Application of Multi Criteria Decision Making As an Alternative of Project Selection in The Case of Adama City Public Projects

Sifen Tilahun Negera

A thesis Submitted to the department of Civil Engineering for the Partial Fulfillment of The Requirement for The Degree of Masters

(Specialization in Construction Engineering and Management)

School of Civil Engineering and Architecture

Office of Graduate Studies

Adama Science and Technology University

November, 2024

Adama, Ethiopia

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Declaration

I hereby declare that this Master Thesis entitled "**Application of Multi criteria decision making as an alternative of project selection in the case of Adama city public projects**" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this Thesis have been duly acknowledged through citation.

Sifen Tilahun Negera		
Name of student	Signature	Date

Recommendation

I, the advisor of this Master Thesis, hereby certify that I have read the revised version of the Thesis entitled **“Application of Multi criteria decision making as an alternative of project selection in the case of Adama city public projects’”** prepared under my guidance by **Sifen Tilahun Negera** submitted in partial fulfillment of the requirements for the degree of Masters of Science in **Construction Engineering Management.** Therefore, I recommend the submission of a revised version of the Thesis to the department following the applicable procedures.

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Approval Sheet

I, the advisor of the Thesis entitled **"Application of Multi criteria decision making as an alternative of project selection in the case of Adama city public projects"** developed by **Sifen Tilahun Negera,** hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis

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We, the undersigned, members of the Board of Reviewers of the Thesis by **Sifen Tilahun Negera** have read and evaluated the Thesis entitled "**Application of Multi criteria decision making as an alternative of project selection in the case of Adama city public projects"** and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in **Construction Engineering Management.**

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List of Acronyms and Abbreviations

AHP:	Analytic Hierarchy Process
ANP:	Analytic Network Process
B/C:	Benefit to Cost Ratio
CI:	Consistency Index
CR:	Consistency Ratio
DCF:	Discounted cash flow
DCFROR:	Discounted Cash Flow Rate of Return
EC:	Ethiopian calendar
EIRR:	Economic Internal Rate of Return
ETB:	Ethiopian Birr
FIRR:	Financial Internal Rate of Return
FNPV:	Financial Net Present Value
FY:	Fiscal Year
GP:	Goal Programming
ILP:	Integer Linear Programming
IRR:	Internal Rate of Return
LP:	Linear Programming
MADM:	Multi Attribute Decision Model
MCA:	Multi-Criteria Analysis
MCDM:	Multi-Criteria Decision Making
MILP:	Mixed Integer Linear Programming
R.I:	Random Index

Abstract

Resources for pursuing and funding new projects are limited, which presents a challenge in prioritizing, selecting, and allocating optimally. Ethiopian public projects have faced difficulties in selecting the best projects, finishing on time, and within budget. The city Adama is one of a rapidly growing city with an extensive development plan aimed at modernizing the city. 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. . The aim of this study is to identify and provide a simple frame work for the criteria that make the most use of resources by weighing multiple decision criteria. An Analytic Hierarchy Process is applied that considers both quantitative and qualitative factors in choosing capital project in Adama city Adminstration. Research surveys were conducted in the representative organizations and secondary documents were used for the analysis Among the three basic categorical factors related to project characteristics are weighted 0.5; related to owner (firm) characteristics are 0.33, and related to external factors are weighted only 0.17 The study shows that the most important project selection sub-criteria found to be project risk, measure of worth, profit, financial standing, and resources with the overall weight of 0.16, 0.12, 0.11, 0.08 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, 0.06, 0.06, 0.05, 0.03, 0.03, 0.03, 0.03, and 0.02. Four projects out of five gravel road 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 help them make challenging decisions. The integrated model is recommended for its ability to capture all possible factors, optimality advantage and applicability in different situations with optimizing the selection criteria.

Key words: analytic hierarchy process, Linear programming, Multi criteria Decision Making, Project appraisal, Resource constraint

CHAPTER ONE

1 INTRODUCTION

1.1 Background

Realization of construction projects is usually long term process which requests significant financial, material, human and other resources to fulfill contracted obligations and achieve a good quality of works. Therefore, making good decisions with the satisfaction of various criteria is one of the main conditions to achieve planed business objectives and finish the project in contracted time with good quality Resources are limited for pursuing and funding new projects hence the challenge is to prioritize, select and allocate optimally. 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.

The construction sector is a vital part of Ethiopia's economy, being the second-largest employment generator after agriculture. The government has invested heavily in both mega and smaller-scale projects to stimulate economic growth, improve infrastructure, and create jobs. The construction market is projected to grow at an annual average growth rate of over 8% from 2025 to 2028, indicating robust future development prospects in various sectors, including infrastructure, residential, and commercial construction Tesfahunegn (1999).

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. 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 Ambaw (June, 2022).

With increased demand for public work projects, there is a need to focus on efficiency of construction project services. Over the last decades, quantitative capital budgeting techniques those provide the highest return over a given period of time have been employed to select projects. 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. Qualitative factors include organizational culture, experience, and project location, political and economic environment. 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.

1.2 Statement of the Problem

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. studies including Shiferaw, Klakegg, and Haavaldsen (2012) 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.

Adama, one of the economic centers in the rift valley, is implementing a new spatial master plan for the coming decade. The city public projects should encounter a modern approach in selecting best projects, finishing in time and cost. The construction project selection methods applied in the city Administration are quantitative in nature applying the easy to implement and highly profitable projects to be given precedence, in which it lacks to account other intangible factors that can affect the results of project assessments. Additionally, they cannot undertake all projects concurrently due to limited resources and other constraints

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 I. C. Ehie, Oyatoye, Joseph, and Management (2016).

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 Kengatharan and management (2018). 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. The selection of proper construction projects can be defined as a Multi-Criteria Decision Making (MCDM) problem as multi-criteria with different weights will be used. Hence, in order to overcome the challenges, multi-criteria decision-making methods were proposed to select the proper projects by ranking the alternatives and to use constrained linear optimization for available budgeting considering serious shortage of finance. Studies showed that MCDM methods have been successfully applied to the infrastructure project selection problems.

1.3 Objectives

1.3.1. General Objective

The overall objective is to develop the application 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 develop project selection decision making process by providing simple hierarchical prioritizing framework.
- To apply the use of multi-criteria decision-making method through combined approaches of Analytic Hierarchy Process and Linear Programming in Adama city administration for effective & efficient public projects selection.

1.4 Research Questions

- How is a frame work developed for project selection decision making?
- How is multi-criteria decision-making method through combined approaches of Analytic Hierarchy Process and Linear Programming used in Adama city administration for effective & efficient public projects selection?

1.5 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 criteria of particular projects

1.6 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 public projects selection. Questionnaires from under study organization experts are used for prioritizing literature reviewed project selection criteria in AHP; project selection criteria is applied on multiple previous public projects from Adama city Administration office with different features which are used in LP analysis.

CHAPTER TWO

2 LITERATURE REVIEW

2.1. 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 (Institute, 2008).

The proclamation No.1210/2020, 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"(Gazette, 2020)

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 (Shiferaw et al., 2012). According to their study, some 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 (Shiferaw et al., 2012).

2.2. Project Selection

Projects are considered the building blocks in the planning and execution of organizational strategies. 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. 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 Institute (2008).

Project selection is a critical process for construction companies, ensuring that they undertake projects that align with their strategic objectives and maximize performance. Key criteria for evaluating projects include alignment with strategic goals, profitability and return on investment (ROI), risk assessment, and resource availability. The selection process typically involves initial screening based on high-level criteria, followed by detailed evaluation, including financial analysis and risk identification, leading to the final selection of the most promising projects. Companies that adopt a disciplined project selection approach benefit from improved financial performance, strategic alignment, efficient resource utilization, and enhanced project delivery outcomes. By developing a structured selection process grounded in clear criteria and past experiences, construction firms can significantly increase their chances of success in a competitive industry.(Bageis & Alsulamy, 2021)

In construction, this process often employs methods like cost-benefit analysis and multi-criteria decision-making to assess the feasibility and impact of each project option. Additionally, stakeholder involvement is crucial; engaging local communities and decision-makers can provide valuable insights into project viability and priority. Ultimately, a well-structured project selection process leads to better planning, improved financial performance, and successful project delivery that meets both client expectations and regulatory requirements (Bageis & Alsulamy, 2021).

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 (Tahri, 2015).

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” Institute (2008).

Portfolio categorization, evaluation, prioritization and selection are essential processes for portfolio management and plays important roles in efforts to accomplish organizational strategic goals. Puthamont and Charoenngam (2007)

According to Tahri (2015) 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.

Project selection is a critical process for construction companies, ensuring that they undertake projects that align with their strategic objectives and maximize performance. Key criteria for evaluating projects include alignment with strategic goals, profitability and return on investment (ROI), risk assessment, and resource availability. The selection process typically involves initial screening based on high-level criteria, followed by detailed evaluation, including financial analysis and risk identification, leading to the final selection of the most promising projects. Companies that adopt a disciplined project selection approach benefit from improved financial performance, strategic alignment, efficient resource utilization, and enhanced project delivery outcomes. By developing a structured selection process grounded in clear criteria and past experiences, construction firms can significantly increase their chances of success in a competitive industry (Pekuri et al., 2015).

2.3. 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 I. Ehie, Oyatoye, and Joseph (2016).

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 including project selection decision modeling Baker and English (2011).

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 Ye, Chen, Li, Li, and Yin (2022) 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(Caballero, Chopra, & Schmidt, 2018)

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(Caballero et al., 2018).

Organizations now rely on projects as an important competitive factor for implementation strategies. According to Unuafe (2017)“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.

The combined AHP and LP approach has been used in researches done byGhodsypour and O'Brien (1998), Thomas L Saaty (2001), (Ambaw, June, 2022) and (Li & Ma, 2007) in which they applied in supplier selection, resource allocation, Road project selection and subcontractor selection respectively. The three studies by (Ghodsypour & O'Brien, 1998), (Thomas L Saaty, 2001), (Ambaw, June, 2022) used the weightings from AHP then constructed a LP model to select the best option. while, (Li & Ma, 2007) constructed a LP model first and Following that, the AHP was used to evaluate the relative performance of the subcontractors and capacity was allocated to the subcontractors with higher AHP weightings in advance.

2.4. Construction Projects Selection

The construction projects cannot be undertaken all 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. 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 Ambaw (June, 2022).

Using multi-criteria decision-making for the public selection project in Adama offers several benefits. One advantage is the ability to recognize the context of each criterion, allowing for a more tailored and context-specific ranking of projects by assigning weights to sub-criteria. This approach can lead to a more accurate and relevant assessment of the project's needs and potential outcomes. Additionally, multi-criteria decision-making methods, such as the Analytic Hierarchy Process (AHP), are capable of handling small sample sizes, which can be beneficial for city public projects that may have limited historical data or precedent.

