1, *P*3, *P*4 and *P*5 were selected while *P*2 and *P*6 were dropped.

The categories related project characteristics are ranked first, it is convincing that neglecting project characteristics like project risk, measure of worth can significantly decrease the chance of achieving project objectives on time, within budget and meeting required functional performance. If we take project risk specifically, it is one of the most important criteria for project clients. The construction industry, in comparison to other industries, is subjected to more risks because construction activities have the unique features such as challenging environment being far from coordinating head office, long duration, complex processes, etc.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

Chapter 4 illustrated the data collection process, analysis, validation, and the final results obtained. This chapter includes the summary of the study and the conclusions drawn from the research conducted on applying Analytic Hierarchy Process and Linear Programming for project selection decision making to meet the overall project objectives. The recommendations for implementation and future research are also discussed in this chapter.

5.1 Conclusions

Resources are limited for pursuing and funding new projects. An effective project selection and prioritization method ensures optimal resource utilization. As a result, they need to be prioritized using criteria that reflect the objectives of project undertaking organizations. Optimization methods for project selection mostly focused on quantitative factors, thus failing to consider intangible and qualitative measures such as organizational culture, the external environment the project operates. On the other hand, MCDM techniques lack the ability to determine the optimum solution when resource is constrained. The integrated AHP-LP provides a useful tool to assist decision maker, especially for those projects with many risks, since it takes out the deficiency of traditional methods and adds the advantage of assigning resources in a most favorable manner.

In this study, the key project selection criteria are identified and assessed based on the nature of Ethiopian Roads Authority, Planning and Development Commission and Ministry of Finance project professionals. The identified criteria will help project client organizations to select the most appropriate projects that provide the most benefit. Using these criteria reduces the probability of project failures and increases the chances of achieving successful completion. This results in budget and effort saving that can be used to undertake other projects that are needed for the country's development.

The results indicate that criteria related to project characteristics, with 0.5 weight, were ranked higher than other criteria related to the firm characteristic and external factors with weights of 0.36 and 0.14 respectively. The most important project selection sub-criteria are profit,

measure of worth, project risk, financial standing, and resources with the overall weight of 0.15, 0.13, 0.12, 0.10 and 0.09 respectively. Four projects among six projects were selected to have the most use of resources under constraints. Capital budgeting techniques selects projects with higher Net Present Value or Internal Rate of Return without other project selection factors this integrates modes incorporates.

The proposed model considers all the different criteria simultaneously. It has the ability to capture both qualitative and quantitative factors in determining the most suitable project portfolio. The use of AHP ensures the full involvement and participation of key decision makers and ensures the consistency of the decision. The model also ensures alignment of the selection decision with the owner's objectives and gives an advantage to owners to allocate the limited resources in an optimal manner in order to maximize benefit.

5.2 Recommendations

The proposed model combines the use of AHP and LP. AHP was used for the pair-wise comparisons amongst the selection criteria and later to compare the available projects against these criteria. The overall weight for each project is calculated and used as a coefficient in the LP. The study offers an application of the model to solve the selection problem and helps validate AHP-LP as an alternative effective decision- making tool. The model can be applied in real life scenarios as is or modified according to the need of owner or organizations can even develop their own comprehensive individual sets of selection criteria as of the situation.

The integrated AHP-LP model is recommended as an alternative technique for its ability to capture all possible factors that affect a capital project selection and its optimality advantage as demonstrated in this study. It is also recommended for its participatory and consensus approach as the top management and critical experts can agree on the main objectives of the organizations, prioritize, and cascade down to functional departments. Other capital budgeting techniques selects projects with limited quantitative criteria such as higher Net Present Value or Internal Rate of Return without other project selection factors this integrates modes incorporates.

Despite that AHP-LP model is good for structuring a capital project selection problem, it uses one-directional hierarchical relationships between the factors. This is an assumption that does not consider the many possible relationship between the factors. AHP does not explicitly consider the interaction between various factors. Overcoming such challenges, customizing the decision factors, and expanding to other sectors of economy are recommendations for further research. This study helps to identify the gaps in the available literature related to the project selection in the Ethiopian public projects and provides a framework that can be used by organizations to make these decisions. The results can also be used by researchers as they can refine the criteria that are applicable in different situations.

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APPENDIX A: RESEARCH SURVEY (QUESTIONNAIRE)

Dear Sir/Madam,

My name is Tewodros Abere and I am a graduate student at Addis Ababa University conducting thesis research for my master degree on: "**Application of Multi-Criteria Decision Making Based on Combined Analytic Hierarchy Process and Linear Programming as an Alternative for Project Selection: The Case of Ethiopian Road Authority Road Projects".**

Objective:

-To analyze and gain better understanding on the topic how Analytic Hierarchy Process (AHP) and Linear Programming (LP) can be used to select better projects **using experts' response and objective natures of the projects.**

Explanation:

-Figure 1: provides a hierarchy chart of the rating factors (in below attached survey file).

-Table 1: provide the definitions of the various rating factors.

Note: The Analytic Hierarchy Process (AHP) is a decision-aiding method aims at quantifying relative priorities for a given set of alternatives on a ratio scale, based on the judgment of the decision-maker. While, Linear Programming (LP) is a mathematical tool; "ways to formulate real-world problems in mathematical terms (models), techniques for solving the models, and engines for executing the steps of algorithms".

-The information provided will be used only in support of the academic research.

-Your completion of this survey is completely voluntary.

-If you have any concern about the survey, please contact: tabere71@gmail.com: +251(9)20255504.

I would like to thank you in advance for your assistance.
Sincerely,
Tewodros Abere,
Graduate Student
School of Civil & Environmental Engineering, Construction Technology & Management Stream
Addis Ababa University Institute of Technology

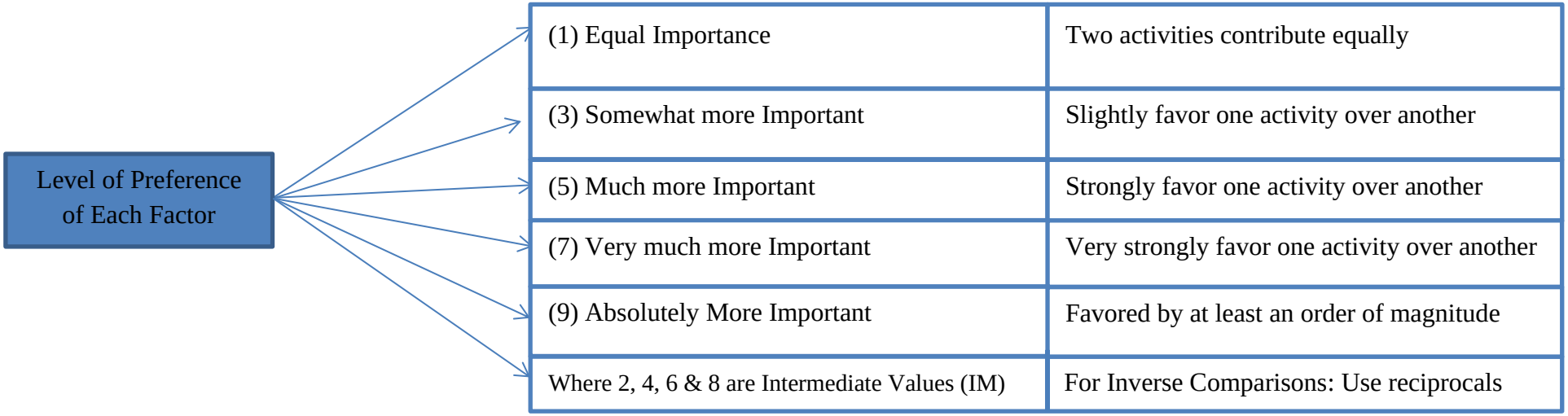
Section One: General

1. **Organization Name: _____**
2. **Educational Background: _____**
3. **Your Position: _____**
4. **Your Experience:**

   A. Less than 5 Years **B. 5-10Years**

   C. 10-15 Years **D. 15-20Years** **E. More than 20 Years**

Section Two: Questions to Fill and Set of Instructions

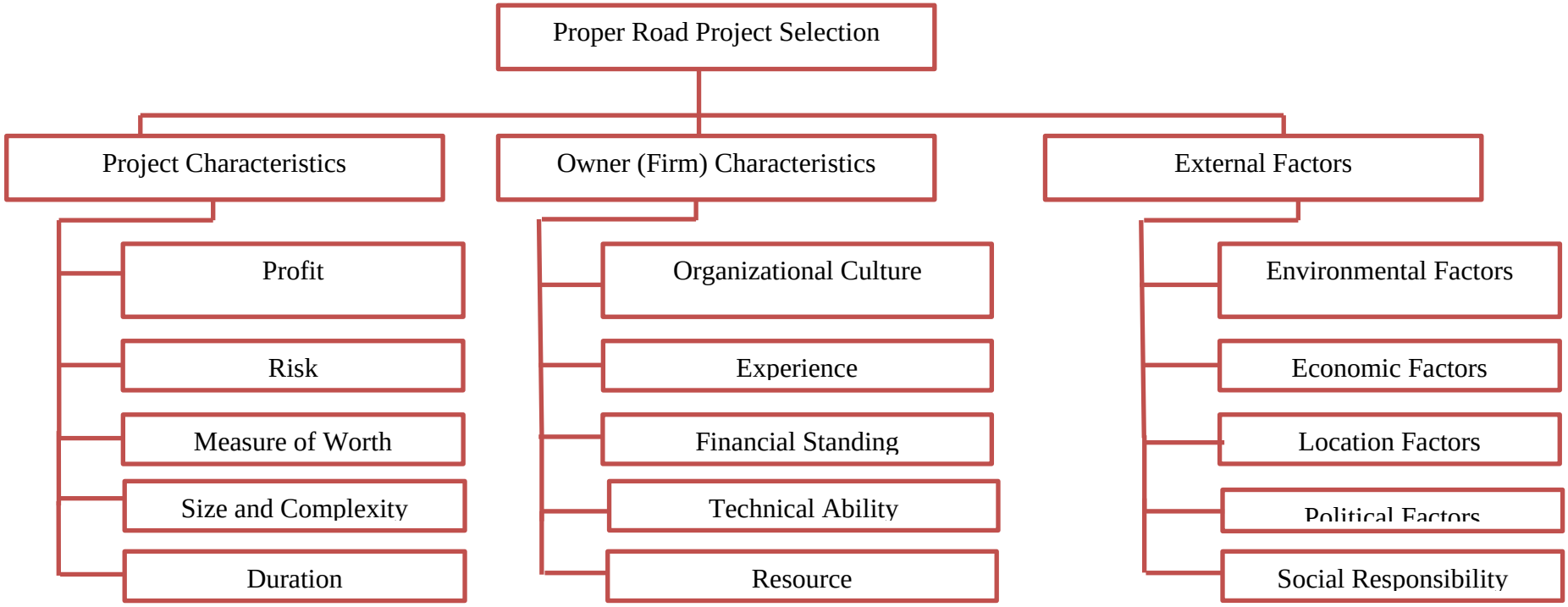


(1) Equal Importance	Two activities contribute equally
(3) Somewhat more Important	Slightly favor one activity over another
(5) Much more Important	Strongly favor one activity over another
(7) Very much more Important	Very strongly favor one activity over another
(9) Absolutely More Important	Favored by at least an order of magnitude
Where 2, 4, 6 & 8 are Intermediate Values (IM)	For Inverse Comparisons: Use reciprocals

From the middle table below, please select the appropriate level of preference of each factor on the **left** to the factor on the **right.**

For Example: If you say: Criteria 1 is very much important to Criteria 2; Criteria 1 is equal importance to criteria 3: You mark X as shown below. IM is Intermediate Value as shown in the above figure.

Factor/ Criteria		Level of Preference							Factor/Criteria
		1	3	5	7	9	IM		
Criteria 1	is				X			to	Criteria 2
		X							Criteria 3



Title	Definition
Project Characteristics	**Related to the project itself, the expected utility of the project and the strategic benefit of the project to the client organization**
Profit	Refers to the amount of expected profit for the project
Risk	Refers to the internal project risks such as lack of technical data, shortage of resources, inadequate expertise etc.
Measure of Worth	Estimates the project feasibility based on quantifiable or tangible measures such as net present value, internal rate of return, payback period and benefit-cost ratio
Size & Complexity	Criterion includes the need for coordination and management of the technological and other elements.
Duration	The total time required to complete the project
Owners (Firm) Characteristics	**Related to strength and capability of the owner to handle available projects both financially and non-financially.**
Organizational Culture	How fit the project is within the mission and strategic direction of the organization.
Experience	Experience is about the capability and past experience and the lessons gained from previous projects.
Financial Standing	Refers to the financial strength of the firm (owner) in terms of budget, capital and their ability to raise adequate capital through different means like credit
Technical Ability	Capability of the firm to handle and apply technological, innovation and research aspect of the project to complete successfully
Resource	Refers to resource availability (technical expert personnel, human resources, materials and equipment) of required specification at precise time at the project location
External Factors	**Category represents the interaction of the firm and its surroundings.**
Environmental Factors	Ecologic sensitiveness and overall impact to the sustainability of the surrounding & to the society at large.
Economic Factors	Economic conditions, both macro and micro, in which the organization competes
Location Factors	Refers to the geographic location as it affects the mobilization cost, accessibility and availability of electricity and water supply and others
Political Factors	Are related to government policies, laws and regulations, threat of war, etc.
Social Responsibility Factors	Includes the social impacts of the project, minimizing negate impacts on society

Questions to Fill (Respond)

Factor/ Criteria		Level of Preference							Factors/Criteria
		1	3	5	7	9	IM		
Profit	is							to	Risk
								>>	Measure of Worth
								>>	Financial Standing
								to	Resource
								>>	Economic Factors
								to	Experience
								>>	Technical Ability
								>>	Size and Complexity
								to	Duration
								>>	Organizational Culture
								>>	Environmental Factors
								to	Location Factors
								>>	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factors/Criteria**
		1	**3**	**5**	**7**	**9**	**IM**		
Risk	is							to	Measure of Worth
								>>	Financial Standing
								>>	Resource
								to	Economic Factors
								>>	Experience
								to	Technical Ability
								>>	Size and Complexity
								>>	Duration

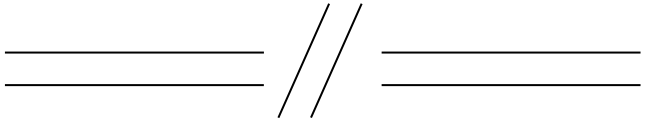
								to	Organizational Culture
								>>	Environmental Factors
								>>	Location Factors
								to	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factors/Criteria**
		1	**3**	**5**	**7**	**9**	**IM**		
Measure of Worth	is							to	Financial Standing
								>>	Resource
								>>	Economic Factors
								to	Experience
								>>	Technical Ability
								to	Size and Complexity
								>>	Duration
								>>	Organizational Culture
								to	Environmental Factors
								>>	Location Factors
								>>	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factor/Criteria**
		1	**3**	**5**	**7**	**9**	**IM**		
								to	Resource

								>>	Economic Factors
Financial Standing	is							>>	Experience
								to	Technical Ability
								>>	Size and Complexity
								to	Duration
								>>	Organizational Culture
								>>	Environmental Factors
								to	Location Factors
								>>	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factors/Criteria**
		1	**3**	**5**	**7**	**9**	**IM**		
								to	Economic Factors
Resource	is							>>	Experience
								>>	Technical Ability
								to	Size and Complexity
								>>	Duration
								to	Organizational Culture
								>>	Environmental Factors
								>>	Location Factors
								to	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factors/Criteria**
		1	**3**	**5**	**7**	**9**	**IM**		
								to	Experience

Economic Factors	is							>>	Technical Ability
								>>	Size and Complexity
								to	Duration
								>>	Organizational Culture
								to	Environmental Factors
								>>	Location Factors
								>>	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factors/Criteria**
		1	**3**	**5**	**7**	**9**	**IM**		
Experience	is							to	Technical Ability
								>>	Size and Complexity
								>>	Duration
								to	Organizational Culture
								>>	Environmental Factors
								to	Location Factors
								>>	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factor/Criteria**
		1	**3**	**5**	**7**	**9**	**IM**		
Technical Ability	is							to	Size and Complexity
								>>	Duration
								>>	Organizational Culture
								to	Environmental Factors
								>>	Location Factors

								to	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factor/Criteria**
		1	**3**	**5**	**7**	**9**	**IM**		
Size and Complexity	is							to	Duration
								>>	Organizational Culture
								>>	Environmental Factors
								to	Location Factors
								>>	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factor/Criteria**
		1	**3**	**5**	**7**	**9**	**IM**		
Duration	is							to	Organizational Culture
								>>	Environmental Factors
								>>	Location Factors
								to	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factor/Criteria**
		1	**3**	**5**	**7**	**9**	**IM**		
Organizational Culture	is							to	Environmental Factors
								>>	Location Factors
								>>	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factor/Criteria**
		1	**3**	**5**	**7**	**9**	**IM**		
Environmental Factors	is							to	Location Factors

								>>	Social Responsibility
								to	Political Factors
Factor/ Criteria		**Level of Preference**							**Factor/Criteria**
Location Factors	is	**1**	**3**	**5**	**7**	**9**	**IM**		
								to	Social Responsibility
								>>	Political Factors
Factor/ Criteria		**Level of Preference**							**Factor/Criteria**
Social Responsibility	is	**1**	**3**	**5**	**7**	**9**	**IM**		
								to	Political Factors



Thank You!!!

APPENDIX B: DATA ANALYSIS

Pairwise Comparision Table Coding

Parameters	Profit	Risk	Measure of Worth	Financial Standing	Resource	Economic Factors	Experience	Technical ability	Size & complexity	Duration	Organizational Culture	Environmneta l Factors	Location Factors	Social Responsibility	Political Factors
Profit	1	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Risk	1/A	1	O	P	Q	R	S	T	U	V	W	X	Y	Z	Z1
Measure of Worth	1/B	1/O	1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	Z9	Z10	Z11	Z12	Z13
Financial Standing	1/C	1/P	1/Z2	1	Z14	Z15	Z16	Z17	Z18	Z19	Z20	Z21	Z22	Z23	Z24
Resource	1/D	1/Q	1/Z3	1/Z14	1	Z25	Z26	Z27	Z28	Z29	Z30	Z31	Z32	Z33	Z34
Economic Factors	1/E	1/R	1/Z4	1/Z15	1/Z25	1	Z35	Z36	Z37	Z38	Z39	Z40	Z41	Z42	Z43
Experience	1/F	1/S	1/Z5	1/Z16	1/Z26	1/Z35	1	Z44	Z45	Z46	Z47	Z48	Z49	Z50	Z51
Technical Ability	1/G	1/T	1/Z6	1/Z17	1/Z27	1/Z36	1/Z44	1	Z52	Z53	Z54	Z55	Z56	Z57	Z58
Size & complexity	1/H	1/U	1/Z7	1/Z18	1/Z28	1/Z37	1/Z45	1/Z52	1	Z59	Z60	Z61	Z62	Z63	Z64
Duration	1/I	1/V	1/Z8	1/Z19	1/Z29	1/Z38	1/Z46	1/Z53	1/Z59	1	Z65	Z66	Z67	Z68	Z69
Organizational culture	1/J	1/W	1/Z9	1/Z20	1/Z30	1/Z39	1/Z47	1/Z54	1/Z60	1/Z65	1	Z70	Z71	Z72	Z73
Environmental Factors	1/K	1/X	1/Z10	1/Z21	1/Z31	1/Z40	1/Z48	Z1/55	1/Z61	1/Z66	1/Z70	1	Z74	Z75	Z76
Location Factors	1/L	1/Y	1/Z11	1/Z22	1/Z32	1/Z41	1/Z49	1/Z56	1/Z62	1/Z67	1/Z71	1/Z74	1	Z77	Z78
Social Responsibility	1/M	1/Z	1/Z12	1/Z23	1/Z33	1/Z42	1/Z50	1/Z57	1/Z63	1/Z68	1/Z72	1/Z75	1/Z77	1	Z79
Political Factors	1/N	1/Z1	1/Z13	1/Z24	1/Z34	1/Z43	1/Z51	1/Z58	1/Z64	1/Z69	1/Z73	1/Z76	1/Z78	1/Z79	1

Pairwise Comparision Matrix

Parameter	Profit	Risk	Measure of Worth	Financial Standing	Resource	Economic Factors	Experience	Technical Ability	Size and Complexity	Duration	Organizational Culture	Environmental Factors	Location Factors	Social Responsibility	Political Factors
Profit	1.00	3.58	2.47	3.04	3.91	4.68	4.45	3.45	3.74	4.73	5.79	6.24	5.68	5.85	6.65
Risk	0.28	1.00	2.40	2.84	2.82	4.36	3.98	3.46	3.85	4.41	5.47	6.21	5.74	5.49	6.45
Measure of Worth	0.41	0.42	1.00	3.10	4.18	4.86	4.49	3.30	3.73	4.91	5.76	6.22	5.67	5.95	6.68
Financial Standing	0.33	0.35	0.32	1.00	3.41	4.29	3.91	3.09	3.59	4.58	5.72	6.40	5.67	5.60	6.40
Resource	0.26	0.36	0.24	0.29	1.00	3.90	3.34	3.02	3.27	4.26	5.51	6.27	5.97	5.64	6.45
Economic Factors	0.21	0.23	0.21	0.23	0.26	1.00	2.99	2.62	2.93	3.77	5.51	5.72	5.51	5.31	5.97
Experience	0.22	0.25	0.22	0.26	0.30	0.33	1.00	2.98	3.02	3.65	5.16	5.60	4.92	5.42	5.90
Technical Ability	0.29	0.29	0.30	0.32	0.33	0.38	0.34	1.00	3.53	4.40	5.51	5.90	5.41	5.38	6.12
Size and Complexity	0.27	0.26	0.27	0.28	0.31	0.34	0.33	0.28	1.00	3.71	5.27	5.41	4.81	5.25	5.86
Duration	0.21	0.23	0.20	0.22	0.23	0.27	0.27	0.23	0.27	1.00	4.60	5.29	5.23	5.05	6.17
Organizational Culture	0.17	0.18	0.17	0.17	0.18	0.18	0.19	0.18	0.19	0.22	1.00	3.78	3.46	3.65	5.00
Environmental Factors	0.16	0.16	0.16	0.16	0.16	0.17	0.18	0.17	0.18	0.19	0.26	1.00	3.48	3.09	4.17
Location Factors	0.18	0.17	0.18	0.18	0.17	0.18	0.20	0.18	0.21	0.19	0.29	0.29	1.00	3.11	3.78
Social Responsibility	0.17	0.18	0.17	0.18	0.18	0.19	0.18	0.19	0.19	0.20	0.27	0.32	0.32	1.00	3.79
Political Factors	0.15	0.16	0.15	0.16	0.16	0.17	0.17	0.16	0.17	0.16	0.20	0.24	0.26	0.26	1.00
Total	4.31	7.81	8.47	12.42	17.58	25.32	26.03	24.31	29.86	40.37	56.34	64.89	63.15	66.05	80.39

Normalization and priority calculation

Parameter	Profit	Risk	Measure of Worth	Financial Standing	Resource	Economic Factors	Experience	Technical Ability	Size & Complexity	Duration	Organizational Culture	Environmental Factors	Location Fctors	Social Responsibility	Political Factors	Total (Sum of Rows)	Priority (criterion weights)
Profit	0.23	0.46	0.29	0.24	0.22	0.18	0.17	0.14	0.13	0.12	0.10	0.10	0.09	0.09	0.08	2.65	0.18
Risk	0.06	0.13	0.28	0.23	0.16	0.17	0.15	0.14	0.13	0.11	0.10	0.10	0.09	0.08	0.08	2.02	0.13
Measure of Worth	0.09	0.05	0.12	0.25	0.24	0.19	0.17	0.14	0.12	0.12	0.10	0.10	0.09	0.09	0.08	1.96	0.13
Financial Standing	0.08	0.05	0.04	0.08	0.19	0.17	0.15	0.13	0.12	0.11	0.10	0.10	0.09	0.08	0.08	1.57	0.10
Resource	0.06	0.05	0.03	0.02	0.06	0.15	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	1.29	0.09
Economic Factors	0.05	0.03	0.02	0.02	0.01	0.04	0.11	0.11	0.10	0.09	0.10	0.09	0.09	0.08	0.07	1.02	0.07
Experience	0.05	0.03	0.03	0.02	0.02	0.01	0.04	0.12	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.93	0.06
Technical Ability	0.07	0.04	0.04	0.03	0.02	0.02	0.01	0.04	0.12	0.11	0.10	0.09	0.09	0.08	0.08	0.91	0.06
Size and Complexity	0.06	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.03	0.09	0.09	0.08	0.08	0.08	0.07	0.74	0.05
Duration	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.08	0.08	0.08	0.08	0.08	0.60	0.04
Organizational Culture	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.06	0.05	0.06	0.06	0.39	0.03
Environmental Factors	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.02	0.06	0.05	0.05	0.30	0.02
Location Factors	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.02	0.05	0.05	0.26	0.02
Social Responsibility	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.05	0.22	0.01
Political Factors	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.15	0.01
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	Total	1.00

Consistency Calculations

	Profit	Risk	Measure of Worth	Financial Standing	Resource	Economic Factors	Experience	Technical Ability	Size and Complexity	Duration	Organizational Culture	Environmental Factors	Location Factors	Social Responsibility	Political Factors	Weighted sum value	Criterion Weights	Lambda (λ)=Weighted sum/criterion weights
Weights	0.18	0.13	0.13	0.10	0.09	0.07	0.06	0.06	0.05	0.04	0.03	0.02	0.02	0.01	0.01			
Profit	1.00	3.58	2.47	3.04	3.91	4.68	4.45	3.45	3.74	4.73	5.79	6.24	5.68	5.85	6.65	3.34	0.18	19
Risk	0.28	1.00	2.40	2.84	2.82	4.36	3.98	3.46	3.85	4.41	5.47	6.21	5.74	5.49	6.45	2.67	0.13	20
Measure of Worth	0.41	0.42	1.00	3.10	4.18	4.86	4.49	3.30	3.73	4.91	5.76	6.22	5.67	5.95	6.68	2.67	0.13	20
Financial Standing	0.33	0.35	0.32	1.00	3.41	4.29	3.91	3.09	3.59	4.58	5.72	6.40	5.67	5.60	6.40	2.17	0.10	21
Resource	0.26	0.36	0.24	0.29	1.00	3.90	3.34	3.02	3.27	4.26	5.51	6.27	5.97	5.64	6.45	1.76	0.09	20
Economic Factors	0.21	0.23	0.21	0.23	0.26	1.00	2.99	2.62	2.93	3.77	5.51	5.72	5.51	5.31	5.97	1.35	0.07	20
Experience	0.22	0.25	0.22	0.26	0.30	0.33	1.00	2.98	3.02	3.65	5.16	5.60	4.92	5.42	5.90	1.19	0.06	19
Technical Ability	0.29	0.29	0.30	0.32	0.33	0.38	0.34	1.00	3.53	4.40	5.51	5.90	5.41	5.38	6.12	1.16	0.06	19
Size and Complexity	0.27	0.26	0.27	0.28	0.31	0.34	0.33	0.28	1.00	3.71	5.27	5.41	4.81	5.25	5.86	0.90	0.05	18
Duration	0.21	0.23	0.20	0.22	0.23	0.27	0.27	0.23	0.27	1.00	4.60	5.29	5.23	5.05	6.17	0.70	0.04	18
Organizational Culture	0.17	0.18	0.17	0.17	0.18	0.18	0.19	0.18	0.19	0.22	1.00	3.78	3.46	3.65	5.00	0.43	0.03	16
Environmental Factors	0.16	0.16	0.16	0.16	0.16	0.17	0.18	0.17	0.18	0.19	0.26	1.00	3.48	3.09	4.17	0.32	0.02	16
Location Factors	0.18	0.17	0.18	0.18	0.17	0.18	0.20	0.18	0.21	0.19	0.29	0.29	1.00	3.11	3.78	0.27	0.02	15
Social Responsibility	0.17	0.18	0.17	0.18	0.18	0.19	0.18	0.19	0.19	0.20	0.27	0.32	0.32	1.00	3.79	0.23	0.01	16
Political Factors	0.15	0.16	0.15	0.16	0.16	0.17	0.17	0.16	0.17	0.16	0.20	0.24	0.26	0.26	1.00	0.17	0.01	17
																	λ (Sum)	275
																	λmax=Average of Lambda	18
																	C.I= (λmax-n)/(n-1)	0.214
																	R.I (for n=15)	1.59
																	C.R = C.I/R.I	0.1348