Furthermore, the use of multi-criteria decision-making can help in developing a sustainable framework, which is crucial for the long-term success and impact of the project. Overall, the application of multi-criteria decision-making methods can lead to more informed and effective decision-making, ultimately contributing to the success of the public project in Adama.

Table 2-1 different selection methods with their advantage and disadvantages (Unuafe, 2017)

Selection Methods	**advantages**	**disadvantages**
Financial Investment Analysis: NPV, ROI, DCFs, payback period 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	Tends to sacrifice some factors for others whenever there are conflicting factors
Linear programming	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 various alternatives generated which in turn helps in judicious allocation of resources.	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.
		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

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	Not appropriate in deprecatory resource restriction conditions
	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.	
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.	Requires top management time and commitment
	Permits the application of diverse criteria for different strategic sets of projects	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.	Unsuccessful in delivering the most financially beneficial set of projects
	Stimulates better administrative participation into the project selection process	Does not take risk into consideration while selecting projects

Source (Unuafe, 2017)

2.5 Adama city public projects

Adama City, one of the business hubs in the rift valley, will implement a new spatial master plan for the coming decade for 11 million Br. The new plan will replace the existing one designed 13 years back. The Oromia Regional Urban Planning Institute designed the master plan after being contracted by the City Administration. The Institute formed a team of 54 individuals for the Plan which took seven months to design. The Plan is expected to solve the problems related to land management, facilitate the expansion of basic public infrastructure and administer slum and shanty areas in the town (fortune, 2018).
Adama City is currently undergoing several significant construction projects aimed at enhancing its infrastructure and services. The latest projects include: Adama City Asphalt Road Project: This project has successfully completed the construction of Hot Mix Asphalt Concrete roads, greatly improving the road infrastructure in Adama City, ensuring durability and better transportation options for residents. Adama II 230 KV Substation Construction.; This project is designed to supply power to the Adama Industry Park and strengthen the electricity delivery system to Adama town and nearby industries, thereby supporting economic growth in the region. Adama Town Water Supply Project: Ongoing efforts are focused on improving water supply systems in Adama. Recent site visits by officials have highlighted significant progress in this project, which aims to enhance access to clean water for the local population. Construction of Asphalt Road from ETUR Textile to Wonji; The Adama City Administration has invited bids for this new asphalt road project, which is expected to take approximately 540 days to complete. This initiative reflects the city's commitment to expanding its road network. These projects collectively aim to bolster Adama City's infrastructure, improve living conditions, and support local economic development (Ozlu et al., 2015).

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

2.6.1 Analytic Hierarchy Process (AHP)

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. AHP, developed in the early 1970s, is capable of catering to both quantitative and qualitative factors. AHP involves structuring multiple criteria into a hierarchy, assessing the relative importance of these criteria, comparing alternatives for each criterion, and determining an overall ranking of the alternatives (Nandi, Paul, & Phadtare, 2017).

According (T. Saaty, 1980), 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.

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.(Mu, Pereyra-Rojas, Mu, & Pereyra-Rojas, 2018)

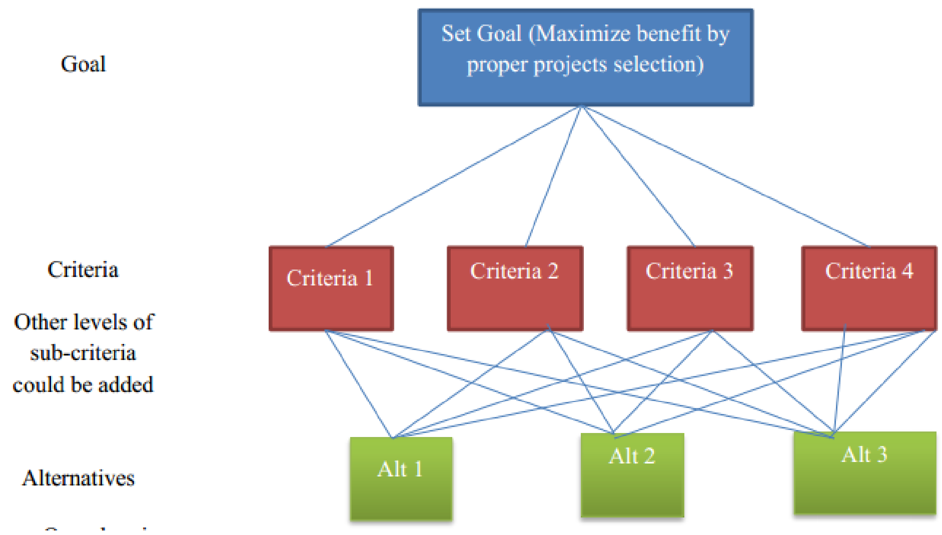
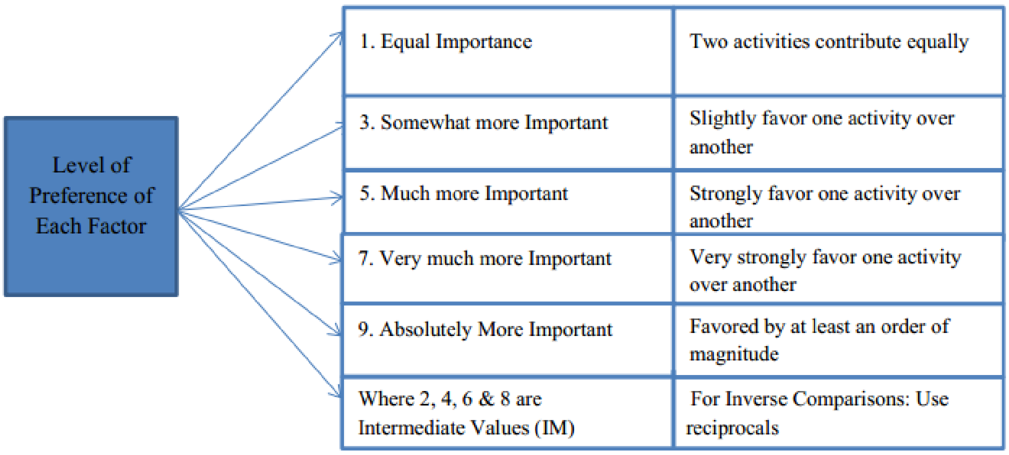


Figure 2.1 example of hierarchy structure Ambaw (June, 2022)

Source: from Ambaw (June, 2022)

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: from (Thomas L. Saaty, 2004)

Figure 2-2 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 (Dalalah, Al-Oqla, Hayajneh, & Engineering, 2010)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 Dalalah et al. (2010),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. The 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.

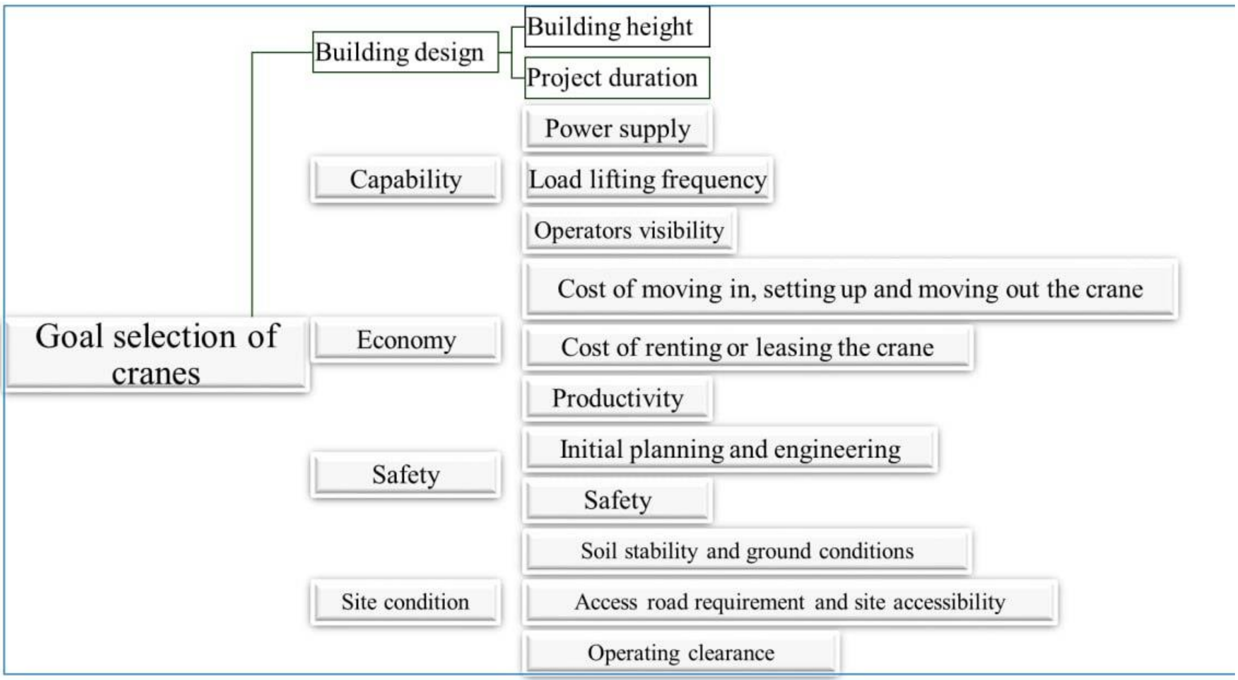


Figure 2-3 Example: AHP crane selection hierarchy

Source: from (Dalalah et al., 2010).

As shown in the figure 2.3, 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 I. C. Ehie et al. (2016) 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.

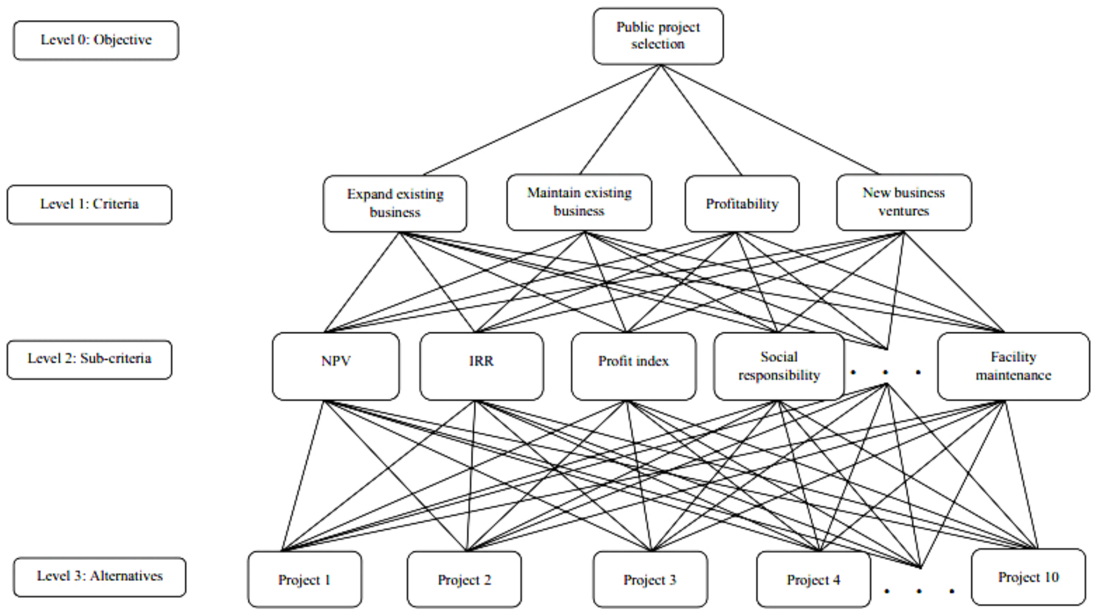


Figure 2-4. The hierarchical structure of the AHP model;

Source: from (I. Ehie et al., 2016)

2.6.2 Linear programming

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 five gravel 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.