Adjusted Pairwise Comparision Matrix

Parameter	Profit	Risk	Measure of Worth	Financial Standing	Resource	Economic Factors	Experience	Technical Ability	Size and Complexity	Duration	Organizational Culture	Environmental Factors	Location Factors	Social Responsibility	Political Factors
Profit	1.00	2.00	1.50	2.00	3.00	3.00	3.00	2.00	3.00	4.00	5.00	5.00	4.00	5.00	5.00
Risk	0.50	1.00	1.50	2.00	2.00	3.00	3.00	2.00	3.00	3.00	4.00	5.00	5.00	4.00	5.00
Measure of Worth	0.66	0.66	1.00	2.00	3.00	4.00	3.00	2.00	3.00	4.00	5.00	5.00	4.00	5.00	5.00
Financial Standing	0.50	0.50	0.50	1.00	2.00	3.00	3.00	2.00	2.00	3.00	5.00	5.00	4.00	4.00	5.00
Resource	0.33	0.50	0.33	0.50	1.00	3.00	2.00	2.00	2.00	3.00	4.00	5.00	5.00	4.00	5.00
Economic Factors	0.33	0.33	0.25	0.33	0.33	1.00	2.00	1.50	2.00	3.00	4.00	5.00	4.00	4.00	5.00
Experience	0.33	0.33	0.33	0.33	0.50	0.50	1.00	2.00	2.00	2.00	4.00	4.00	4.00	4.00	5.00
Technical Ability	0.50	0.50	0.50	0.50	0.50	0.66	0.50	1.00	2.00	3.00	4.00	5.00	4.00	4.00	5.00
Size and Complexity	0.33	0.33	0.33	0.50	0.50	0.50	0.50	0.50	1.00	3.00	4.00	4.00	4.00	4.00	5.00
Duration	0.25	0.33	0.25	0.33	0.33	0.33	0.50	0.33	0.33	1.00	3.00	4.00	4.00	4.00	5.00
Organizational Culture	0.20	0.25	0.20	0.20	0.25	0.25	0.25	0.25	0.25	0.33	1.00	3.00	2.00	2.00	4.00
Environmental Factors	0.20	0.20	0.20	0.20	0.20	0.20	0.25	0.20	0.25	0.25	0.33	1.00	2.00	2.00	3.00
Location Factors	0.25	0.20	0.25	0.25	0.20	0.25	0.25	0.25	0.25	0.25	0.50	0.50	1.00	2.00	3.00
Social Responsibility	0.20	0.25	0.20	0.25	0.25	0.25	0.25	0.25	0.22	0.25	0.50	0.50	0.50	1.00	3.00
Political Factors	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.25	0.33	0.33	0.33	1.00
Total	5.78	7.58	7.54	10.59	14.26	20.14	19.70	16.48	21.50	30.28	44.58	52.33	47.83	49.33	64.00

Adjusting using simple order					
First Run Value	2	3	4	5	>6
Simple Ordering	>=2.7	>=3.7	>=4.7	>=5.7	>=6.7
Adjusted Value	2	3	4	5	6
Simple Ordering	<=2.7	<=3.7	<=4.7	<=5.7	<=6.7
Adjusted Value	1.5	2	3	4	5

Adjusted Normalization Calculation

Parameter	Profit	Risk	Measure of Worth	Financial Standing	Resource	Economic Factors	Experience	Technical Ability	Size and Complexity	Duration	Organizational Culture	Environmental Factors	Location Factors	Social Responsibility	Political Factors	Total (Sum of rows)	Priority (Criterion Weights)
Profit	0.17	0.26	0.20	0.19	0.21	0.15	0.15	0.12	0.14	0.13	0.11	0.10	0.08	0.10	0.08	2.20	0.15
Risk	0.09	0.13	0.20	0.19	0.14	0.15	0.15	0.12	0.14	0.10	0.09	0.10	0.10	0.08	0.08	1.86	0.12
Measure of Worth	0.11	0.09	0.13	0.19	0.21	0.20	0.15	0.12	0.14	0.13	0.11	0.10	0.08	0.10	0.08	1.95	0.13
Financial Standing	0.09	0.07	0.07	0.09	0.14	0.15	0.15	0.12	0.09	0.10	0.11	0.10	0.08	0.08	0.08	1.52	0.10
Resource	0.06	0.07	0.04	0.05	0.07	0.15	0.10	0.12	0.09	0.10	0.09	0.10	0.10	0.08	0.08	1.30	0.09
Economic Factors	0.06	0.04	0.03	0.03	0.02	0.05	0.10	0.09	0.09	0.10	0.09	0.10	0.08	0.08	0.08	1.05	0.07
Experience	0.06	0.04	0.04	0.03	0.04	0.02	0.05	0.12	0.09	0.07	0.09	0.08	0.08	0.08	0.08	0.98	0.07
Technical Ability	0.09	0.07	0.07	0.05	0.04	0.03	0.03	0.06	0.09	0.10	0.09	0.10	0.08	0.08	0.08	1.04	0.07
Size and Complexity	0.06	0.04	0.04	0.05	0.04	0.02	0.03	0.03	0.05	0.10	0.09	0.08	0.08	0.08	0.08	0.86	0.06
Duration	0.04	0.04	0.03	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.07	0.08	0.08	0.08	0.08	0.67	0.04
Organizational Culture	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.06	0.04	0.04	0.06	0.42	0.03
Environmental Factors	0.03	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.04	0.05	0.33	0.02
Location Factors	0.04	0.03	0.03	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.04	0.05	0.33	0.02
Social Responsibility	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.05	0.29	0.02
Political Factors	0.03	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.21	0.01
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	Total	1.00

Adjusted Consistency Calculations

	Profit	Risk	Measure of Worth	Financial Standing	Resource	Economic Factors	Experience	Technical Ability	Size and Complexity	Duration	Organizational Culture	Environmental Factors	Location Factors	Social Responsibility	Political Factors	Weighted Sum Value	Criterion Weights	Lambda (l)=Weighted sum/Criterion weights
Weights	0.15	0.12	0.13	0.10	0.09	0.07	0.07	0.07	0.06	0.04	0.03	0.02	0.02	0.02	0.01			
Profit	1.00	2.00	1.50	2.00	3.00	3.00	3.00	2.00	3.00	4.00	5.00	5.00	4.00	5.00	5.00	2.44	0.15	16.60
Risk	0.50	1.00	1.50	2.00	2.00	3.00	3.00	2.00	3.00	3.00	4.00	5.00	5.00	4.00	5.00	2.08	0.12	16.80
Measure of Worth	0.66	0.66	1.00	2.00	3.00	4.00	3.00	2.00	3.00	4.00	5.00	5.00	4.00	5.00	5.00	2.23	0.13	17.16
Financial Standing	0.50	0.50	0.50	1.00	2.00	3.00	3.00	2.00	2.00	3.00	5.00	5.00	4.00	4.00	5.00	1.74	0.10	17.19
Resource	0.33	0.50	0.33	0.50	1.00	3.00	2.00	2.00	2.00	3.00	4.00	5.00	5.00	4.00	5.00	1.47	0.09	17.03
Economic Factors	0.33	0.33	0.25	0.33	0.33	1.00	2.00	1.50	2.00	3.00	4.00	5.00	4.00	4.00	5.00	1.17	0.07	16.70
Experience	0.33	0.33	0.33	0.33	0.50	0.50	1.00	2.00	2.00	2.00	4.00	4.00	4.00	4.00	5.00	1.07	0.07	16.37
Technical Ability	0.50	0.50	0.50	0.50	0.50	0.66	0.50	1.00	2.00	3.00	4.00	5.00	4.00	4.00	5.00	1.12	0.07	16.10
Size and Complexity	0.33	0.33	0.33	0.50	0.50	0.50	0.50	0.50	1.00	3.00	4.00	4.00	4.00	4.00	5.00	0.92	0.06	16.05
Duration	0.25	0.33	0.25	0.33	0.33	0.33	0.50	0.33	0.33	1.00	3.00	4.00	4.00	4.00	5.00	0.69	0.04	15.50
Organizational Culture	0.20	0.25	0.20	0.20	0.25	0.25	0.25	0.25	0.25	0.33	1.00	3.00	2.00	2.00	4.00	0.42	0.03	15.05
Environmental Factors	0.20	0.20	0.20	0.20	0.20	0.20	0.25	0.20	0.25	0.25	0.33	1.00	2.00	2.00	3.00	0.33	0.02	14.89
Location Factors	0.25	0.20	0.25	0.25	0.20	0.25	0.25	0.25	0.25	0.25	0.50	0.50	1.00	2.00	3.00	0.33	0.02	14.99
Social Responsibility	0.20	0.25	0.20	0.25	0.25	0.25	0.25	0.25	0.22	0.25	0.50	0.50	0.50	1.00	3.00	0.29	0.02	15.09
Political Factors	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.25	0.33	0.33	0.33	1.00	0.22	0.01	15.55
																	λ(Sum)	241.06
																	λmax=Average of Lambda	16.07
																	C.I= (λmax-n)/(n-1)	0.08
																	R.I (for n=15)	1.59
															CR < 0.1 (Acceptable)		C.R = C.I/R.I	0.048

Project Comparison in AHP

Local priority Weights (preferences) of the alternative projects with respect to each criterion, just grasped from project profile

	Profit (%) ↑	Measure of Worth ↑	Risk ↓	Financial Standing	Resource (In billion ETB) ↓
Project 1	25.5	3.7	3	1	2.29
Project 2	19.33	1.98	1	1	2.89
Project 3	43.8	5.02	5	1	9.24
Project 4	11.9	4.9	1	1	3.53
Project 5	17.3	1.858	1	1	2.072
Project 6	18.2	2.517	1	1	1.79

Local priority Weights (preferences) of the alternative projects with respect to each criterion, by increasing or decreasing

	Profit	Measure of Worth	Risk	Financial Standing	Resource
Project 1	0.58	0.74	0.33	1.00	0.78
Project 2	0.44	0.39	1.00	2.00	0.62
Project 3	1.00	1.00	0.20	3.00	0.19
Project 4	0.27	0.98	1.00	4.00	0.51
Project 5	0.39	0.37	1.00	5.00	0.86
Project 6	0.42	0.50	1.00	6.00	1.00

Profit	P1	P2	P3	P4	P5	P6
P1	1	1.32	0.58	2.14	1.47	1.4
P2	0.75	1	0.44	1.62	1.11	1.06
P3	1.72	2.27	1	3.7	2.56	2.38
P4	0.46	0.62	0.27	1	0.68	0.65
P5	0.68	0.9	0.39	1.47	1	0.95
P6	0.71	0.94	0.42	1.53	1.05	1
Total	5.32	7.05	3.1	11.46	7.87	7.44

Measure of Worth	P1	P2	P3	P4	P5	P6
P1	1	1.86	0.74	0.76	2	1.47
P2	0.54	1	0.39	0.4	1.06	0.79
P3	1.35	2.56	1	1.02	2.7	2
P4	1.32	2.5	0.98	1	2.63	1.95
P5	0.5	0.63	0.37	0.38	1	0.74
P6	0.68	1.27	0.5	0.51	1.35	1
Total	5.39	9.82	3.98	4.07	10.74	7.95

Risk	P1	P2	P3	P4	P5	P6
P1	1	0.33	1.66	0.33	0.33	0.33
P2	3	1	5	1	1	1
P3	0.6	0.2	1	0.2	0.2	0.2
P4	3	1	5	1	1	1
P5	3	1	5	1	1	1
P6	3	1	5	1	1	1
Total	13.6	4.53	22.66	4.53	4.53	4.53

Financial Standing	P1	P2	P3	P4	P5	P6
P1	1	1	1	1	1	1
P2	1	1	1	1	1	1
P3	1	1	1	1	1	1
P4	1	1	1	1	1	1
P5	1	1	1	1	1	1
P6	1	1	1	1	1	1
Total	6	6	6	6	6	6

Resource	P1	P2	P3	P4	P5	P6
P1	1	1.26	4	1.54	0.9	0.79
P2	0.79	1	3.2	1.22	0.72	0.62
P3	0.25	0.31	1	0.38	0.22	0.19
P4	0.65	0.82	2.63	1	0.58	0.51
P5	1.1	1.39	4.54	1.72	1	0.87
P6	1.27	1.61	5.1	1.97	1.15	1
Total	5.06	6.39	20.47	7.83	4.57	3.98

Normalization and Priority Calculation

Profit	P1	P2	P3	P4	P5	P6	Total (Sum of rows)	Priority Weights
P1	0.19	0.187	0.19	0.19	0.19	0.19	1.12	0.19
P2	0.14	0.142	0.14	0.14	0.14	0.14	0.85	0.14
P3	0.32	0.322	0.32	0.32	0.33	0.32	1.94	0.32
P4	0.09	0.088	0.09	0.09	0.09	0.09	0.52	0.09
P5	0.13	0.128	0.13	0.13	0.13	0.13	0.76	0.13
P6	0.13	0.133	0.14	0.13	0.13	0.13	0.80	0.13
							Total	1.00

Measure of Worth	P1	P2	P3	P4	P5	P6	Total (Sum of rows)	Priority Weights
P1	0.19	0.18941	0.19	0.19	0.19	0.18	1.12	0.19
P2	0.1	0.10183	0.1	0.1	0.1	0.1	0.60	0.10
P3	0.25	0.26069	0.25	0.25	0.25	0.25	1.52	0.25
P4	0.24	0.25458	0.25	0.25	0.24	0.25	1.48	0.25
P5	0.09	0.06415	0.09	0.09	0.09	0.09	0.53	0.09
P6	0.13	0.12933	0.13	0.13	0.13	0.13	0.76	0.13
							Total	1

Risk	P1	P2	P3	P4	P5	P6	Total (Sum of rows)	Priority Weights
P1	0.07	0.07	0.07	0.07	0.07	0.07	0.44	0.07
P2	0.22	0.22	0.22	0.22	0.22	0.22	1.32	0.22
P3	0.04	0.04	0.04	0.04	0.04	0.04	0.26	0.04
P4	0.22	0.22	0.22	0.22	0.22	0.22	1.32	0.22
P5	0.22	0.22	0.22	0.22	0.22	0.22	1.32	0.22
P6	0.22	0.22	0.22	0.22	0.22	0.22	1.32	0.22
							Total	1

Financial Standing	P1	P2	P3	P4	P5	P6	Total (Sum of rows)	Priority Weights
P1	0.17	0.17	0.17	0.17	0.17	0.17	1	0.17
P2	0.17	0.17	0.17	0.17	0.17	0.17	1	0.17
P3	0.17	0.17	0.17	0.17	0.17	0.17	1	0.17
P4	0.17	0.17	0.17	0.17	0.17	0.17	1	0.17
P5	0.17	0.17	0.17	0.17	0.17	0.17	1	0.17
P6	0.17	0.17	0.17	0.17	0.17	0.17	1	0.17
							Total	1.00

Resource	P1	P2	P3	P4	P5	P6	Total (Sum of rows)	Priority Weights
P1	0.2	0.2	0.2	0.2	0.2	0.2	1.18	0.20
P2	0.16	0.16	0.16	0.16	0.16	0.16	0.94	0.16
P3	0.05	0.05	0.05	0.05	0.05	0.05	0.29	0.05
P4	0.13	0.13	0.13	0.13	0.13	0.13	0.77	0.13
P5	0.22	0.22	0.22	0.22	0.22	0.22	1.31	0.22
P6	0.25	0.25	0.25	0.25	0.25	0.25	1.51	0.25
							Total	1.00

Consistency Calculation

Profit	P1	P2	P3	P4	P5	P6	Weighted Sum Value	Priority Weights	Lambda (l)=Weighted sum/Criterion weights
Priority Weights	0.19	0.14	0.32	0.09	0.13	0.13			
P1	1	1.32	0.58	2.14	1.47	1.4	1.13	0.19	6.01
P2	0.75	1	0.44	1.62	1.11	1.06	0.85	0.14	6.01
P3	1.72	2.27	1	3.7	2.56	2.38	1.94	0.32	6.01
P4	0.46	0.62	0.27	1	0.68	0.65	0.52	0.09	6.01
P5	0.68	0.9	0.39	1.47	1	0.95	0.77	0.13	6.01
P6	0.71	0.94	0.42	1.53	1.05	1	0.81	0.13	6.01
							l(Sum)		36.07
							lmax=Average of Lambda		6.01
							C.I= (lmax-n)/(n-1)		0.00227423
							R.I (for n=6)		1.24
						CR < 0.1 (Acceptable)	C.R = C.I/R.I		0.001834056

Measure of Worth	P1	P2	P3	P4	P5	P6	Weighted Sum Value	Priority Weights	Lambda (l)=Weighted sum/Criterion weights
Priority Weights	0.19	0.1	0.25	0.25	0.09	0.13			
P1	1	1.86	0.74	0.76	2	1.47	1.12	0.19	6.02
P2	0.54	1	0.39	0.4	1.06	0.79	0.60	0.10	6.02
P3	1.35	2.56	1	1.02	2.7	2	1.52	0.25	6.02
P4	1.32	2.5	0.98	1	2.63	1.95	1.49	0.25	6.02
P5	0.5	0.63	0.37	0.38	1	0.74	0.53	0.09	6.03
P6	0.68	1.27	0.5	0.51	1.35	1	0.76	0.13	6.02
							l(Sum)		36.12
							lmax=Average of Lambda		6.02
							C.I= (lmax-n)/(n-1)		0.003871524
							R.I (for n=6)		1.24
						CR < 0.1 (Acceptable)	C.R = C.I/R.I		0.003122197

Risk	P1	P2	P3	P4	P5	P6	Weighted Sum Value	Priority Weights	Lambda (l)=Weighted sum/Criterion weights
Priority Weights	0.07	0.22	0.04	0.22	0.22	0.22			
P1	1	0.33	1.66	0.33	0.33	0.33	0.43	0.07	5.84
P2	3	1	5	1	1	1	1.29	0.22	5.84
P3	0.6	0.2	1	0.2	0.2	0.2	0.26	0.04	5.84
P4	3	1	5	1	1	1	1.29	0.22	5.84
P5	3	1	5	1	1	1	1.29	0.22	5.84
P6	3	1	5	1	1	1	1.29	0.22	5.84
							l(Sum)		35.07
							lmax=Average of Lambda		5.84
							C.I= (lmax-n)/(n-1)		-0.03
							R.I (for n=6)		1.24
						CR < 0.1 (Acceptable)	C.R = C.I/R.I		-0.025041807

Financial Standing	P1	P2	P3	P4	P5	P6	Weighted Sum Value	Priority Weights	Lambda (l)=Weighted sum/Criterion weights
Priority Weights	0.17	0.17	0.17	0.17	0.17	0.17			
P1	1	1	1	1	1	1	1.02	0.17	6
P2	1	1	1	1	1	1	1.02	0.17	6
P3	1	1	1	1	1	1	1.02	0.17	6
P4	1	1	1	1	1	1	1.02	0.17	6
P5	1	1	1	1	1	1	1.02	0.17	6
P6	1	1	1	1	1	1	1.02	0.17	6
							l(Sum)		36
							lmax=Average of Lambda		6
							C.I= (lmax-n)/(n-1)		0
							R.I (for n=6)		1.24
						CR < 0.1 (Acceptable)	C.R = C.I/R.I		0

Resource	P1	P2	P3	P4	P5	P6	Weighted Sum Value	Priority Weights	Lambda (l)=Weighted sum/Criterion weights
Priority Weights	0.2	0.16	0.05	0.13	0.22	0.25			
P1	1	1.26	4	1.54	0.9	0.79	1.20	0.20	6.08
P2	0.79	1	3.2	1.22	0.72	0.62	0.95	0.16	6.08
P3	0.25	0.31	1	0.38	0.22	0.19	0.29	0.05	6.08
P4	0.65	0.82	2.63	1	0.58	0.51	0.78	0.13	6.08
P5	1.1	1.39	4.54	1.72	1	0.87	1.33	0.22	6.08
P6	1.27	1.61	5.1	1.97	1.15	1	1.53	0.25	6.08
							l(Sum)		36.46
							lmax=Average of Lambda		6.08
							C.I= (lmax-n)/(n-1)		0.015251337
							R.I (for n=6)		1.24
						CR < 0.1 (Acceptable)	C.R = C.I/R.I		0.012299465

APPENDIX C: 2020/21 G.C ERA ALLOTTED CAPITAL BUDGET FOR NEW PROJECTS (OWN TABULATION)

NoteThat: ERA 2020/21 G.C alloted capita budget for all works including rehabilitation, upgrading, maintenace & feasibility study works is 58,080,201,000 ETB					
Own Tabulation: ERA 2020/21 G.C alloted capital budget for new projects					
		Finance source in (000 ETB)			
MoF Budget Code	**Project Name**	**Treasury**	**Loan**	**Foreign Grant**	**Total**
273/02/02/00/034	Abay bridge access road	65,000			65,000
273/03/02/00/035	Shashemene-Alaba	250,000			250,000
273/03/02/00/192	Alemgena-Butajira-Sodolot-1	97,000			97,000
273/03/02/00/193	Alemgena-Butajira-Sodolot-2	238,000			238,000
273/03/02/00/194	Arbaminch-Wezeka-Konso-Jinka-lot 1	115,000			115,000
273/03/02/00/195	Arbaminch-Wezeka-Konso-Jinka-lot 2	115,000			115,000
273/03/02/00/191	Ginir-Gode	52,500			52,500
273/04/02/00/115	Nekemete Bure Contract 1	70,357	232,978		303,335
273/04/02/00/117	Nekemete Bure Contract 3	78,019	306,900		384,919
273/04/02/00/142	Jimma-Chida	70,251	345,103		415,354
273/04/02/00/159	Dombidolo-Gambella	137,500			137,500
273/04/02/00/163	Adele-Grawa	281,244			281,244
273/04/02/00/166	Diredawa-Shinile & diredawa town bypass road	104,000			104,000
273/04/02/00/172	Dira-Masha-lot 2	138,500			138,500
273/04/02/00/173	Negele-Boren- Dolooda-melka Sufti- lot 1	110,000			110,000
273/04/02/00/398	Seka-Atnago-alga-seyo-Shenen-guder-lot 2	232,000			232,000
273/04/02/00/399	Nejo-jarso-South Sudan border-lot 1	150,000			150,000
273/04/02/00/175	Kombolcha-Mekanselam	95			95,000
273/04/02/00/176	Mekanselam-Abay bridge-Gindeweyne	100,000			100,000
273/04/02/00/400	Seka-Atnago-alga-seyo-Shenen-guder-lot 1	83,500			83,500
273/04/02/00/401	Nejo-jarso-South Sudan border-lot 2	78,500			78,500
273/04/02/00/403	Negele-Boren- Dolooda-melka Sufti- lot 2	70,000			70,000
273/04/02/00/404	Negele-Boren- Dolooda-melka Sufti- lot 3	70,000			70,000
273/04/02/00/405	Seka-Atnago-alga-seyo-Shenen-guder-lot 3	33,500			33,500
273/04/02/00/406	Agaro-Gera-Medabo	52,500			52,500
273/04/02/00/407	Wacha-Maje	27,000			27,000
273/04/02/00/408	Gilgele-Belese-Dibate-Wenbera	22,000			22,000
273/04/02/00/409	Goba-negele borena	27,700			27,700
273/02/02/00/027	Adama-Awash Express way	14,,768	1,089,750		1,204,218
273/05/02/00/043	Salayish-omo	72,448			72,448
273/05/02/00/076	Shebele-Imi	92,500			92,500
273/05/02/00/202	Hayke-bitsima-chifra	165,000			165,000
273/05/02/00/207	Derme-Shakiso	115,000			115,000
273/05/02/00/210	Shambu-Agamsa	60,000	523,425		583,425
273/05/02/00/214	Hawila-Weranche	135,000			135,000
273/05/02/00/221	Endesilassie-Rama-lot 1	160,000			160,000
273/05/02/00/222	Yaso-Galso-Debate-lot 1	223,000			223,000
273/05/02/00/223	Eleya-Makye	117,000			117,000
273/05/02/00/224	Etang-Wankye-mera	152,000			152,000
273/05/02/00/229	Jigjiga-Segege-lot 2	160,000			160,000
273/05/02/00/230	Gode-Hargele-lot 1	180,000			180,000
273/05/02/00/235	Gimbe-Tenta	215,000			215,000
273/05/02/00/240	Kimer dingaye-Guna	33,000			33,000
273/05/02/00/251	Bozhabore0N-Bilalo	121,000			121,000
273/05/02/00/253	Addis Alem-Maygeba-maytemene	147,000			147,000
273/05/02/00/246	Zalambesa-edegahamuse-lot 1	90,000			90,000

Own Tabulation: ERA 2020/21 G.C alloted capital budget for new projects					
		Finance source in (000 ETB)			
MoF Budget Code	Project Name	Treasury	Loan	Foreign Grant	Total
273/05/02/00/248	Dubti-Biyokobebe-contract 1	110,000			110,000
273/05/02/00/255	Fike-Segege-denane-lot 3	126,000			126,000
273/05/02/00/263	Gode-Ferfere-lot 2	205,000			205,000
273/05/02/00/265	Cheti-Gordmole-lot 3	234,200			234,200
273/05/02/00/266	Nekemete-koncho	191,200			191,200
273/05/02/00/267	Pawijuction-Renaissance dam-lot 2	95,000			95,000
273/05/02/00/270	Gode-Hargele-lot 2	135,000			135,000
273/05/02/00/271	Bulbula-Bireshelko	222,000			222,000
273/05/02/00/274	Debremarkose-mota-lot 1	57,000	305,142		362,142
273/05/02/00/275	Debremarkose-mota-lot 2	60,118	329,939		390,057
273/05/02/00/276	Dila-Shakiso-lot 1	58,500	497,534		556,034
273/05/02/00/277	Arsi robe-Al-lot 1	128,000			128,000
273/05/02/00/278	omo-maje-lot 2	151,000			151,000
273/05/02/00/279	Yaso-chagni-lot 2	260,000			260,000
273/05/02/00/280	Kemte-koncho-lot 1	169,000			169,000
273/05/02/00/281	Tenta-Gashena-lot 2	115,000			115,000
273/05/02/00/282	Debremarkose-chagni-lot 2	155,000			155,000
273/05/02/00/283	Debremarkose-chagni-lot 3	154,000			154,000
273/05/02/00/284	Homosha-hidase dam-lot 1	128,000			128,000
273/05/02/00/285	Shekehusssen-delosebro	169,000			169,000
273/05/02/00/286	Guliso-biji-lot 1	139,000			139,000
273/05/02/00/287	Weldehana-Durgi	161,500			161,500
273/05/02/00/288	Kobo-lalibela-lot 2	93,500			93,500
273/05/02/00/289	Supe-Kilo	158,000			158,000
273/05/02/00/290	Dembecha-Fersebate-Adate-lot 1	138,000			138,000
273/05/02/00/291	Desse town bypass	23,000			23,000
273/05/02/00/292	Mettu town bypass	23,598			23,598
273/05/02/00/293	Mehalemeda-milemile-lot 1	170,000			170,000
273/05/02/00/294	Durebate-metema-lot 1	189,000			189,000
273/05/02/00/295	Durebate-metema-lot 2	174,000			174,000
273/05/02/00/296	Durebate-metema-lot 3	179,000			179,000
273/05/02/00/297	Dangela-Jawi	154,000			154,000
273/05/02/00/298	Bonosha-Achamo	59,000			59,000
273/05/02/00/299	Dima-Kibisi-lot 1	218,000			218,000
273/05/02/00/301	Alaba-Angecho-wato	171,000			171,000
273/05/02/00/302	Alamta-dela-lot 1	129,000			129,000
273/05/02/00/304	Gelego-guba-lot 1	140,000			140,000
273/05/02/00/305	Goge-akobo-lot 1	179,000			179,000
273/05/02/00/306	Turmi-Weito	193,000			193,000
273/05/02/00/308	Gimbi-Metu-lot 1	128,000			128,000
273/05/02/00/309	Jiga-tilile-lot 2	142,000			142,000
273/05/02/00/310	Tongo-Asosa	116,000			116,000
273/05/02/00/311	Chanka-gidami	84,000			84,000
273/05/02/00/312	Bulehora-Shakiso	178,500			178,500
273/05/02/00/313	Jigjiga town bypass road	33,997			33,997
273/05/02/00/300	Dayo-kibremengiste	158,000			158,000
273/05/02/00/315	Metema-Sanja-lot 2	68,000			68,000
273/05/02/00/314	Juhare-guguftu-lot 1	77,500			77,500
273/05/02/00/316	Durgi-omo-nada-lot 3	72,500			72,500
273/05/02/00/318	Golago-ttewodros town-guba-lot 2	98,000			98,000