Linear programming is a mathematical method used in project selection to determine the optimal solution for a problem by minimizing or maximizing a linear function under linear equality and inequality constraints. Linear programming is a constrained optimization method for project selection that is used to select the project with the least risk and maximum profitability. It is widely used in various industries to make informed decisions and optimize resource allocation (Pérez-Canedo, Verdegay, & Engineering, 2023).

The following points shows the procedures of the (Anyaeche & Okwara, 2011) 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, and 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 (Anyaeche & Okwara, 2011);

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:

Xi = { 1. If project i is selected or included in the portfolio

0, if otherwise

Where $i = 1 \ldots N$

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

Objective Function: the objective function is expressed thus:

$$\sum_{i=1}^{N} aiXi$$

Where;

Z is the value function to be optimized (maximized)

Xi is 1 or 0 depending in weather project i is selected or not

ai 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

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

Where:

N = the total number of projects being included Ci= 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.

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.

The combined AHP and LP research approach is a method to prioritize construction Projects selection criteria under some constraints. According to Abanda et al. (2022) research indication, 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 Abanda et al. (2022), 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.

The study by Pangsri (2015) titled, 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.

Study by Puthamont and Charoenngam (2007) applied AHP to investigate factors influencing the three stages of the military construction project selection process in Thailand. Roodposhti, Rahimi, and Beglou (2014)utilized AHP and fuzzy set theory.de Almeida Guimarães, Junior, and da Silva (2018) used AHP and Monte Carlo Simulation to rank transportation projects. Lee and Kim (2001) presented an integrated approach for interdependent information system (IS) project selection problems by using the Delphi method and Analytic Network Process (ANP). Although these previous studies used AHP and/or ANP in the selection decision, they did not use optimization techniques (such as linear programming) in order to optimize the selection decision (i.e. that is subject to budget constraints).

The research I. C. Ehie et al. (2016) 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.

2.7. Summary of Literature

Different 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 project selections and prioritization to meet project objectives under constrained resource envelope.

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

The use of AHP integrated with other approaches has been studied by different researchers in a variety of Areas. The most common way of using AHP in their research is to find the criteria weights and then using those values in the integrated tool to select the best available option with budget restrictions. The combined AHP and LP approach has been used in researches done by Ghodsypour and O'Brien (1998), Saaty et al. (2003), Ambaw, (2022) and Lee and Hsu (2004) in which they applied in supplier selection, resource allocation, Road project selection and subcontractor selection respectively. The three studies by Ghodsypour and O'Brien (1998), Saaty et al. (2003) and Ambaw, (2022) used the weightings from AHP then constructed a LP model to select the best option. While, Lee and Hsu (2004) constructed a LP model first and following that, the AHP was used to evaluate the relative performance of the subcontractors and capacity was allocated to the subcontractors with higher AHP weightings in advance.

2.8 Research gap

The research gap lies in the lack of studies focusing on the application of multi-criteria decision-making (MCDM) models for the selection of public projects at the city level. Existing research tends to concentrate on specific technologies, infrastructure, or aspects of urban life, rather than addressing the broader challenges and opportunities associated with the selection of public projects at the city level. 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 or 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.

CHAPTER THREE

3 **RESEARCH METHODOLOGY**

3.1. Study Area

The study area selected for this particular study is Adama, Ethiopia. Adama has 6 sub cities, located at 8°32′N 39°16′E / 8.54°N 39.27°E / 8.54; 39.27 at an elevation of 1712 meters, 99 km southeast of Addis Ababa. The city sits between the base of an escarpment to the west, and the Great Rift Valley to the east. Climate ranges from the month with the highest relative humidity.

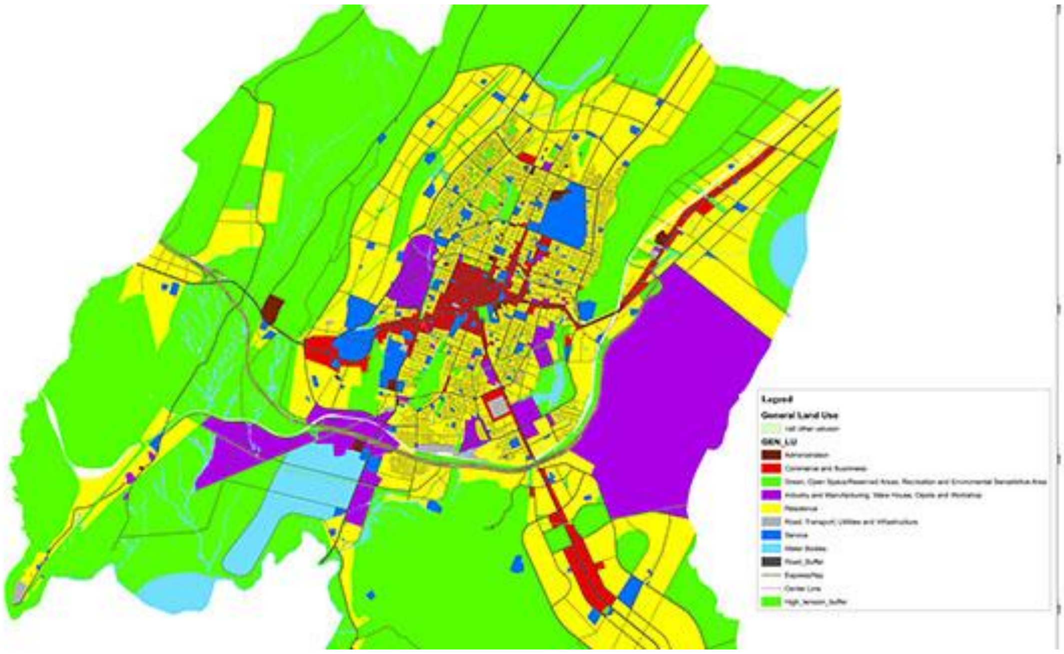


Figure 3-1 Map of Adama city

Source (fortune, 2018)

3.2. 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 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.

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. Thomas L. Saaty (2004) 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.

Methodology used to acquire data is through primary and secondary data. A research approach known as combined Analytic Hierarchy process (AHP) and Linear Programming (LP) is 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.

Primary data is collected through questionnaire surveys. The secondary data is collected from the cities' master plan, capital projects status report, projects approved for expenditure, thesis works, electronic retrieval, journals, and relevant books. After identifying key selection criteria, a questionnaire is designed and distributed Adama city finance office, Adama city municipality, Adama city construction authority and Adama city administration office, with different department experts and managers on the criteria based on values, strategic direction, and available resources to get their professional opinion based on their experience. After data analysis using AHP, the weights of selected projects is linearly optimized and used to as the coefficients of the decision variables in the linear programming. 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 projects. List of those fifteen projects selections criteria is within the categories related to project characteristics, firm (owner) characteristics and external factors. 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.

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.

3.3 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; first to Define the goal of the decision. Then, Structure the decision problem in a hierarchy. After that, Pair comparisons of criteria in each category. Calculating the priorities and consistency index was done to check if the comparisons are logical and consistent. And the final step was to evaluate alternatives according to the priorities identified.

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

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:

$$\begin{bmatrix} C11 & C12 & C13 \\ C21 & C22 & C23 \\ C31 & C32 & C3 \end{bmatrix}$$

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-wisematrix

$$x_{ij} = \frac{c_{ij}}{\sum_{i=1}^{n} c_{ij}} = \begin{matrix} w_{11} & w_{12} & w_{13} \\ w_{21} & w_{22} & w_{23} \\ w_{31} & w_{32} & w_{33} \end{matrix}$$

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

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

2. Linear Optimization with resource constraints (from allocated capital budgeting): the AHP prioritized project selection criteria from the respondents of the target organizations treated five demonstrative projects. The priority ratios (weights) obtained from the AHP were used as the coefficients of the decision variables in the linear programming.

3.4 Sampling Design

3.4.1 Sample population

The target population refers to the specific group relevant to a particular study. The objective of sampling is to provide a practical means of enabling the data collection and processing components of research to be carried out while ensuring that the sample provides a good representation of population. Taherdoost (2017) indicated that the sample should be free from bias. Otherwise, the type of selected sample will greatly affect the reliability of subsequent generalization.

For the purpose of collecting data, the study conducted a survey on professionals working in Adama city finance office, Adama city municipality, Adama city construction authority and Adama city administration office, which are prime stakeholders in public projects selection. The survey was sent to project management professionals who are actively engaged in construction projects, targeting decision makers, project development specialists, Engineers, and related disciplines.

3.4.2 Sampling techniques

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 construction projects), then snowball/networking techniques were used.

3.4.3 Sampling size

The total sample size is fifty respondents (considering 4 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 work stream 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.

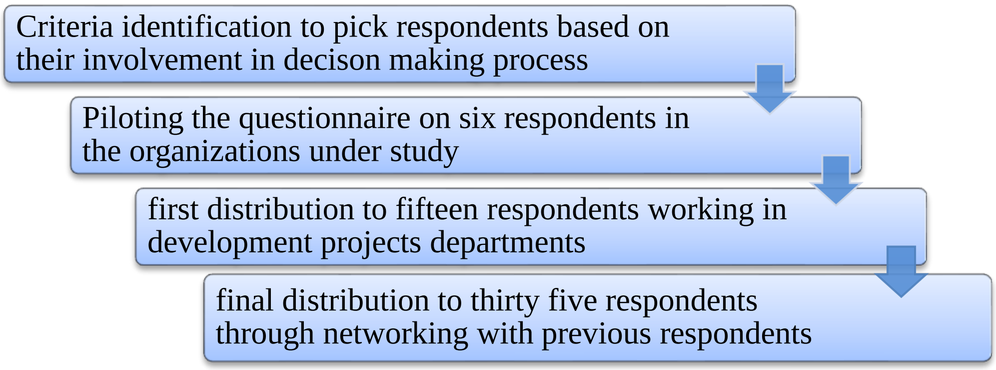


Figure 3-1 sampling and data collection Process

3.5 Data collection tools

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 city construction projects as project evaluator, supervisors, project implementation specialists and other experienced professionals. For collection of data from primary and secondary sources, various data collection techniques were employed. The secondary data types are from published and unpublished documents, maps, plans, standard documents, statistical information and other related material collected from different sources. A questionnaire was used as the main tool to collect a primary data from the target respondents. The survey objective is to for a set of factors and alternatives on a ratio scale, based on the responses of the professionals' quantify relative priorities 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 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.