Own Tabulation: ERA 2020/21 G.C alloted capital budget for new projects					
		Finance source in (000 ETB)			
MoF Budget Code	Project Name	Treasury	Loan	Foreign Grant	Total
273/05/02/00/319	Fike-denane-lot 1	76,000			76,000
273/05/02/00/320	Fike-denane-lot 2	81,000			81,000
273/05/02/00/321	Dubti-Bitokobeb-cont 3	86,000			86,000
273/05/02/00/322	Dubti-Bitokobeb-cont 4	86,000			86,000
273/05/02/00/323	Dombidola-Gambela-lot 2	63,500			63,500
273/05/02/00/324	Zalambesa-edegahamuse-lot 2	58,500			58,500
273/05/02/00/325	Debremarkose-chagni-lot 4	138,500			138,500
273/05/02/00/326	Dembecha-Fersebate-Adate-lot 2	60,500			60,500
273/05/02/00/327	Jiga-tilile-lot 1	123,500			123,500
273/05/02/00/328	Mehalemeda-milemile-lot 2	68,500			68,500
273/05/02/00/329	Dima-Kibishi-lot 2	158,500			158,500
273/05/02/00/331	Fishagenete-segene-gebelebino-lot 3	138,500			138,500
273/05/02/00/332	Gambela-abebo-dima-lot 3	68,500			68,500
273/05/02/00/333	Dila-Shakiso-lot 2	58,000			58,000
273/05/02/00/334	Homosha-hidase dam-lot 2	48,500			48,500
273/05/02/00/335	Kobo-lalibela-lot 1	88,500			88,500
273/05/02/00/336	Guliso-biji-lot 2	73,500			73,500
273/05/02/00/337	Guliso-biji-lot 3	73,500			73,500
273/05/02/00/338	Alamta-dela-lot 2	68,500			68,500
273/05/02/00/339	Gimbi-Metu-lot 2	78,500			78,500
273/05/02/00/340	Gode-Jore-Akobo-lot 2	73,500			73,500
273/05/02/00/341	Bulehora-Shakiso-kibremengiste-lot 2	68,500			68,500
273/05/02/00/343	Sodo-tercha-lot 3	48,500			48,500
273/05/02/00/344	Morca-chano-lot 2	33,500			33,500
273/05/02/00/345	Hamusete-este-lot 3	58,500			58,500
273/05/02/00/346	Hagayo-metu	85,000			85,000
273/05/02/00/347	Halaba-Irba junction	101,000			101,000
273/05/02/00/348	Gerehusenaye-siro	41,000			41,000
273/05/02/00/349	Sekota-Addis zemen	90,000			90,000
273/05/02/00/350	Bati-kemese	97,000			97,000
273/05/02/00/351	Kesa-Gimjabeta-ambela	52,500			52,500
273/05/02/00/352	Hawassa-Chiko	36,500			36,500
273/05/02/00/353	Aletawendo-dila	31,000			31,000
273/05/02/00/354	Hosana-Jako	36,000			36,000
273/05/02/00/355	Filtu-Moyale	50,000			50,000
273/05/02/00/356	Ibantu-Yaso	36,500			36,500
273/05/02/00/357	Pegnanege-Rike	41,500			41,500
273/05/02/00/358	Tolta-sepere	46,000			46,000
273/05/02/00/359	Bishoftu-Expressroad access	42,500			42,500
273/05/02/00/367	Adola-harenfama	43,500			43,500
273/05/02/00/360	Gendesheno-keyemaberate-lot 1	22,000			22,000
273/05/02/00/361	Maksegete-degoma-arbaya-adi junction	18,000			18,000
273/05/02/00/362	Chebera-gudumu	58,500			58,500
273/05/02/00/363	Bure-Gomere	12,000			12,000
273/05/02/00/364	Hoja-dure-kenate	22,000			22,000
273/05/02/00/364	Kofele-bilalo junction	22,000			22,000
273/05/02/00/366	Deghamdo-degahabure	22,000			22,000
273/05/02/00/368	Adigu-Yechala	17,000			17,000
273/05/02/00/369	Birki-asibi junction	17,000			17,000
273/05/02/00/370	Ninnango-too/Ongonge/	17,000			17,000
273/05/02/00/371	Semera-Mehoni	12,000			12,000
273/07/02/00/012	Dawa bridge	51,071			51,071
273/07/02/00/013	Weleka bridge	45,263			45,263
273/07/02/00/018	Tekeze bridge/humera/	18,500			18,500
273/07/02/00/019	Merebe bridge/Adiabune-merebe/	13,000			13,000

APPENDIX D: RESPONDENTS RESPONSE DATA

Respondents Data (1-25)

		Coding	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Profit	Risk	A	3	7	5	1	1	3	5	5	5	0.2	9	3	1	1	5	5	1	3	5	3	0.33	0.2	3	3	1
	Measure of Worth	B	9	1	3	7	1	1	3	5	3	0.14	5	1	0.2	1	3	5	0.2	1	3	1	0.2	0.14	1	1	1
	Financial Standing	C	7	5	3	7	4	1	7	7	3	0.33	3	3	0.33	3	3	1	0.33	1	7	1	1	0.2	1	1	3
	Resource	D	9	6	3	7	9	3	7	7	3	1	3	5	1	3	5	1	1	3	7	3	1	1	3	3	5
	Economic Factors	E	7	3	1	3	1	5	7	7	5	1	7	5	1	3	2	7	3	5	7	3	3	1	3	5	7
	Experience	F	5	1	3	3	9	3	5	9	5	0.33	3	5	0.33	1	5	5	0.33	5	7	1	1	1	3	5	9
	Technical Ability	G	9	1	2	3	9	6	3	7	1	0.33	7	1	0.14	3	3	0.33	0.14	2	7	3	0.33	0.33	1	1	9
	Size and Complexity	H	5	1	3	1	1	5	3	9	4	0.2	7	3	0.2	1	3	5	0.5	3	9	5	1	0.33	3	1	8
	Duration	I	7	5	7	5	9	5	3	9	5	2	9	1	1	1	5	1	1	5	9	7	3	1	3	5	8
	Organizational Culture	J	3	7	3	5	1	7	9	9	5	3	1	7	5	5	7	1	5	6	3	9	5	1	5	7	8
	Environmental Factors	K	7	7	9	5	1	9	3	9	7	5	7	5	6	7	7	7	7	9	3	5	9	5	5	9	4
	Location Factors	L	5	1	7	5	1	7	9	9	5	1	7	7	5	1	6	9	3	7	3	5	5	3	5	5	2
	Social Responsibility	M	7	3	7	5	7	7	9	9	3	1	7	7	5	7	7	1	3	7	9	7	5	3	5	5	2
	Political Factors	N	5	7	9	9	1	9	7	9	7	7	9	3	8	5	9	9	8	9	3	7	7	4	5	7	2
Risk	Measure of Worth	O	3	1	1	9	9	1	1	3	1	0.33	1	1	0.33	1	1	1	0.33	1	7	1	0.2	1	5	1	9
	Financial Standing	P	3	2	2	3	9	1	1	3	1	1	1	1	0.33	3	1	3	0.33	1	5	1	1	2	3	1	9
	Resource	Q	5	1	3	5	9	1	5	3	2	1	1	1	1	1	2	0.33	1	2	7	3	1	3	3	3	9
	Economic Factors	R	3	5	3	9	7	3	5	3	3	3	1	3	3	1	3	3	3	3	5	3	3	5	5	5	9
	Experience	S	3	1	1	9	1	5	3	3	3	1	3	1	1	3	3	0.2	1	5	9	3	1	3	3	5	9
	Technical Ability	T	7	3	1	1	9	3	1	3	1	0.33	1	1	0.2	1	3	7	0.2	3	9	3	0.33	1	3	3	9
	Size and Complexity	U	3	1	3	3	9	5	1	3	3	0.2	1	3	0.33	3	1	1	0.33	4	9	5	0.33	1	7	3	9
	Duration	V	7	5	4	3	9	7	1	3	5	1	1	3	1	3	4	5	1	3	3	7	3	2	3	5	8
	Organizational Culture	W	5	5	7	3	4	3	7	3	7	5	1	7	5	1	5	7	5	5	3	7	5	5	5	7	8
	Environmental Factors	X	7	6	7	9	9	7	3	3	9	7	1	3	6	7	7	3	7	7	3	9	7	9	5	9	8
	Location Factors	Y	4	7	5	9	9	5	7	5	7	4	1	7	4	5	5	7	3	5	5	7	5	5	5	7	9
	Social Responsibility	Z	9	5	6	9	7	3	7	5	9	4	1	9	4	1	5	3	3	3	5	7	5	3	5	7	6
	Political Factors	Z1	4	5	9	9	9	7	5	9	9	8	9	5	9	1	7	5	9	8	5	9	8	7	5	9	9
Measure of Worth	Financial Standing	Z2	6	5	3	1	1	1	5	7	1	1	1	3	1	1	1	1	3	3	5	1	3	3	1	1	9
	Resource	Z3	9	3	3	3	9	2	7	5	3	1	1	5	1	3	2	5	5	4	1	3	5	3	2	3	9
	Economic Factors	Z4	3	5	1	7	9	3	7	5	3	2	1	5	2	5	3	3	5	4	3	3	5	5	2	5	9
	Experience	Z5	3	5	4	5	4	3	5	5	5	2	3	3	2	1	3	5	4	5	3	5	5	3	2	5	9
	Technical Ability	Z6	8	3	3	5	9	1	1	5	1	0.2	1	1	0.33	1	1	1	0.33	1	5	3	3	1	3	3	9
	Size and Complexity	Z7	2	5	3	5	1	1	3	5	2	0.33	1	3	1	1	3	5	1	2	7	5	1	1	2	3	9
	Duration	Z8	8	7	5	7	7	5	3	7	5	1	1	1	2	5	4	3	2	3	7	7	3	2	2	7	9
	Organizational Culture	Z9	3	7	3	9	6	7	7	7	9	5	1	7	4	5	7	5	4	6	9	7	5	5	3	7	7
	Environmental Factors	Z10	7	9	7	7	9	7	3	5	5	7	1	3	8	1	9	3	8	8	9	9	8	9	3	9	7
	Location Factors	Z11	3	7	7	7	7	5	9	5	6	5	1	7	6	5	7	1	5	5	9	7	7	3	1	7	4
	Social Responsibility	Z12	7	7	5	7	9	5	9	5	3	5	1	7	5	3	9	5	6	5	8	9	6	3	1	5	4
	Political Factors	Z13	3	7	9	7	9	7	7	7	9	6	9	3	9	1	9	7	9	6	9	9	9	9	1	9	4
Financial Standing	Resource	Z14	1	1	3	9	1	3	3	7	1	1	1	1	1	1	3	3	3	3	1	3	3	1	5	3	5
	Economic Factors	Z15	1	1	3	9	1	3	3	7	3	2	1	3	2	5	3	5	5	5	3	5	5	3	5	5	5
	Experience	Z16	3	3	5	5	1	5	3	7	3	1	1	1	1	5	3	5	1	3	5	5	3	1	3	5	7
	Technical Ability	Z17	1	1	5	3	1	3	1	7	1	0.33	5	1	0.33	5	1	3	0.33	2	7	5	1	0.33	5	3	7
	Size and Complexity	Z18	3	5	3	9	9	5	1	7	3	0.2	7	3	1	3	3	5	0.33	3	7	5	1	0.2	5	3	9
	Duration	Z19	2	5	5	3	4	7	3	7	5	1	2	3	2	7	5	5	1	4	7	7	3	2	5	7	9
	Organizational Culture	Z20	3	7	3	9	4	7	7	7	7	5	9	7	3	7	5	5	5	7	5	7	6	5	3	7	5
	Environmental Factors	Z21	3	7	7	9	1	9	3	9	9	7	1	1	9	7	7	7	7	9	5	9	8	9	3	9	5
	Location Factors	Z22	2	7	7	9	1	6	7	5	7	4	7	5	5	1	5	3	5	7	5	7	5	5	3	7	7
	Social Responsibility	Z23	2	9	5	3	1	6	9	7	5	4	7	7	5	5	5	5	5	5	8	5	7	5	3	3	5
	Political Factors	Z24	3	9	9	3	1	9	9	7	9	8	9	3	7	3	7	7	8	9	5	7	9	8	5	7	5
Resource	Economic Factors	Z25	3	7	1	9	9	2	3	3	1	2	3	3	1	5	3	9	0.33	1	7	3	1	1	9	3	7
	Experience	Z26	2	5	2	3	1	3	1	3	3	1	1	1	1	3	3	3	0.33	3	5	5	1	1	5	5	5
	Technical Ability	Z27	3	5	3	3	1	1	1	5	1	0.33	7	1	0.33	7	1	7	0.14	1	1	3	0.33	0.2	3	3	7
	Size and Complexity	Z28	1	3	3	7	9	1	1	5	1	3	7	1	0.2	7	3	7	1	2	1	3	1	0.33	7	3	5
	Duration	Z29	3	7	5	7	9	5	1	5	3	1	7	1	3	7	3	5	1	3	3	5	4	2	7	5	7
	Organizational Culture	Z30	3	9	3	7	4	8	7	5	5	5	5	7	5	7	5	7	3	5	3	7	5	5	4	7	7
	Environmental Factors	Z31	5	9	9	7	9	9	3	5	7	8	1	3	5	7	9	5	7	7	3	7	7	9	8	7	7
	Location Factors	Z32	2	8	7	7	9	6	7	7	5	5	2	7	5	9	5	7	3	5	5	5	5	7	9	9	6
	Social Responsibility	Z33	3	8	7	7	6	8	9	7	7	5	7	7	5	7	3	5	3	3	5	5	5	7	9	9	4
	Political Factors	Z34	8	8	7	7	1	9	7	7	9	9	7	5	7	7	9	5	3	5	5	9	7	8	9	9	4

Respondents Data (1-25)																										
`		Coding	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Economic Factors	Experience	Z35	1	1	3	3	3	1	1	5	3	1	3	1	1	1	2	5	0.33	3	9	3	0.33	1	4	3	5
	Technical Ability	Z36	2	1	3	7	3	1	1	5	1	0.33	3	1	0.33	1	1	3	0.2	1	7	1	0.2	0.33	4	3	5
	Size and Complexity	Z37	3	5	3	7	1	1	1	5	3	0.2	3	1	0.33	1	1	5	1	1	5	3	0.33	0.33	9	3	5
	Duration	Z38	4	3	4	5	1	2	1	3	5	2	3	1	1	1	3	9	1	2	5	5	3	2	5	7	5
	Organizational Culture	Z39	3	5	3	7	6	7	5	5	4	5	3	5	4	3	7	3	3	4	3	5	5	5	7	7	5
	Environmental Factors	Z40	2	5	7	7	8	7	3	3	9	6	1	3	6	1	9	5	5	6	3	7	5	9	9	5	3
	Location Factors	Z41	3	7	5	9	8	5	9	3	7	4	1	7	4	3	7	3	5	7	1	7	5	5	9	5	3
	Social Responsibility	Z42	4	7	5	9	1	5	7	3	7	5	1	9	4	3	5	0.2	5	5	3	5	5	5	9	7	3
	Political Factors	Z43	3	7	9	9	1	6	7	3	9	9	7	7	8	1	9	1	3	9	3	7	7	6	9	9	3
Experience	Technical Ability	Z44	3	3	2	9	2	1	1	9	1	0.33	5	1	0.33	5	3	5	0.2	1	1	1	0.33	0.2	7	1	7
	Size and Complexity	Z45	2	7	1	5	9	1	1	9	1	0.2	5	1	1	3	1	9	0.33	1	3	1	0.33	0.33	6	1	7
	Duration	Z46	1	5	2	9	9	2	1	9	3	1	7	1	1	3	2	3	1	2	3	3	3	1	9	3	9
	Organizational Culture	Z47	1	7	3	9	1	5	5	9	5	3	7	5	3	3	7	0.2	3	7	5	5	3	5	9	5	9
	Environmental Factors	Z48	3	7	7	7	9	7	3	9	8	5	7	1	5	5	7	7	5	7	5	7	5	8	2	5	7
	Location Factors	Z49	4	7	5	5	4	5	7	9	6	3	7	5	5	3	5	0.143	3	5	5	5	3	5	2	3	9
	Social Responsibility	Z50	1	7	3	5	9	5	7	7	5	3	7	7	5	5	5	5	3	7	7	5	3	3	7	3	9
	Political Factors	Z51	2	7	7	5	1	8	5	7	8	5	7	5	6	7	9	7	7	7	5	7	8	3	7	7	9
Technical Ability	Size and Complexity	Z52	7	7	1	9	9	2	3	5	1	1	7	3	1	7	1	5	1	2	1	1	1	1	5	1	9
	Duration	Z53	7	7	4	9	9	5	1	5	3	3	7	1	2	7	5	5	3	2	1	3	3	2	5	5	7
	Organizational Culture	Z54	7	7	5	7	9	5	7	5	6	5	5	7	4	7	4	1	5	5	3	5	5	5	5	5	9
	Environmental Factors	Z55	5	7	7	7	1	7	3	5	8	7	5	3	7	5	7	3	7	7	3	7	7	9	3	7	7
	Location Factors	Z56	7	7	7	7	1	5	9	5	5	3	3	5	6	5	5	5	6	5	3	5	5	3	3	5	7
	Social Responsibility	Z57	9	7	5	7	6	5	7	5	5	3	7	7	6	1	5	7	6	3	5	5	5	3	3	5	9
	Political Factors	Z58	9	7	7	7	1	7	5	5	8	8	7	3	9	7	7	5	9	7	3	9	8	3	3	9	8
Size and Complexity	Duration	Z59	2	5	3	9	9	3	1	3	2	3	1	1	3	7	3	3	3	4	7	3	3	3	7	5	1
	Organizational Culture	Z60	3	5	5	7	9	7	5	7	5	7	5	5	4	5	5	5	5	7	5	5	5	5	4	5	1
	Environmental Factors	Z61	1	7	6	7	1	9	1	7	7	7	5	3	6	7	7	1	7	7	5	7	7	7	4	7	5
	Location Factors	Z62	2	5	5	5	1	7	5	3	5	5	5	5	5	1	5	5	5	7	5	5	5	5	2	7	1
	Social Responsibility	Z63	4	7	7	5	3	7	7	9	3	5	5	7	5	7	6	0.2	6	5	7	5	5	5	2	5	5
	Political Factors	Z64	5	7	7	5	1	8	5	9	7	7	3	7	7	1	9	3	8	9	9	7	7	8	2	7	5
Duration	Organizational Culture	Z65	1	7	3	7	1	5	7	9	3	3	7	5	3	7	3	5	3	3	9	3	3	3	3	5	1
	Environmental Factors	Z66	3	7	9	9	1	6	3	9	9	5	7	3	3	9	5	3	5	6	1	5	5	5	2	7	5
	Location Factors	Z67	1	7	7	9	9	7	7	7	7	3	7	5	3	7	3	5	3	4	1	3	5	3	2	7	7
	Social Responsibility	Z68	1	7	5	5	5	7	7	9	5	3	7	7	3	7	3	5	3	5	3	3	5	3	2	5	9
	Political Factors	Z69	2	7	9	5	1	9	5	9	9	6	7	7	5	7	7	7	2	7	7	7	6	6	2	9	9
Organizational Culture	Environmental Factors	Z70	2	5	7	9	2	3	1	3	3	1	2	1	1	7	7	3	2	5	9	5	3	3	5	5	5
	Location Factors	Z71	3	3	5	9	2	1	5	3	5	1	2	3	1	7	5	7	1	3	9	3	1	1	5	3	3
	Social Responsibility	Z72	2	5	3	9	2	1	7	9	3	1	2	1	1	7	5	5	1	1	7	3	1	1	5	3	7
	Political Factors	Z73	3	5	6	9	4	5	5	9	7	2	2	1	3	7	7	7	4	6	9	5	4	4	5	5	9
Environmental Factors	Location Factors	Z74	1	1	2	9	9	1	5	3	1	0.2	1	5	0.33	7	1	5	3	5	7	5	0.33	1	5	3	3
	Social Responsibility	Z75	1	1	1	9	7	1	7	3	1	1	5	3	0.33	7	1	7	1	3	9	5	0.33	1	2	1	7
	Political Factors	Z76	2	1	3	9	5	5	5	3	3	5	7	1	1	7	3	5	2	5	9	7	3	2	2	5	8
Location Factors	Social Responsibility	Z77	2	3	1	7	9	3	1	3	1	1	2	3	0.33	1	1	7	1	1	7	3	1	1	2	1	9
	Political Factors	Z78	2	3	5	7	1	5	1	3	3	5	2	1	1	3	5	5	3	5	9	5	3	2	2	7	7
Social Responsibility	Political Factors	Z79	3	3	5	9	3	5	3	9	1	3	7	1	1	5	1	9	1	1	9	5	3	1	5	5	5

			Respondents Response (26-50)																								
`		Coding	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Profit	Risk	A	9	9	3	1	0.2	3	9	1	3	0.2	1	3	3	3	1	5	1	3	2	9	9	0.2	3	3	9
	Measure of Worth	B	9	9	1	0.2	0.2	1	9	3	1	0.14	5	1	1	7	0.33	3	7	1	1	1	5	0.14	1	1	7
	Financial Standing	C	9	9	1	0.33	0.33	1	9	3	1	0.33	7	1	1	5	0.2	5	1	3	1	5	9	0.33	3	1	7
	Resource	D	9	7	3	1	1	3	9	7	1	1	7	3	3	5	1	5	1	5	5	3	9	1	3	2	9
	Economic Factors	E	9	7	5	3	3	5	9	9	3	1	5	7	5	7	3	3	3	7	7	7	7	1	5	2	5
	Experience	F	7	7	3	1	1	5	7	7	5	1	7	7	5	3	1	3	3	3	7	4	9	1	5	3	9
	Technical Ability	G	7	9	6	1	0.33	5	9	5	3	1	5	7	5	3	1	3	7	1	1	2	9	1	3	1	3
	Size and Complexity	H	7	9	5	1	0.2	5	5	3	4	1	5	3	5	5	1	3	7	7	1	2	5	1	5	1	9
	Duration	I	5	9	5	3	3	7	9	1	7	3	7	3	7	7	2	5	9	3	1	9	9	3	5	4	1
	Organizational Culture	J	9	7	7	5	5	7	9	1	7	5	7	7	7	3	5	5	3	5	9	3	5	5	7	5	9
	Environmental Factors	K	5	9	9	9	9	9	7	1	9	7	3	7	9	5	9	5	5	1	3	7	9	7	7	7	9
	Location Factors	L	9	9	7	5	5	7	5	3	7	2	1	9	7	7	5	7	3	7	7	6	7	3	5	5	7
	Social Responsibility	M	3	9	7	5	3	7	9	3	9	2	5	9	7	7	5	9	1	3	9	8	9	3	7	5	5
	Political Factors	N	7	9	9	7	7	9	7	5	9	7	5	1	9	7	9	3	9	3	5	8	9	7	9	9	9
Risk	Measure of Worth	O	9	7	1	1	0.33	1	9	7	1	1	3	1	1	1	1	3	1	1	1	2	3	0.33	1	0.33	5
	Financial Standing	P	7	7	1	1	1	1	9	5	1	1	5	3	1	3	1	3	3	3	1	5	5	0.33	1	0.33	9
	Resource	Q	7	7	1	3	1	1	5	5	1	3	3	1	1	3	1	3	3	5	3	3	0.3	1	1	3	3
	Economic Factors	R	7	9	3	3	3	3	7	7	2	3	3	7	3	5	3	5	3	7	7	3	7	1	5	3	9
	Experience	S	9	9	5	1	0.33	5	6	9	2	1	7	7	5	5	1	5	5	3	7	2	7	1	5	1	1
	Technical Ability	T	9	9	3	1	0.2	5	9	7	1	1	5	7	5	3	1	5	5	1	1	2	9	1	3	1	5
	Size and Complexity	U	9	9	5	1	0.33	5	7	5	1	1	5	9	5	3	1	3	7	1	3	7	9	1	3	1	9
	Duration	V	3	9	7	2	3	7	9	3	7	2	5	3	7	3	2	3	7	3	1	4	5	3	5	5	9
	Organizational Culture	W	3	7	3	3	5	7	7	1	5	5	7	3	7	3	5	3	3	7	9	3	3	5	5	5	9
	Environmental Factors	X	9	7	7	7	7	9	5	1	9	8	3	9	9	5	8	5	1	3	5	5	7	9	9	7	9
	Location Factors	Y	5	7	5	5	5	7	9	3	5	6	3	3	7	5	3	5	5	7	9	3	5	8	7	5	7
	Social Responsibility	Z	1	9	3	3	5	7	7	3	7	5	7	3	7	7	3	3	3	7	7	5	3	6	7	5	3
	Political Factors	Z1	9	9	7	7	8	7	3	3	9	6	1	7	9	7	5	9	7	5	3	3	9	9	9	7	7
Measure of Worth	Financial Standing	Z2	9	9	1	3	1	1	9	1	2	0.33	3	7	3	1	0.33	7	9	3	4	1	7	3	1	3	7
	Resource	Z3	9	9	2	5	3	3	9	5	3	3	5	7	5	3	3	7	9	7	1	5	7	3	1	3	9
	Economic Factors	Z4	9	7	3	5	5	5	9	5	5	3	7	7	5	3	5	7	9	7	7	5	5	5	5	5	7
	Experience	Z5	7	7	3	3	3	5	7	5	3	4	7	7	5	5	3	5	1	5	7	4	5	5	5	3	3
	Technical Ability	Z6	7	5	1	1	1	5	9	5	1	2	5	3	5	1	1	5	7	1	1	2	7	3	3	1	3
	Size and Complexity	Z7	5	5	1	1	1	5	9	7	3	3	3	1	5	3	1	5	7	3	3	2	9	3	5	1	7
	Duration	Z8	5	7	5	2	3	7	9	3	5	4	3	1	7	7	3	5	1	3	1	3	7	3	7	3	9
	Organizational Culture	Z9		3	7	5	5	7	1	9	7	5	7	3	9	5	5	5	1	7	7	3	5	5	7	5	9
	Environmental Factors	Z10	7	3	7	8	7	9	1	9	9	9	5	5	9	5	8	5	1	5	1	6	7	9	9	7	9
	Location Factors	Z11	3	3	5	5	5	7	7	9	5	5	3	1	9	7	5	5	3	9	7	4	5	5	7	5	5
	Social Responsibility	Z12	3	3	5	5	5	7	1	9	5	5	7	1	9	7	5	5	3	7	9	3	9	4	7	5	9
	Political Factors	Z13	3	7	7	9	7	9	1	9	7	9	1	5	9	7	9	7	3	5	3	3	9	9	9	7	3
Financial Standing	Resource	Z14	9	5	3	1	3	3	1	3	3	1	9	7	3	3	1	5	9	1	2	1	9	3	3	3	9
	Economic Factors	Z15	9	5	3	3	3	3	1	5	5	3	7	7	5	5	3	5	9	3	7	7	7	5	4	3	1
	Experience	Z16	5	5	5	1	1	5	5	5	3	3	5	7	5	5	1	3	5	1	5	7	9	3	5	3	7
	Technical Ability	Z17	7	5	3	0.33	0.33	3	1	1	1	1	5	7	5	3	1	3	9	1	1	3	9	1	5	1	9
	Size and Complexity	Z18	5	5	5	0.2	1	3	3	1	3	1	5	1	5	3	1	3	9	1	1	3	7	3	5	1	5
	Duration	Z19	5	7	7	2	3	5	6	1	5	3	3	3	7	5	3	3	9	1	1	3	7	3	7	5	1
	Organizational Culture	Z20	5	7	7	5	5	7	1	1	7	4	7	3	7	7	5	3	5	7	7	4	5	5	7	5	9
	Environmental Factors	Z21	5	7	9	7	9	9	5	5	9	8	3	7	9	7	9	3	1	5	3	6	5	9	9	9	7
	Location Factors	Z22	5	7	6	3	7	7	7	5	5	5	3	3	7	5	3	3	1	5	9	6	3	7	9	7	9
	Social Responsibility	Z23	5	5	6	3	7	5	1	5	7	8	7	3	7	5	3	3	1	7	9	3	9	7	9	7	9
	Political Factors	Z24	5	5	9	9	9	7	1	5	9	9	1	7	9	9	7	3	5	3	7	8	9	9	9	9	3
Resource	Economic Factors	Z25	9	9	2	1	3	3	1	3	3	1	7	9	3	3	3	5	9	3	6	5	7	3	3	1	9
	Experience	Z26	7	9	3	1	1	5	1	5	5	2	7	1	3	3	1	5	9	3	1	5	7	3	3	3	1
	Technical Ability	Z27	5	7	1	1	1	3	1	1	3	2	7	7	3	5	1	5	9	1	1	5	9	1	1	1	7
	Size and Complexity	Z28	5	7	1	1	1	3	1	3	3	2	5	1	3	3	1	5	9	1	1	5	7	1	1	1	3
	Duration	Z29	7	7	5	2	3	5	3	3	5	5	3	1	5	7	2	5	9	3	1	3	7	3	5	3	9
	Organizational Culture	Z30	5	5	8	5	5	5	1	5	7	5	7	7	5	3	5	7	5	7	9	3	5	3	7	6	9
	Environmental Factors	Z31	9	5	9	8	9	9	1	5	7	9	5	7	7	7	9	5	1	5	3	8	7	7	9	8	9
	Location Factors	Z32	9	9	6	5	6	7	1	3	7	5	3	7	5	5	4	5	9	7	7	6	7	5	7	5	7
	Social Responsibility	Z33	5	9	8	3	9	5	3	3	5	5	7	1	5	5	5	5	1	9	9	6	5	5	7	5	9
	Political Factors	Z34	9	9	9	8	6	7	1	3	7	9	3	3	7	7	7	7	9	7	7	8	5	9	9	7	9