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.

Case study data was used as a secondary data source from Adama city Municipality data base to excute the linear programming process. 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 by selecting five gravel road projects. The project being research in partial fulfillment of an academic qualification, all the projects were not addressed but some upon which reasonable conclusions can be determined.

3.6 Data analysis

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 normalizing matrix using AHP. In absolute measurement, selected projects were compared to each other based on the absolute nature/profiles of projects found in their feasibility studies after identifying highest project selection criteria from AHP analysis.

Table 3-1 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 demonstratedimportance	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 (R. W. Saaty, 1987)

The first task was to develop the AHP hierarchy structure for the decision problem. The criteria were selected, and alternatives were identified. The data was collected from respondents of the four organizations, Adama city finance office, Adama city municipality, Adama city construction authority and Adama city administration office. 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 five 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.

3.6.1 Consistency Analysis

As per (Thomas L Saaty, 2001), 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.

3.6.1.2 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 (T. Saaty, 1980), "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

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

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

$$c_v 11 = \frac{1}{w_{11}} c_{11}w_{11} + c_{12}w_{21} + c_{13}w_{31}$$

$$c_v 21 = \frac{1}{w_{21}} c_{21}w_{11} + c_{22}w_{21} + c_{23}w_{31}$$

$$c_v 31 = \frac{1}{w_{31}} c_{31}w_{11} + c_{32}w_{21} + c_{33}w_{31}$$

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

3.6.1.3Consistency 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, denoted by λmax

4) The approximate CI is:

CI= $\frac{\lambda max - n}{n-1}$ where n is the number of criteria

3.6.1.4 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) (T. Saaty, 1980). 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 3-2: 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

3.6.1.5 Consistency Ratio (C.R)

According to (R. W. Saaty, 1987) "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 7 respondents in those four organizations, the CR was calculated as 0.095. It is expected that upon mass distribution with such high expertise questionnaires in higher number of respondents with different subjective response may differ slightly.

3.7 Validity of the Research

In order to test the appropriateness, validity of the questionnaires, it provides a trial run for the questionnaire, which involves testing the wordings of the question, identifying ambiguous questions, testing the techniques that used to collect data, and measuring the effectiveness of standard invitation to respondents. 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: 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 maybe 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 (Young, 2015).

It was done before mass distributions. 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 (0.13), measure of worth (0.14), risk (0.17), 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.

3.8 Reliability of the Research

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 coefficient alpha test functional to measure the internal consistency of questionnaire that is, how closely related a set of items are as a group.

Cronbach's alpha reliability coefficient normally ranges between 0 and 1. The closer Cronbach's alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale.(Koonce & Kelly, 2014) provide the following rules of thumb: ≥. – Excellent, ≥ .8– Good, ≥ .7– Acceptable, ≥ .6– Questionable, ≥ .5– Poor, and ≤ .5 – Unacceptable". Cronbach's alpha most commonly used to assess the internal consistency of a questionnaire (or survey) that is made up of multiple Liker-type scales and items (Taber, 2018). Cronbach's alpha was calculated using the formula:

$$a = \frac{k}{k-1}(1-\frac{\sum_{i=1}^{k} \delta y^2}{\delta^2 x})$$

Where K is the number of test item, δy^2 is the sum of the item variance, and $\delta^2 x$ is the variance of total score.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 (Cronbach, 1951).

CHAPTER FOUR

4 RESULTS AND DISCUSSION

4.1 Description of the respondents profile and response rate

4.1.1 Demographic Profile

A questionnaire survey has been conducted to gather the required information from professionals at Adama city finance office, Adama city municipality, Adama city construction authority and Adama city administration office. A total of 50 questionnaires were distributed to selected respondents and 45 of the questionnaires were returned implying response rate of 90%. The data of respondents of the survey was analyzed according to the participants' level of experience and organization.

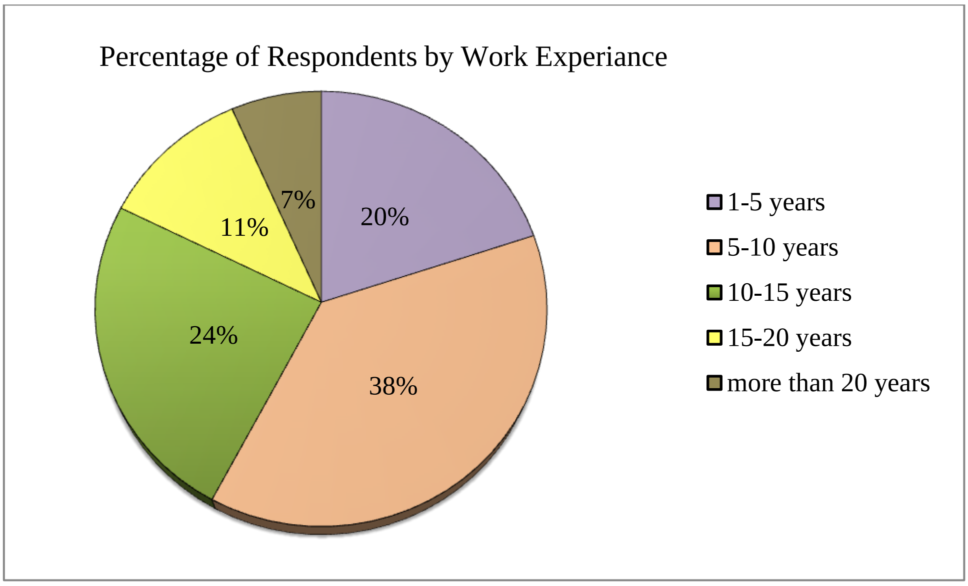


Figure 4-1. Percentage of respondents

Source: from respondent's response, 2024

4.1.2 Response Rate

From the distributed 50 questioner, 8 were distributed to Adama City finance office and 7 were returned, 14 were distributed to Adama city Municipality and 12 were returned, 16 were distributed to Adama City construction authority and 15 were returned, 12 were distributed to

Adama city Administration and 11 were returned with proper filling of the questioner. Figure 4.2 shows their response rate by organization.

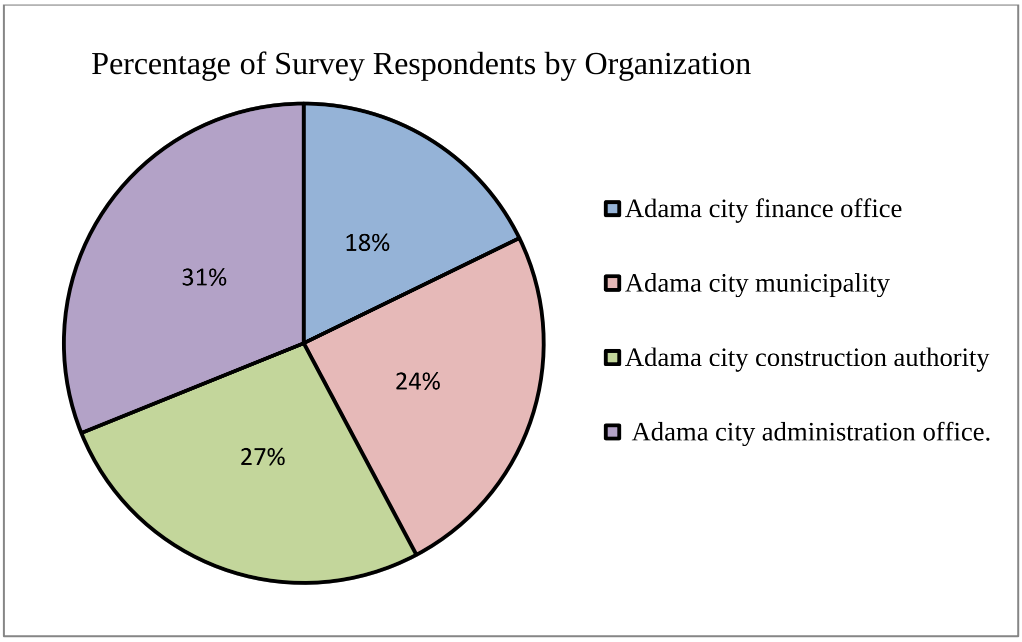


Figure 4-2. Response rate by organization

Source: from respondent's response, 2024

4.2 Project Selection Decision Making Process using simple Hierarchical Prioritizing Framework

4.2.1 Analytic Hierarchy Process

A decision hierarchy structured and AHP was applied in order to examine the relationship between public 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 projects in the public sector arena, the case of Adama city Administration.

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 Thomas L. Saaty (2004)"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.

4.2.1.2 Comparison Matrix

To evaluate the pair-wise comparison, a comparison matrix was created for all criterions. The following figure illustrates (Figure 4.3) 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.

PARAMETERS	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	1.82	3.58	1.79	2.07	2.77	3.72	3.76	3.10	3.58	1.92	3.06	2.71	4.09	5.69
Risk	0.55	1.00	4.00	4.95	5.69	2.29	3.48	5.00	5.13	4.50	4.82	5.67	3.11	5.26	4.68
Measure of Worth	0.28	0.25	1.00	4.16	4.38	5.11	3.82	4.40	4.62	4.46	5.49	3.02	2.71	2.58	4.63
Financial Standing	0.56	0.20	0.24	1.00	2.24	2.13	3.54	1.90	3.13	3.08	4.59	4.70	3.73	5.11	1.38
Resource	0.48	0.18	0.23	0.45	1.00	4.38	5.11	3.82	4.29	4.62	4.66	5.62	3.10	2.83	4.45
Economic Factors	0.36	0.44	0.20	0.47	0.23	1.00	1.84	1.26	1.57	2.56	4.62	4.79	4.68	3.91	4.98
Experience	0.27	0.29	0.26	0.28	0.20	0.54	1.00	1.38	1.56	2.62	3.92	5.35	3.94	5.13	5.78
Technical Ability	0.27	0.20	0.23	0.53	0.26	0.80	0.73	1.00	2.25	3.33	4.79	5.13	4.47	4.82	5.67
Size and Complexity	0.32	0.19	0.22	0.32	0.23	0.64	0.64	0.44	1.00	3.06	5.13	4.68	4.02	4.51	5.30
Duration	0.28	0.22	0.22	0.32	0.22	0.39	0.38	0.30	0.33	1.00	3.82	4.40	4.43	4.46	5.57
Organizational Culture	0.52	0.21	0.18	0.22	0.21	0.22	0.26	0.21	0.19	0.26	1.00	3.07	2.80	2.58	4.63
Environmental Factors	0.33	0.18	0.33	0.21	0.18	0.21	0.19	0.19	0.21	0.23	0.33	1.00	2.15	2.13	3.60
Location Factors	0.37	0.32	0.37	0.27	0.32	0.21	0.25	0.22	0.25	0.23	0.36	0.47	1.00	1.84	3.07
Social Responsibility	0.24	0.19	0.39	0.20	0.35	0.26	0.19	0.21	0.22	0.22	0.39	0.47	0.54	1.00	3.04
Political Factors	0.18	0.21	0.22	0.73	0.22	0.20	0.17	0.18	0.19	0.18	0.22	0.28	0.33	0.33	1.00
Total	6.01	5.89	11.65	15.89	17.81	21.14	25.32	24.27	28.04	33.93	46.04	51.72	43.71	50.59	63.48

Figure 4-3 pair wise comparison matrix

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

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:

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{I=1}^{K} \delta_{Yi}^{2}}{\delta_{x}^{2}}\right)$$

Where:

- K refers to the number/quantity of components/items or questions
- δ_{Yi}^{2} refers to the variance associated with item *i*
- δ_{x}^{2}refers to the variance associated with the observed total scores Using the above formula in MS-Excel, the results are:

  K =105

  $\sum\delta_{Yi}^{2}$ = 562.096

  δ_{x}^{2} = 6783.512, and

The Cronbach's alpha (α) was calculated as 0.925.