			Respondents Response (26-50)																								
`		Coding	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Economic Factors	Experience	Z35	7	5	1	0.33	0.33	3	9	3	2	1	7	5	3	3	1	5	9	1	1	3	7	1	1	3	7
	Technical Ability	Z36	9	5	1	0.2	0.2	1	1	5	1	1	5	5	3	3	1	5	9	1	1	5	7	0.33	1	1	5
	Size and Complexity	Z37	7	7	1	0.33	0.33	1	1	5	1	1	5	5	3	3	1	5	9	3	1	5	7	0.33	1	1	9
	Duration	Z38	7	7	2	2	3	3	3	7	2	2	3	5	5	5	2	5	9	1	1	4	7	3	5	3	9
	Organizational Culture	Z39	9	7	7	4	5	5	1	7	7	5	7	3	7	5	5	5	7	7	7	8	5	5	7	5	9
	Environmental Factors	Z40	9	7	7	9	7	7	1	7	7	9	5	3	9	9	9	5	1	3	3	3	5	7	9	8	7
	Location Factors	Z41	9	9	5	4	5	5	1	1	5	3	5	7	7	6	5	5	9	7	5	3	5	5	9	5	7
	Social Responsibility	Z42	5	9	5	4	5	3	1	1	5	3	7	1	9	9	5	3	1	5	9	3	7	5	9	5	7
	Political Factors	Z43	9	9	6	9	9	7	1	1	7	7	1	5	9	9	7	7	3	5	3	3	7	7	9	7	3
Experience	Technical Ability	Z44	9	9	1	0.33	1	1	1	1	2	0.33	7	9	1	3	1	5	9	1	1	1	7	1	1	1	9
	Size and Complexity	Z45	9	9	1	0.33	1	1	1	1	2	1	5	5	1	5	1	5	9	1	1	1	7	1	1	1	7
	Duration	Z46	3	7	2	1	3	1	1	1	5	3	7	3	3	5	3	5	9	1	3	1	7	2	5	3	9
	Organizational Culture	Z47	7	7	5	3	5	5	1	1	7	3	9	3	7	5	3	5	9	5	7	3	5	5	7	5	3
	Environmental Factors	Z48	5	9	7	7	9	7	1	1	7	7	3	1	9	3	7	5	3	1	3	8	5	7	9	8	9
	Location Factors	Z49	5	9	5	3	7	5	3	1	5	5	1	1	7	3	5	5	3	7	5	5	5	5	7	5	5
	Social Responsibility	Z50	5	9	5	3	7	5	1	1	5	5	7	1	7	5	5	5	1	5	7	5	7	5	9	5	7
	Political Factors	Z51	5	7	8	8	9	7	1	1	9	7	1	1	9	5	7	9	1	3	5	8	1	8	9	9	9
Technical Ability	Size and Complexity	Z52	9	7	2	3	1	1	1	1	1	3	5	7	1	3	1	7	9	3	1	7	9	1	1	1	5
	Duration	Z53	9	7	5	5	3	3	1	1	2	5	7	5	3	5	3	7	9	1	1	7	7	3	5	3	9
	Organizational Culture	Z54	9	5	5	5	5	5	1	3	5	5	7	3	5	3	3	7	9	7	5	3	7	5	7	3	7
	Environmental Factors	Z55	7	7	7	8	7	7	1	3	9	9	7	3	7	5	7	5	1	3	3	8	7	9	9	9	9
	Location Factors	Z56	7	5	5	6	6	5	1	3	7	7	7	3	7	3	5	5	1	7	7	5	7	5	5	5	3
	Social Responsibility	Z57	1	5	5	4	5	3	3	1	7	5	9	1	7	5	5	7	1	5	5	6	5	5	5	3	1
	Political Factors	Z58	1	5	7	9	8	5	9	1	9	9	3	1	9	5	5	9	1	5	3	8	3	9	7	9	3
Size and Complexity	Duration	Z59	9	9	3	1	3	3	1	1	3	3	3	7	5	5	3	7	9	1	1	1	5	2	3	3	9
	Organizational Culture	Z60	9	9	7	3	5	5	1	3	5	5	7	3	7	5	5	5	9	5	5	4	7	5	5	5	7
	Environmental Factors	Z61	5	5	9	5	7	7	1	3	7	7	5	7	9	5	9	3	7	3	3	5	5	7	7	7	5
	Location Factors	Z62	5	5	7	3	5	5	1	1	5	5	5	7	7	3	5	5	7	5	5	5	7	5	5	5	1
	Social Responsibility	Z63	1	5	7	3	5	5	9	1	5	5	9	1	7	5	5	3	3	7	7	6	7	5	5	5	5
	Political Factors	Z64	1	5	8	8	8	7	9	1	7	7	5	1	9	5	7	7	5	3	5	8	9	8	7	7	9
Duration	Organizational Culture	Z65	7	5	5	3	3	5	1	1	5	3	7	3	3	7	3	3	9	5	5	4	5	3	4	3	9
	Environmental Factors	Z66	9	5	6	7	5	7	1	3	7	7	5	5	7	5	5	5	7	3	3	7	7	7	5	7	7
	Location Factors	Z67	9	7	7	5	3	5	1	3	7	5	5	5	5	5	3	5	9	5	7	7	5	5	5	3	9
	Social Responsibility	Z68	5	7	7	5	3	5	1	3	5	5	7	1	5	5	3	5	7	7	7	6	7	3	5	3	1
	Political Factors	Z69	7	7	9	9	7	9	1	3	7	7	5	1	7	7	7	9	5	5	3	7	5	7	7	7	9
Organizational Culture	Environmental Factors	Z70	5	3	3	3	3	5	1	7	3	1	7	1	5	7	3	3	1	1	1	8	3	3	3	5	5
	Location Factors	Z71	5	3	1	1	1	3	3	7	1	1	7	1	3	7	1	3	3	3	5	3	3	1	3	3	7
	Social Responsibility	Z72	5	3	1	1	1	1	1	7	3	1	7	1	3	7	3	3	3	1	3	7	7	3	3	3	9
	Political Factors	Z73	5	3	5	3	7	7	1	7	6	3	5	1	7	7	5	9	7	1	1	8	9	5	5	7	7
Environmental Factors	Location Factors	Z74	9	9	1	0.33	0.2	1	1	7	1	1	7	7	1	1	1	5	7	5	7	1	7	1	1	1	9
	Social Responsibility	Z75	1	9	1	1	0.33	1	9	7	1	1	7	1	1	3	1	5	3	3	3	4	7	1	1	1	1
	Political Factors	Z76	9	9	5	2	5	3	9	7	2	3	5	1	5	3	1	9	7	1	3	8	9	2	3	3	5
Location Factors	Social Responsibility	Z77	9	7	3	2	1	1	9	1	1	1	7	1	3	3	1	5	5	1	3	3	7	1	1	3	7
	Political Factors	Z78	9	7	5	4	3	5	1	1	5	3	5	1	5	3	3	5	7	1	1	8	0.14	3	5	5	5
Social Responsibility	Political Factors	Z79	9	7	5	1	1	1	1	5	3	3	5	5	7	3	1	9	9	3	3	3	9	1	1	3	3

Respondents Response (51-78)																														
`		Coding	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
Profit	Risk	A	1	5	9	1	9	3	5	0.33	3	1	9	3	1	5	3	3	3	3	3	1	9	3	0.33	9	5	5	3	1
	Measure of Worth	B	5	1	1	1	1	3	1	0.33	1	1	3	1	1	3	1	1	1	3	1	9	1	1	0.33	7	3	1	5	3
	Financial Standing	C	7	3	3	1	1	3	1	0.2	1	1	7	3	1	3	1	5	3	0.2	1	1	5	1	1	7	3	9	3	5
	Resource	D	7	5	3	3	1	1	2	1	3	3	5	5	1	5	3	5	5	5	3	1	1	1	1	9	3	7	5	7
	Economic Factors	E	5	5	7	5	1	1	5	1	5	0.33	7	7	1	5	5	7	7	3	5	9	5	5	1	5	5	9	7	7
	Experience	F	9	5	9	5	1	1	5	1	5	5	5	5	5	3	5	5	5	7	5	5	5	3	1	9	7	3	5	9
	Technical Ability	G	5	1	1	3	1	1	3	1	5	2	1	1	1	5	5	3	1	7	3	9	3	3	1	5	5	3	5	7
	Size and Complexity	H	5	3	3	3	1	1	3	1	5	4	5	3	7	3	5	1	3	3	3	7	7	3	1	3	5	9	5	7
	Duration	I	7	1	3	3	1	3	5	3	7	7	1	1	9	4	7	1	3	3	5	7	3	5	3	9	7	5	7	5
	Organizational Culture	J	7	9	7	5	3	1	7	5	9	9	9	5	7	7	7	9	9	3	7	9	1	7	5	2	9	5	6	9
	Environmental Factors	K	3	1	9	7	7	1	8	5	7	9	5	3	3	9	9	3	3	5	9	9	3	7	7	2	9	5	8	7
	Location Factors	L	1	7	9	5	5	1	7	3	7	9	9	5	2	5	7	7	7	5	7	7	5	7	5	9	9	7	9	9
	Social Responsibility	M	5	9	7	7	5	1	5	3	9	9	9	7	2	5	7	9	9	3	7	9	3	5	5	5	9	1	9	5
	Political Factors	N	5	7	7	9	9	1	7	5	9	7	7	3	1	7	9	5	5	7	9	1	5	7	7	3	9	9	9	7
Risk	Measure of Worth	O	3	1	7	1	1	1	1	0.2	1	3	1	1	1	1	1	1	1	3	1	9	5	1	1	7	1	1	1	9
	Financial Standing	P	5	3	5	1	1	7	1	1	1	2	3	3	1	1	1	4	1	1	1	4	7	1	1	9	1	9	1	9
	Resource	Q	3	3	5	3	1	1	1	1	1	3	5	3	1	1	1	5	3	3	3	7	5	1	3	7	1	3	1	3
	Economic Factors	R	3	1	7	5	1	7	3	3	3	9	7	5	0.33	2	3	5	5	5	5	9	3	3	3	5	4	7	5	5
	Experience	S	7	3	7	5	3	5	2	1	1	7	5	3	1	3	5	5	3	5	3	7	3	3	3	9	3	5	5	9
	Technical Ability	T	5	1	1	3	7	7	2	1	1	7	1	1	1	1	5	1	1	5	3	1	7	3	1	9	3	7	5	7
	Size and Complexity	U	5	3	5	3	7	7	3	1	3	1	3	1	2	3	5	3	3	3	4	9	9	3	1	7	3	3	4	7
	Duration	V	5	1	1	5	3	7	4	3	5	5	3	3	7	5	7	1	1	1	5	9	5	5	5	9	7	9	6	3
	Organizational Culture	W	7	7	7	7	1	7	5	5	7	7	9	7	4	7	7	7	7	5	7	7	3	7	5	5	9	7	7	9
	Environmental Factors	X	3	1	7	9	3	1	7	7	9	8	3	5	1	9	9	5	5	3	9	9	3	7	7	7	9	1	9	7
	Location Factors	Y	3	5	9	7	7	3	7	3	7	7	9	7	1	7	7	7	7	7	7	3	5	7	5	7	6	5	7	5
	Social Responsibility	Z	7	9	5	5	6	7	5	3	7	6	9	9	1	5	7	5	9	3	9	9	3	5	5	9	6	3	9	5
	Political Factors	Z1	1	7	5	9	3	7	9	7	9	8	7	3	1	7	7	3	5	1	9	1	5	7	7	5	9	1	9	7
Measure of Worth	Financial Standing	Z2	3	1	7	1	3	7	2	0.33	1	1	1	1	1	1	1	1	3	3	1	7	9	1	1	9	1	1	1	9
	Resource	Z3	5	3	5	3	3	5	3	2	3	2	3	3	3	2	3	5	5	5	3	1	5	1	3	9	3	3	3	9
	Economic Factors	Z4	7	5	9	5	7	3	4	3	5	3	5	5	3	3	5	3	5	1	5	9	9	3	3	5	5	3	5	1
	Experience	Z5	7	5	1	5	9	7	5	1	5	5	5	5	7	3	5	3	3	3	5	9	5	3	1	5	5	9	3	5
	Technical Ability	Z6	5	1	5	3	9	3	2	1	5	3	1	3	1	5	5	1	1	5	5	1	5	3	0.33	7	5	7	3	7
	Size and Complexity	Z7	3	1	3	3	9	5	3	1	5	7	3	1	7	3	5	3	3	5	4	7	7	3	0.33	3	5	7	5	9
	Duration	Z8	3	1	9	5	9	5	5	3	7	9	1	7	9	5	7	7	1	7	4	7	5	5	3	5	7	9	5	7
	Organizational Culture	Z9	7	9	9	7	7	5	5	5	7	9	5	7	4	7	7	3	7	5	7	9	3	7	5	3	8	3	7	5
	Environmental Factors	Z10	5	1	1	7	9	1	7	7	9	8	3	3	5	9	9	3	3	3	9	9	5	9	7	1	8	7	9	7
	Location Factors	Z11	1	3	7	5	9	7	5	5	9	5	9	7	7	7	7	9	7	3	5	6	5	7	5	1	6	9	7	9
	Social Responsibility	Z12	7	9	9	5	1	7	5	5	9	6	9	9	6	9	7	9	9	3	9	9	3	7	5	3	8	5	7	7
	Political Factors	Z13	1	9	9	9	5	7	7	5	9	7	7	5	1	9	9	7	7	3	9	2	5	9	9	7	8	9	9	7
Financial Standing	Resource	Z14	9	1	7	1	1	1	3	3	1	1	5	5	5	2	3	3	1	1	1	9	7	1	3	7	3	3	3	9
	Economic Factors	Z15	7	5	9	3	1	5	5	3	3	3	7	3	3	3	3	5	3	3	3	9	7	3	3	5	5	3	5	7
	Experience	Z16	5	5	1	3	1	1	3	1	5	9	3	1	7	3	5	5	1	5	3	9	5	3	3	5	4	5	5	5
	Technical Ability	Z17	5	1	1	3	1	3	2	1	5	3	1	1	1	1	3	1	1	5	3	7	7	3	1	5	4	5	5	7
	Size and Complexity	Z18	5	1	1	1	5	1	5	1	5	3	3	1	7	2	3	1	1	5	5	9	7	5	1	3	3	3	5	7
	Duration	Z19	3	1	7	5	7	1	5	5	7	5	1	3	9	5	5	1	1	7	7	9	7	5	3	7	6	7	7	5
	Organizational Culture	Z20	7	7	5	5	3	1	7	6	7	7	9	7	7	5	7	9	7	3	7	9	5	5	5	2	7	3	7	7
	Environmental Factors	Z21	3	5	9	7	1	7	5	8	9	5	3	3	5	7	9	7	3	7	9	9	5	7	7	6	9	5	9	5
	Location Factors	Z22	3	7	9	5	3	7	5	7	7	7	9	5	7	5	7	9	7	3	9	9	3	5	5	4	4	7	8	7
	Social Responsibility	Z23	7	7	7	5	1	7	4	3	7	6	7	7	6	3	5	9	5	5	7	9	5	5	7	7	6	3	8	7
	Political Factors	Z24	1	7	9	7	1	7	7	9	9	5	7	3	3	7	7	3	3	3	9	1	7	7	9	8	9	5	9	5
Resource	Economic Factors	Z25	7	1	5	1	1	5	3	1	3	3	3	3	1	1	3	3	3	3	3	4	7	3	1	9	3	5	3	9
	Experience	Z26	7	1	3	1	5	1	2	3	5	5	1	1	2	3	5	1	1	5	3	7	9	3	1	7	3	7	3	5
	Technical Ability	Z27	7	1	1	1	5	1	1	1	3	7	1	1	1	1	3	1	1	5	3	3	7	1	1	7	3	7	3	5
	Size and Complexity	Z28	5	1	5	1	7	1	1	4	5	5	3	3	5	1	3	1	1	7	3	7	5	1	0.33	5	3	3	3	9
	Duration	Z29	3	1	1	3	7	5	5	5	5	3	1	1	3	5	5	1	3	0.33	5	9	3	3	1	9	7	9	6	3
	Organizational Culture	Z30	7	2	9	5	3	1	7	5	7	5	9	5	3	5	5	7	7	5	6	5	3	5	5	5	8	1	9	9
	Environmental Factors	Z31	5	3	3	7	1	5	8	7	9	9	3	3	2	7	9	3	3	1	9	9	5	7	7	5	9	3	9	7
	Location Factors	Z32	3	7	7	5	1	5	7	5	9	9	7	5	7	5	7	9	7	1	7	9	7	5	5	3	6	5	7	7
	Social Responsibility	Z33	7	7	9	5	1	7	3	5	7	1	7	7	8	3	5	9	7	1	7	9	5	5	5	1	6	1	7	5
	Political Factors	Z34	3	7	9	9	1	7	7	7	9	3	5	3	1	7	7	5	5	5	9	2	7	9	7	3	8	1	9	5

			Respondents Response (51-78)																												
		Coding	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
Economic Factors	Experience	Z35	7	1	1	1	7	1	2	3	3	5	1	1	7	3	3	1	1	3	3	1	7	1	3	5	3	1	1	5
	Technical Ability	Z36	5	1	1	1	9	1	1	1	5	3	1	1	1	1	1	1	1	3	3	3	7	1	1	5	3	3	3	5
	Size and Complexity	Z37	5	1	3	1	5	1	2	1	5	2	1	3	3	2	1	1	1	3	3	3	5	1	1	7	3	3	3	7
	Duration	Z38	3	1	1	3	5	1	5	6	7	7	1	1	7	3	3	1	1	3	5	5	5	3	3	7	4	5	5	5
	Organizational Culture	Z39	7	7	7	5	7	1	7	7	7	3	7	7	8	5	5	9	5	3	7	1	3	5	5	9	7	3	8	7
	Environmental Factors	Z40	5	3	5	7	1	1	7	7	9	9	3	3	3	7	7	3	3	3	9	9	5	7	5	9	9	1	9	7
	Location Factors	Z41	3	7	7	5	3	1	7	5	7	3	7	9	5	5	5	7	5	3	7	7	7	5	5	9	7	7	8	5
	Social Responsibility	Z42	7	9	9	5	1	1	7	5	7	3	9	7	3	9	3	9	7	3	7	9	5	5	5	5	6	7	8	5
	Political Factors	Z43	1	5	7	7	3	1	7	9	7	7	5	3	1	9	7	5	5	3	9	1	7	7	7	9	9	5	9	9
Experience	Technical Ability	Z44	7	1	1	3	1	1	2	1	1	1	1	1	1	1	1	1	1	7	1	9	7	1	0.33	9	1	9	1	9
	Size and Complexity	Z45	5	1	3	1	3	1	3	1	1	3	1	3	2	1	1	1	1	7	1	9	9	1	0.33	7	1	7	1	7
	Duration	Z46	7	1	1	1	1	1	5	3	3	7	3	3	9	2	1	3	1	3	3	9	5	3	1	5	3	7	3	5
	Organizational Culture	Z47	9	9	9	7	1	1	7	6	5	2	7	7	5	5	5	7	5	3	5	7	3	3	3	9	6	5	5	7
	Environmental Factors	Z48	3	3	1	7	1	5	9	9	7	7	3	3	2	7	7	5	3	3	7	9	5	5	5	7	8	5	7	5
	Location Factors	Z49	1	7	7	5	1	5	7	7	5	9	9	5	1	5	5	7	5	3	6	3	7	3	3	9	6	3	6	7
	Social Responsibility	Z50	7	9	9	5	1	7	5	7	5	7	7	9	1	3	5	9	5	5	8	9	3	3	3	9	8	3	6	5
	Political Factors	Z51	1	5	9	7	1	7	7	9	7	9	7	3	1	9	7	5	3	5	9	1	5	5	5	5	9	1	8	7
Technical Ability	Size and Complexity	Z52	5	3	1	1	3	1	1	1	1	3	1	1	7	1	1	3	3	7	1	7	9	1	1	7	3	9	3	9
	Duration	Z53	7	3	1	3	5	7	4	2	3	7	1	1	9	3	3	1	1	5	3	9	5	3	3	3	4	9	6	5
	Organizational Culture	Z54	7	7	7	5	5	1	5	5	5	5	9	7	5	5	5	7	5	7	5	7	5	5	5	7	7	5	8	7
	Environmental Factors	Z55	7	3	3	7	1	7	7	7	7	9	3	9	3	6	7	3	3	3	7	9	5	7	5	5	7	3	9	7
	Location Factors	Z56	7	7	9	5	3	7	5	3	5	9	9	9	3	5	5	9	5	3	7	5	3	7	5	9	7	3	9	5
	Social Responsibility	Z57	9	9	9	5	1	7	5	5	7	9	9	7	5	3	3	7	7	3	8	9	3	7	5	9	6	3	8	7
	Political Factors	Z58	3	7	9	9	3	7	9	7	9	9	7	2	3	7	5	5	5	3	9	1	5	9	7	9	9	1	9	5
Size and Complexity	Duration	Z59	3	1	1	3	1	5	4	3	3	5	1	1	2	2	3	1	1	3	3	9	9	3	3	9	3	5	3	5
	Organizational Culture	Z60	7	9	7	3	1	1	5	4	5	3	7	5	1	5	5	9	5	7	5	9	4	5	5	5	5	3	7	7
	Environmental Factors	Z61	5	3	1	5	1	1	3	7	7	7	3	1	3	7	7	3	3	3	7	9	7	7	7	9	8	3	9	5
	Location Factors	Z62	5	4	7	3	1	1	3	5	5	5	9	5	1	5	5	7	5	3	5	7	7	7	5	9	7	5	7	7
	Social Responsibility	Z63	9	9	5	3	1	5	5	5	5	9	9	9	1	5	5	9	5	3	5	9	5	5	3	1	8	1	7	5
	Political Factors	Z64	5	5	9	7	1	5	7	7	7	2	7	7	1	7	7	5	3	5	7	1	5	7	7	1	9	1	8	5
Duration	Organizational Culture	Z65	7	9	7	5	1	1	3	4	3	5	9	9	1	4	5	9	5	3	4	7	5	3	3	7	3	5	5	7
	Environmental Factors	Z66	5	1	1	7	1	1	6	7	5	7	3	3	1	7	7	5	3	3	7	9	7	5	5	7	7	7	7	5
	Location Factors	Z67	5	7	5	5	1	1	7	3	3	3	7	7	3	5	5	7	5	5	5	7	9	5	3	7	5	7	5	7
	Social Responsibility	Z68	7	9	7	5	1	5	5	3	5	9	9	9	1	5	5	7	5	3	7	9	5	3	3	5	7	3	5	5
	Political Factors	Z69	5	5	7	9	1	5	7	7	7	9	5	9	1	7	9	3	3	3	8	1	7	7	5	7	9	9	7	5
Organizational Culture	Environmental Factors	Z70	7	1	1	7	1	5	3	3	5	9	3	1	1	5	5	1	1	3	3	9	5	3	3	9	5	1	1	5
	Location Factors	Z71	7	3	3	5	1	5	3	1	3	7	5	3	1	3	3	3	3	3	1	5	7	3	1	7	3	3	1	7
	Social Responsibility	Z72	7	7	1	5	1	5	1	1	3	9	3	5	1	3	1	3	5	3	3	9	5	1	1	9	3	3	1	7
	Political Factors	Z73	5	9	1	7	1	5	5	5	7	9	1	3	1	5	7	1	3	3	5	1	7	5	5	7	7	1	5	5
Environmental Factors	Location Factors	Z74	7	7	5	1	7	1	2	1	3	7	1	7	3	3	1	5	3	1	1	1	3	1	0.33	9	1	7	1	7
	Social Responsibility	Z75	7	9	7	1	1	1	1	1	3	3	3	5	1	2	1	3	3	1	1	7	5	1	1	5	1	3	1	5
	Political Factors	Z76	5	5	5	3	3	5	3	3	5	3	5	3	1	4	3	3	1	1	3	2	7	3	3	5	3	1	3	7
Location Factors	Social Responsibility	Z77	7	5	3	1	1	1	1	3	3	3	3	1	1	3	1	1	5	1	5	9	4	1	1	5	3	3	3	7
	Political Factors	Z78	5	3	5	3	1	1	3	5	5	5	1	1	1	7	5	1	3	3	6	2	3	3	3	5	5	7	3	5
Social Responsibility	Political Factors	Z79	5	1	1	3	5	1	1	3	5	5	3	3	1	5	1	1	1	3	5	2	6	5	1	7	3	7	3	5