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. A frequently specified acceptable range is a value of 0.70 or above. According to (Streiner, 2003) 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

For the matrix of pair-wise elements:

$$\begin{vmatrix} C11 & C12 & C13 \\ C21 & C22 & C23 \\ C31 & C32 & C3 \end{vmatrix}$$

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-wisematrix

$$x_{ij} = \frac{c_{ij}}{\sum_{i=1}^{n} c_{ij}} = \begin{matrix} w_{11} & w_{12} & w_{13} \\ w_{21} & w_{22} & w_{23} \\ w_{31} & w_{32} & w_{33} \end{matrix}$$

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

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

The table below illustrates the normalization and priorities calculations.

Table 4-1 Normalization and Priority Calculations

parameters	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	criteria weights
profit	0.17	0.31	0.31	0.11	0.12	0.13	0.15	0.15	0.11	0.11	0.04	0.06	0.06	0.08	0.09	1.99	0.133
Risk	0.09	0.17	0.34	0.31	0.32	0.11	0.14	0.21	0.18	0.13	0.10	0.11	0.07	0.10	0.07	2.47	0.164
Measure of Worth	0.05	0.04	0.09	0.26	0.25	0.24	0.15	0.18	0.16	0.13	0.12	0.06	0.06	0.05	0.07	1.92	0.128
Financial Standing	0.09	0.03	0.02	0.06	0.13	0.10	0.14	0.08	0.11	0.09	0.10	0.09	0.09	0.10	0.02	1.26	0.084
Resource	0.08	0.03	0.02	0.03	0.06	0.21	0.20	0.16	0.15	0.14	0.10	0.11	0.07	0.06	0.07	1.48	0.098
Economic Factors	0.06	0.07	0.02	0.03	0.01	0.05	0.07	0.05	0.06	0.08	0.10	0.09	0.11	0.08	0.08	0.95	0.064
Experience	0.04	0.05	0.02	0.02	0.01	0.03	0.04	0.06	0.06	0.08	0.09	0.10	0.09	0.10	0.09	0.87	0.058
Technical Ability	0.04	0.03	0.02	0.03	0.01	0.04	0.03	0.04	0.08	0.10	0.10	0.10	0.10	0.10	0.09	0.92	0.061
Size and Complexity	0.05	0.03	0.02	0.02	0.01	0.03	0.03	0.02	0.04	0.09	0.11	0.09	0.09	0.09	0.08	0.80	0.054
Duration	0.05	0.04	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.03	0.08	0.09	0.10	0.09	0.09	0.67	0.045
Organizational	0.09	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.06	0.06	0.05	0.07	0.48	0.032
Environmental	0.05	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.05	0.04	0.06	0.35	0.023
Location Factors	0.06	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.05	0.35	0.023
Social Responsibility	0.04	0.03	0.03	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.05	0.28	0.019
Political Factors	0.03	0.04	0.02	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.22	0.015
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

Source: from the collected data excel analysis, 2024

4.2.1.5 Percent Ratio of Priorities and Results

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

Table 4-2 priorities and results

Decision factors	priority
profit	0.133
Risk	0.164
Measure of Worth	0.128
Financial Standing	0.084
Resource	0.098
Economic Factors	0.064

Experience	0.058
Technical Ability	0.061
Size and Complexity	0.054
Duration	0.045
Organizational Culture	0.032
Environmental Factors	0.023
Location Factors	0.023
Social Responsibility	0.019
Political Factors	0.015

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 0.52 with profit (0.13), risk (0.16), measure of worth (0.13), size and complexity (0.05), and duration (0.04); related to owner(firm) characteristics are 0.33 with organizational culture (0.03), experience (0.06), financial standing (0.08), technical ability (0.06), and resource(0.10), and related to external factors are weighted only 0.14 with environmental factors (0.02), economic factors (0.06), location factors (0.02), political factors (0.01), and social responsibility (0.02).

Table 4-3 decision criterion and their rank

Decision Factors Category	Selection Criterion/Decision Factors	Percentage	Rank
Project Characteristics	Profit	13.3%	2nd
	Measure of Worth	12.8%	3rd
	Risk	16.4%	1st
	Size and Complexity	5.4%	9th
	Duration	4.5%	10th
	Sub-Total	**52.4%**	

Owner /Firm characteristics	Financial Standing	8.4%	5th
	Resource	9.8%	4th
	Experience	5.8%	8th
	Technical Ability	6.1%	7th
	Organizational Culture	3.2%	11th
	Sub-Total	**33.3%**	
External Factors	Economic Factors	6.4%	6th
	Environmental Factors	2.3%	12th
	Location Factors	2.3%	12th
	Social Responsibility	1.9%	13th
	Political Factors	1.5%	14th
	Sub-Total	**14.4%**	
Total		**100%**	

Source: own tabulation, 2024

4.2.1.6 Method Validation

Reliability and validity are ensured in this section.

4.2.1.6.1 Piloting the Questionnaires: It was done before mass distributions. 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 (0.13), measure of worth (0.14), risk (0.17), 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.

4.2.1.6.2 Consistency Analysis

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.

4.2.1.6.3 Consistency Measure

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

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

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

$$c_v 11 = \frac{1}{w_{11}} c_{11} w_{11} + c_{12} w_{21} + c_{13} w_{31}$$

$$c_v 21 = \frac{1}{w_{21}} c_{21} w_{11} + c_{22} w_{21} + c_{23} w_{31}$$

$$c_v 31 = \frac{1}{w_{31}} c_{31} w_{11} + c_{32} w_{21} + c_{33} w_{31}$$

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

   λ_{Max}=18.402

4.2.1.6.4 Consistency Index (C.I)

The CI value was calculated to be 0.243.

4.2.1.6.5 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) (T. Saaty, 1980). 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 4-4 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

4.2.1.6.6 Consistency Ratio (C.R)

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 7 respondents in those four organizations, the CR was calculated as 0.095. It is expected that upon mass distribution with such high expertise questionnaires in higher number of respondents with different subjective response may differ slightly.

$$consistency\ ratio\ CR = \frac{consistency\ index\ CI}{random\ index\ RI}$$

$$CR = \frac{0.243}{1.59} = 0.1528 > 0.1$$

The following table (table 4.4) illustrates the calculations for the above steps

Table 4.5 consistency ratio calculation

PARAMETERS	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	criteria weight	λ=wsv/crwt
profit	1.00	1.82	3.58	1.79	2.07	2.77	3.72	3.76	3.10	3.58	1.92	3.06	2.71	4.09	5.69	2.545	0.133	19.159
Risk	0.55	1.00	4.00	4.95	5.69	2.29	3.48	5.00	5.13	4.50	4.82	5.67	3.11	5.26	4.68	3.377	0.164	20.544
Measure of Worth	0.28	0.25	1.00	4.16	4.38	5.11	3.82	4.40	4.62	4.46	5.49	3.02	2.71	2.58	4.63	2.672	0.128	20.919
Financial Standing	0.56	0.20	0.24	1.00	2.24	2.13	3.54	1.90	3.13	3.08	4.59	4.70	3.73	5.11	1.38	1.664	0.084	19.853
Resource	0.48	0.18	0.23	0.45	1.00	4.38	5.11	3.82	4.29	4.62	4.66	5.62	3.10	2.83	4.45	1.972	0.098	20.040
Economic Factors	0.36	0.44	0.20	0.47	0.23	1.00	1.84	1.26	1.57	2.56	4.62	4.79	4.68	3.91	4.98	1.166	0.064	18.358
Experience	0.27	0.29	0.26	0.28	0.20	0.54	1.00	1.38	1.56	2.62	3.92	5.35	3.94	5.13	5.78	1.058	0.058	18.222
Technical Ability	0.27	0.20	0.23	0.53	0.26	0.80	0.73	1.00	2.25	3.33	4.79	5.13	4.47	4.82	5.67	1.139	0.061	18.537
Size and Complexity	0.32	0.19	0.22	0.32	0.23	0.64	0.64	0.44	1.00	3.06	5.13	4.68	4.02	4.51	5.30	0.975	0.054	18.162
Duration	0.28	0.22	0.22	0.32	0.22	0.39	0.38	0.30	0.33	1.00	3.82	4.40	4.43	4.46	5.57	0.770	0.045	17.277
Organizational Culture	0.52	0.21	0.18	0.22	0.21	0.22	0.26	0.21	0.19	0.26	1.00	3.07	2.80	2.58	4.63	0.514	0.032	16.188
Environmental Factors	0.33	0.18	0.33	0.21	0.18	0.21	0.19	0.19	0.21	0.23	0.33	1.00	2.15	2.13	3.60	0.384	0.023	16.437
Location Factors	0.37	0.32	0.37	0.27	0.32	0.21	0.25	0.22	0.25	0.23	0.36	0.47	1.00	1.84	3.07	0.393	0.023	16.759
Social Responsibility	0.24	0.19	0.39	0.20	0.35	0.26	0.19	0.21	0.22	0.22	0.39	0.47	0.54	1.00	3.04	0.325	0.019	17.502
Political Factors	0.18	0.21	0.22	0.73	0.22	0.20	0.17	0.18	0.19	0.18	0.22	0.28	0.33	0.33	1.00	0.262	0.015	18.076
Total	6.01	5.89	11.65	15.89	17.81	21.14	25.32	24.27	28.04	33.93	46.04	51.72	43.71	50.59	63.48	λ(sum)		276
															λ max=average of λ			18.402
															CI=(λmax-n)/(n-1)			0.243
															RI (for n=15)			1.59
															CR=CI/RI			0.1528

4.2.1.6.7 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.(Thomas L. Saaty, 2004) puts "AHP should be a science of scaling based on mathematics, philosophy, and psychology". As a clarification of inconsistency ration, (Thomas L Saaty, 2001) 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 weightsobtained 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. After simple order adjustment the consistency index value was found to be 0.0935 which is less than o.1 and acceptable. In the Appendix B, the simple ordering ranks, the adjusted pair-wise comparisonmatrixes, the adjusted normalization and priority calculations, the adjusted consistencymeasurement calculations are presented. The figure below shows the consistency ratio, and consistency index calculations.

Adgusted consistency analysis

parameters	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	cr wt	λ=wsv/cr wt
profit	0.11	0.23	0.35	0.12	0.14	0.14	0.20	0.19	0.11	0.10	0.05	0.05	0.06	0.08	0.08	2.02	0.11	17.83
Risk	0.08	0.16	0.46	0.31	0.47	0.10	0.13	0.31	0.23	0.16	0.13	0.13	0.06	0.10	0.06	2.90	0.16	18.50
Measure of Worth	0.04	0.04	0.12	0.23	0.28	0.27	0.20	0.19	0.23	0.16	0.13	0.05	0.06	0.04	0.08	2.12	0.12	18.29
Financial Standing	0.08	0.04	0.04	0.08	0.14	0.10	0.13	0.09	0.11	0.10	0.10	0.11	0.09	0.10	0.03	1.35	0.08	17.38
Resource	0.08	0.03	0.04	0.05	0.09	0.21	0.27	0.19	0.17	0.16	0.10	0.11	0.06	0.05	0.06	1.66	0.09	17.82
Economic Factors	0.06	0.10	0.03	0.05	0.03	0.07	0.10	0.09	0.09	0.08	0.10	0.11	0.09	0.08	0.08	1.16	0.07	16.83
Experience	0.04	0.08	0.04	0.04	0.02	0.05	0.07	0.09	0.09	0.08	0.10	0.11	0.09	0.10	0.12	1.11	0.07	16.66
Technical Ability	0.04	0.03	0.04	0.05	0.03	0.05	0.04	0.06	0.09	0.10	0.13	0.11	0.09	0.10	0.08	1.05	0.06	16.77
Size and Complexity	0.06	0.04	0.03	0.04	0.03	0.05	0.04	0.04	0.06	0.10	0.13	0.08	0.09	0.08	0.08	0.95	0.06	16.58
Duration	0.06	0.05	0.04	0.04	0.03	0.05	0.04	0.03	0.03	0.05	0.10	0.08	0.09	0.08	0.08	0.85	0.05	16.39
Organizational Culture	0.08	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.02	0.03	0.05	0.06	0.04	0.06	0.54	0.03	16.00
Environmental Factors	0.06	0.03	0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.05	0.04	0.04	0.44	0.03	16.38
Location Factors	0.06	0.08	0.06	0.03	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.51	0.03	16.66
Social Responsibility	0.04	0.04	0.08	0.02	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.44	0.03	17.19
Political Factors	0.03	0.05	0.03	0.05	0.03	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.34	0.02	16.95
Total	0.88	1.05	12.33	14.83	15.50	17.17	19.83	22.00	22.50	22.58	35.50	39.83	31.67	37.50	47.50		λmax=	17.08
weights	0.11	0.16	0.12	0.08	0.09	0.07	0.07	0.06	0.06	0.05	0.03	0.03	0.03	0.03	0.02	CI=λmax-n/(n-1)		
																	CI	0.1487
																	RI	1.59
														< 1 (Acceptable)			CR=CI/RI	0.0935

Figure 4-1 Adjusted consistency Analysis

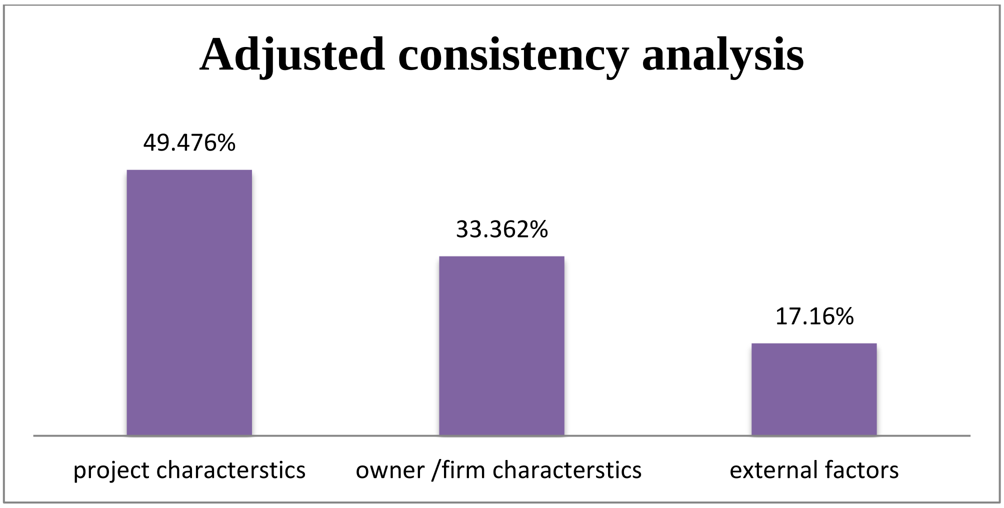


Figure 4-2. priority after adjustment in percentage

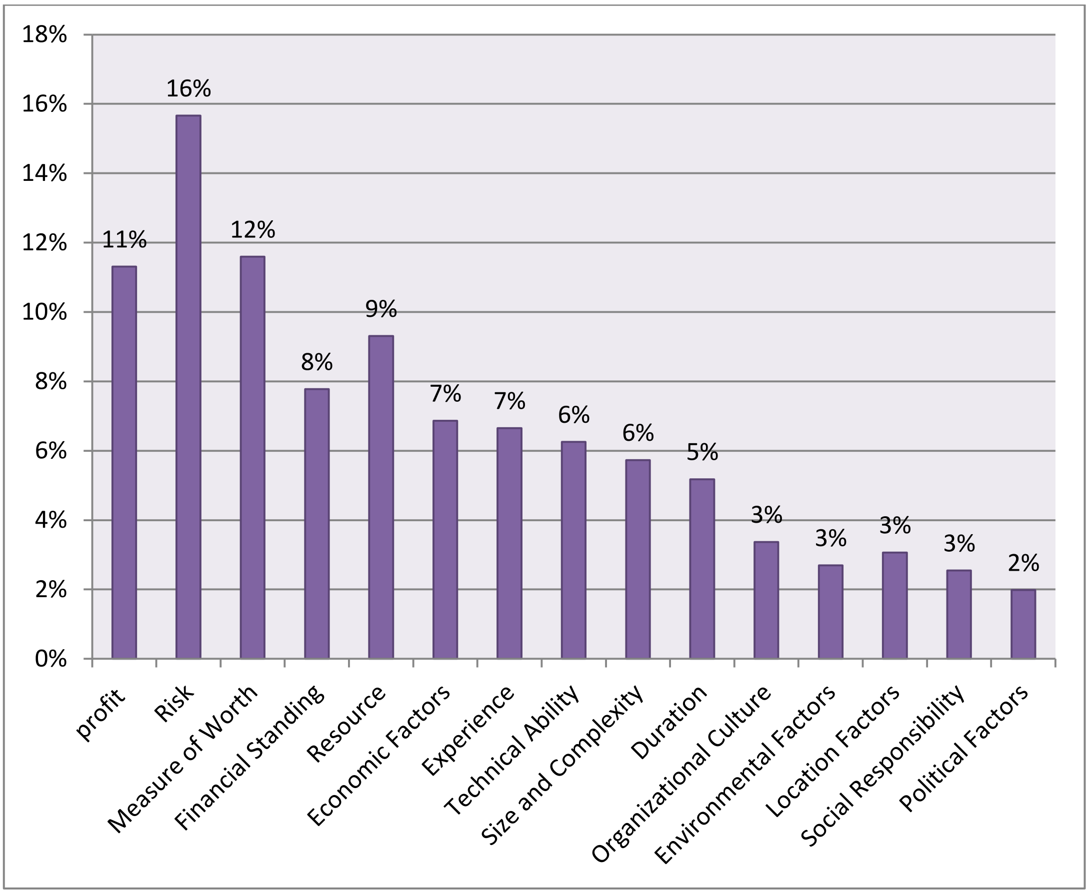


Figure 4-3 criteria weight in percentage for each parameter

4.3 Use of Multi-Criteria Decision-Making Method through Analytic Hierarchy Process and Linear Programming

4. 3.1 Derive Overall Priorities (Model Synthesis)

For this study, the available investing options for the client (Adama City Municipality) are considered five road projects, specifically gravel road being constructed with allocated budget for 2015/2016 EC. 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 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, comparison of the projects against each other in terms of meeting each section criterion was done. The score (weight) of each project is then calculated. The decomposition of the problem into a hierarchy is presented in the following figure.

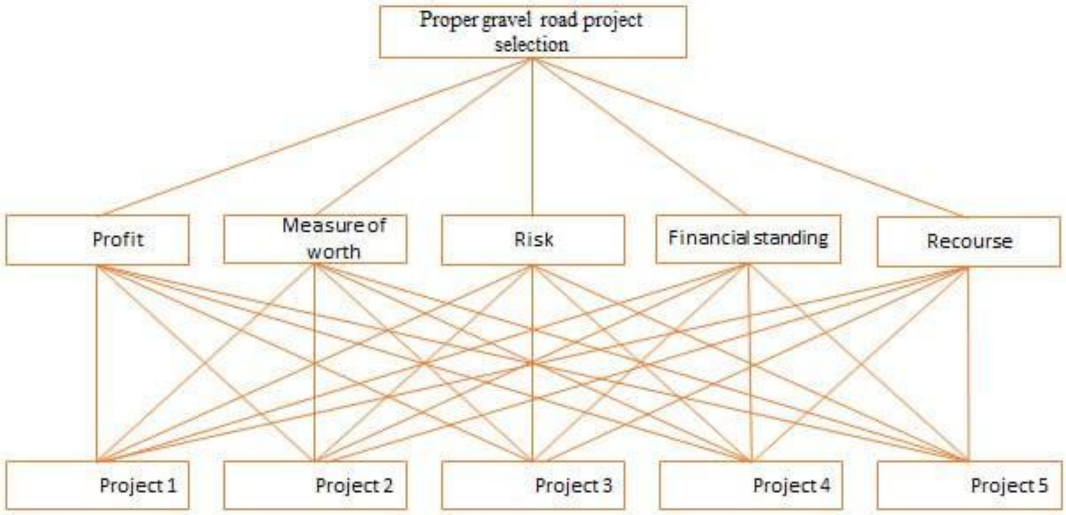


Figure 4-1 hierarchical decomposition of the problem

The selected projects for the comparison are

Project 1.Gravel Road express way 0+00- 1+700km and around Bole preparatory school, with an allocated budget of 143,654,554.3 birr awarded to contractor KIDKON General Contractor. The EIRR 15.25%, the B/C is 3.7.

Project 2.Gravel road from Assela asphalt to Ali Birra Road with an allocated budget of 106,355,689.6 birr awarded to contractor KIDKON General Contractor. The EIRR 21.83%, B/C is 1.98.

Project 3.Gravel Road express way to Boku spring, with an allocated budget of 323,626,315.1 birr awarded to contractor KIDKON General Contractor. The EIRR 24.73%, the B/C is 5.02.

Project 4.Gravel Road from Flora recreation to Deka Adi kebele, with an allocated budget of 113,214,084.6 birr awarded to contractor KIDKON General Contractor. The EIRR 10.95%, the B/C is 4.9.

Project 5.Gravel Road from Moenco to 40m and Finfine asphalt to Sire Aba Bune secondary school, with an allocated budget of 125,481,595.5 birr awarded to contractor Aklesiya General Contractor. The EIRR 11.27%, the B/C is 1.858.

Table 4.6 projects profile

	Project cost (in 10,000,000)	Benefit to cost ratio B/C	EIRR	Functional classification
Project 1	14.36546	3.7	15.25%	Gravel Road
Project 2	10.63557	1.98	21.83%	Gravel Road
Project 3	32.36263	5.02	24.73%	Gravel Road
Project 4	11.32141	4.9	10.95%	Gravel Road
Project 5	12.54816	1.858	11.27%	Gravel 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 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(Li & Ma, 2007). 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 4-7 project profiles with selection factors

	Risk	Profit	Measure of worth	Project resource(Mill ETB)	Financial standing
Project 1	1	15.25%	3.7	14.36546	1
Project 2	3	21.83%	1.98	10.63557	1
Project 3	3	24.73%	5.02	32.36263	1
Project 4	1	10.95%	4.9	11.32141	1
Project 5	1	11.27%	1.858	12.54816	1

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 4-8 Comparison matrices and local priorities for each project

profit	p1	p2	p3	p4	p5	CR WT
p1	1	0.70	0.62	1.39	1.35	0.18
p2	1.4	1.0	0.9	2.0	1.9	0.26
p3	1.6	1.1	1.0	2.3	2.2	0.29
p4	0.7	0.5	0.4	1.0	1.0	0.13
p5	0.7	0.5	0.5	1.0	1.0	0.13
λ max= 5.1		CI=0.01407		CR= 0.01256<0.1		

B/C	p1	p2	p3	p4	p5	CR WT
p1	1.0	1.9	0.7	0.8	2.0	0.21
p2	0.5	1.0	0.4	0.4	1.1	0.11
p3	1.4	2.5	1.0	1.0	2.7	0.29
p4	1.3	2.5	1.0	1.0	2.6	0.28
p5	0.5	0.9	0.4	0.4	1.0	0.11
λ max= 4.28		CI=-0.177		CR= -0.15<0.1		

RISK	p1	p2	p3	p4	p5	CR WT
p1	1	0.3333	0.3	1	1	0.11
p2	3	1	1	3	3	0.33
p3	3	1	1	3	3	0.33
p4	1	0.3333	0.3	1	1	0.11
p5	1	0.3333	0.3	1	1	0.11
λ max= 5.05		CI=0.0126		CR= 0.01127<0.1		

RESOURCE	p1	p2	p3	p4	p5	CR WT
p1	1.0	1.4	0.4	1.3	1.1	0.18
p2	0.7	1.0	0.3	0.9	0.8	0.13
p3	2.3	3.0	1.0	2.9	2.6	0.40
p4	0.8	1.1	0.3	1.0	0.9	0.14
p5	0.9	1.2	0.4	1.1	1.0	0.15
λ max= 5.1		CI=0.0272		CR= 0.00242<0.1		

Financial standing	p1	p2	p3	p4	p5	CR WT
p1	1	1	1	1	1	0.20
p2	1	1	1	1	1	0.20

p3	1	1	1	1	1	0.20
p4	1	1	1	1	1	0.20
p5	1	1	1	1	1	0.20
λ max= 5.144		CI=0.03618		CR= 0.0323<0.1		

Source: from excel analysis based on selected projects and the selection criteria, 2024

Table 4 -9 local and Global priorities of each project

	Risk(0.29)	Profit(0.2)	Measure of worth(0.21)	Project resource(0.16)	Financial standing (0.14)	Overall priorities
Project 1	0.11	0.18	0.21	0.18	0.20	0.169
Project 2	0.33	0.26	0.11	0.13	0.20	0.22
Project 3	0.33	0.29	0.29	0.40	0.20	0.31
Project 4	0.11	0.13	0.28	0.14	0.20	0.167
Project 5	0.11	0.13	0.11	0.15	0.20	0.13

$$\begin{matrix} \text{Project 1} \\ \text{Project 2} \\ \text{Project 3} \\ \text{Project 4} \\ \text{Project 5} \end{matrix} \quad \begin{pmatrix} 0.11 & 0.18 & 0.21 & 0.18 & 0.2 \\ 0.33 & 0.26 & 0.11 & 0.13 & 0.2 \\ 0.33 & 0.29 & 0.29 & 0.4 & 0.2 \\ 0.11 & 0.13 & 0.28 & 0.14 & 0.2 \\ 0.11 & 0.13 & 0.11 & 0.15 & 0.2 \end{pmatrix} \quad X \quad \begin{pmatrix} 0.29 \\ 0.2 \\ 0.21 \\ 0.16 \\ 0.14 \end{pmatrix}$$

In order to find out the overall priority, the score (weight) for each project was 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. The overall priorities of each project and the ranks are presented below.

Table 4-10 projects weights and ranks

Alternatives	Overall priority weights	Rank
Project 1	0.169	3rd
Project 2	0.22	2nd
Project 3	0.31	1st
Project 4	0.167	4th
Project 5	0.13	5th

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.

4.3.1.1 Linear Programming (LP) Analysis

Under the direction of the Adama City Administration, projects are started in the public interest, with a focus on addressing societal problems, available project funding and employment opportunities. Priority is given to easily implemented and highly beneficial projects. For easy comparison the same category gravel road public projects are selected for the comparison and investigated which projects increase the overall benefits. Maximizing the AHP priority weights actually shows the contribution of each project 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 4-11 Linear optimization Table

Project information	Project 1	Project 2	Project 3	Project 4	Project 5	Constraint (Mill ETB)
Priority weights	0.169	0.22	0.31	0.167	0.13	
Annual budget(mill ETB)	14.36546	10.63557	32.36263	11.32141	12.54816	81.23322

The notations are defined as follows:

X1=1 if project 1 is selected, 0 otherwise

X2=1 if project 2 is selected, 0 otherwise

Or

Xj: 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

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

aij: Amount of capital i required by project j

Di: 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} =14.36546$X1$ + 10.63557$X2$ + 32.36263$X3$ + 11.32141$X4$ + 12.54816$X5$

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

a. Availability of capital

$\sum aij\ Xj \leq Di\ \forall i,j$

14.36546$X1$ + 10.63557$X2$ + 32.36263$X3$ + 11.32141$X4$ + 12.54816$X5$ ≤ 81.23322

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:

$X4 + X5 \leq 1$

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

$X1 + X2 + \cdots + X5 \leq 4$

d. $Xj \geq 0\ \forall i$, or Xj=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 4-12 excel solver linear programming calculations

$$Zmax = 0.169X1 + 0.22X2 + 0.31X3 + 0.167X4 + 0.13X5$$
$$14.36546X1 + 10.63557X2 + 32.36263X3 + 11.32141X4 + 12.54816X5 \leq 81.23322$$
$$X4 + X5 \leq 1$$

$$X1 + X2 + \cdots + X5 \leq 4$$
$Xj \geq 0\ \forall i,j$ or Xj=0-1

	X1	X2	X3	X4	X5			
obj function	0.169	0.22	0.31	0.167	0.13	0.866		
BINARY	1	1	1	1	0			
						LHS		RHS
constraints	14.36546	10.63557	32.36263	11.32141	12.54816	68.68507	<=	81.23322
				1	1	1	<=	1
	1	1	1	1	1	4	<=	4

The optimal solution is found to be Projects 1, 2, 3, and 4 with a combined benefit of 0.866. This infers the organization should invest in project 1, 2, 3, and 4 in order to maximize their benefit. It also means that by investing in those projects, the organization gets 86.6 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 812332238.9 ETB budgeted, 68685070 ETB will be finally allocated to the four projects selected.

4.4 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 0.5 ; related to owner (firm) characteristics are 0.33, and related to external factors are weighted only 0.17,. The study shows that the most important project selection sub-criteria found to be profit, project risk, measure of worth, financial standing, and resources with the overall weight of 0.11, 0.16, 0.12, 0.08 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, 0.06, 0.06, 0.05, 0.03, 0.03, 0.03, 0.03, and 0.02.Based on the integrated AHP-LP model, Projects P1, P2, P3 and P4 were selected while P5 was dropped.

Related results were found with researches done by Parvaneh and El-Sayegh (2016) and Ambaw, (2022), in which they stated that criteria related to the characteristics of the project were ranked higher than other criteria related to the firm or the external factors. In the research by Parvaneh and El-Sayegh (2016),The results indicate that the most important criteria are profit, financial standing and risk with overall weight of 0.161, 0.144 and 0.100 respectively in which it differs having 6%less value in risk and 5%more in profit in than this ressearch . Also in the study done by Ambaw, (2022), it was stated that among the three basic categorical factors related to project characteristics are weighted 0.50; related to owner (firm) characteristics are 0.36), and related to external factors are weighted only 0.14. In this study in case of Adama city administration the external factors weighted 3% more than the study done by Ambaw, (2022), in the case of Ethiopian Road Authority.

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, and more.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1Conclusions

The Analytic Hierarchy Process is a measurement theory used to derive ratio scales from comparisons of actual measurements or preferences. It is widely used in multicriteria decision making, planning, resource allocation, and conflict resolution. The AHP considers various factors simultaneously, allowing for dependence and feedback. It is particularly useful in establishing measures in physical and social domains, revealing that profit, risk, worth, size, complexity, duration, organizational culture, experience, financial status, technical competence, and resource all impact project characteristics. The study shows that risk, measure of worth, profit, size and complexity, duration, organizational culture, experience, financial status, technical competence, and resource all have a substantial impact on project characteristics, owner characteristics, and external factors. Among the three basic categorical factors related to project characteristics are weighted 0.5; related to owner (firm) characteristics are 0.33, and related to external factors are weighted only 0.17. The study shows that the most important project selection sub-criteria found to be project risk, measure of worth, profit, financial standing, and resources with the overall weight of 0.16, 0.12, 0.11, 0.08 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, 0.06, 0.06, 0.05, 0.03, 0.03, 0.03, 0.03, and 0.02. Based on the integrated AHP-LP model, Projects P1, P2, P3 and P4 were selected while P5 was dropped. The weight given to various factors in selecting public projects is influenced by a combination of rigorous appraisal methodologies, political dynamics, and alignment with strategic goals, standardized selection criteria, and integration into the budgeting process. These elements collectively aim to maximize societal benefits while minimizing inefficiencies and biases in city's project selection.

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 used exactly as it is in real-world situations, or it can be customized to suit the needs of the owner or organization. In certain cases, organizations can even create their own unique, thorough sets of selection criteria based on the circumstances. 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 possible relationships 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 city’s 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 Sifen Tilahun and I am a graduate student at Adama Science and Technology University conducting thesis research for my master degree on: "**Application of Multi criteria decision making as an alternative of project selection in the case of Adama city public 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: sifentilahun9@gmail.com +21946575970

I would like to thank you in advance for your assistance. Sincerely,

Sifen Tilahun, Graduate Student

School of Civil Engineering and Architecture, Construction Engineering Management Stream

Adama Science and Technology University

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 Year D. 15-20Years E. More than 20 Years

Section Two: Questions to Fill and Set of Instructions

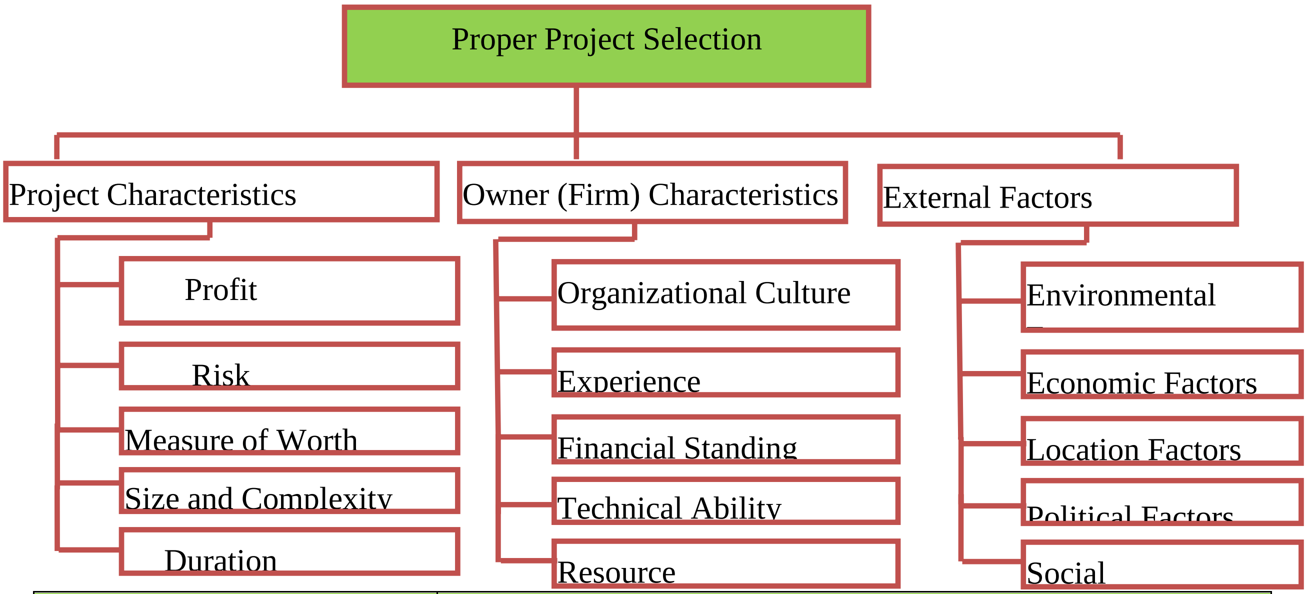
Level of Preferenceof Each Factor

(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 anothe
(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 asshown 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 theclient 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 specificationat 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 negative 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**		
								to	Financial Standing
Measure of Worth	is							>>	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**		
Resource	is							to	Economic Factors
								>>	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**		
								to	Technical Ability
								>>	Size and Complexity
Experience	is							>>	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**		
								to	Size and Complexity
								>>	Duration
Technical Ability	is							>>	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**		
	is							to	Duration
Size and Complexity								>>	Organizational Culture
								>>	Environmental

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

Appendix B: Data Analysis

Pairwise comparision coding

Paramets	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	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
Risk	1/R1	1	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27
Measure of Worth	1/R2	1/R15	1	R28	R29	R30	R31	R32	R33	R34	R35	R36	R37	R38	R39
Financial Standing	1/R3	1/R16	1/R28	1	R40	R41	R42	R43	R44	R45	R46	R47	R48	R49	R50
Resource	1/R4	1/R17	1/R29	1/R40	1	R51	R52	R53	R54	R55	R56	R57	R58	R59	R60
Economic Factors	1/R5	1/R18	1/R30	1/R41	1R51	1	R61	R62	R63	R64	R65	R66	R67	R68	R69
Experience	1/R6	1/R19	1/R31	1/R42	1R52	1/R61	1	R70	R71	R72	R73	R74	R75	R76	R77
Technical Ability	1/R7	1/R20	1/R32	1/R43	1R53	1/R62	1/R70	1	R78	R79	R80	R81	R82	R83	R84
Size and Complexity	1/R8	1/R21	1/R33	1/R44	1R54	1/R63	1/R71	1/R78	1	R85	R86	R87	R88	R89	R90
Duration	1/R9	1/R22	1/R34	1/R45	1R55	1/R64	1/R72	1/R79	1/R85	1	R91	R92	R93	R94	R95
Organizational Culture	1/R10	1/R23	1/R35	1/R46	1R56	1/R65	1/R73	1/R80	1/R86	1/R91	1	R96	R97	R98	R99
Environmental Factors	1/R11	1/R24	1/R36	1/R47	1R57	1/R66	1/R74	1/R81	1/R87	1/R92	1/R96	1	R100	R101	R102
Location Factors	1/R12	1/R25	1/R37	1/R48	1R58	1/R67	1/R75	1/R82	1/R88	1/R93	1/R97	1/R100	1	R103	R104
Social Responsibility	1/R13	1/R26	1/R38	1/R49	1R59	1/R68	1/R76	1/R83	1/R89	1/R94	1/R98	1/R101	1/R103	1	R105
Political Factors	1/R14	1/R27	1/R39	1/R50	1R60	1/R69	1/R77	1/R84	1/R90	1/R95	1/R99	1/R102	1/R104	1/R105	1

Pairwise comparison Matrix

PARAMETERS	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
profit	1.00	1.82	3.58	1.79	2.07	2.77	3.72	3.76	3.10	3.58	1.92	3.06	2.71	4.09	5.69	44.66
Risk	0.55	1.00	4.00	4.95	5.69	2.29	3.48	5.00	5.13	4.50	4.82	5.67	3.11	5.26	4.68	60.13
Measure of Worth	0.28	0.25	1.00	4.16	4.38	5.11	3.82	4.40	4.62	4.46	5.49	3.02	2.71	2.58	4.63	50.91
Financial Standing	0.56	0.20	0.24	1.00	2.24	2.13	3.54	1.90	3.13	3.08	4.59	4.70	3.73	5.11	1.38	37.54
Resource	0.48	0.18	0.23	0.45	1.00	4.38	5.11	3.82	4.29	4.62	4.66	5.62	3.10	2.83	4.45	45.21
Economic Factors	0.36	0.44	0.20	0.47	0.23	1.00	1.84	1.26	1.57	2.56	4.62	4.79	4.68	3.91	4.98	32.91
Experience	0.27	0.29	0.26	0.28	0.20	0.54	1.00	1.38	1.56	2.62	3.92	5.35	3.94	5.13	5.78	32.51
Technical Ability	0.27	0.20	0.23	0.53	0.26	0.80	0.73	1.00	2.25	3.33	4.79	5.13	4.47	4.82	5.67	34.46
Size and Complexity	0.32	0.19	0.22	0.32	0.23	0.64	0.64	0.44	1.00	3.06	5.13	4.68	4.02	4.51	5.30	30.72
Duration	0.28	0.22	0.22	0.32	0.22	0.39	0.38	0.30	0.33	1.00	3.82	4.40	4.43	4.46	5.57	26.35
Organizational Culture	0.52	0.21	0.18	0.22	0.21	0.22	0.26	0.21	0.19	0.26	1.00	3.07	2.80	2.58	4.63	16.56
Environmental Factors	0.33	0.18	0.33	0.21	0.18	0.21	0.19	0.19	0.21	0.23	0.33	1.00	2.15	2.13	3.60	11.46
Location Factors	0.37	0.32	0.37	0.27	0.32	0.21	0.25	0.22	0.25	0.23	0.36	0.47	1.00	1.84	3.07	9.55
Social Responsibility	0.24	0.19	0.39	0.20	0.35	0.26	0.19	0.21	0.22	0.22	0.39	0.47	0.54	1.00	3.04	7.92
Political Factors	0.18	0.21	0.22	0.73	0.22	0.20	0.17	0.18	0.19	0.18	0.22	0.28	0.33	0.33	1.00	4.62
Total	6.01	5.89	11.65	15.89	17.81	21.14	25.32	24.27	28.04	33.93	46.04	51.72	43.71	50.59	63.48	

Normalization and Priority Analysis

parameters	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	criteria weights
profit	0.17	0.31	0.31	0.11	0.12	0.13	0.15	0.15	0.11	0.11	0.04	0.06	0.06	0.08	0.09	1.99	0.13
Risk	0.09	0.17	0.34	0.31	0.32	0.11	0.14	0.21	0.18	0.13	0.10	0.11	0.07	0.10	0.07	2.47	0.16
Measure of Worth	0.05	0.04	0.09	0.26	0.25	0.24	0.15	0.18	0.16	0.13	0.12	0.06	0.06	0.05	0.07	1.92	0.13
Financial Standing	0.09	0.03	0.02	0.06	0.13	0.10	0.14	0.08	0.11	0.09	0.10	0.09	0.09	0.10	0.02	1.26	0.08
Resource	0.08	0.03	0.02	0.03	0.06	0.21	0.20	0.16	0.15	0.14	0.10	0.11	0.07	0.06	0.07	1.48	0.10
Economic Factors	0.06	0.07	0.02	0.03	0.01	0.05	0.07	0.05	0.06	0.08	0.10	0.09	0.11	0.08	0.08	0.95	0.06
Experience	0.04	0.05	0.02	0.02	0.01	0.03	0.04	0.06	0.06	0.08	0.09	0.10	0.09	0.10	0.09	0.87	0.06
Technical Ability	0.04	0.03	0.02	0.03	0.01	0.04	0.03	0.04	0.08	0.10	0.10	0.10	0.10	0.10	0.09	0.92	0.06
Size and Complexity	0.05	0.03	0.02	0.02	0.01	0.03	0.03	0.02	0.04	0.09	0.11	0.09	0.09	0.09	0.08	0.80	0.05
Duration	0.05	0.04	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.03	0.08	0.09	0.10	0.09	0.09	0.67	0.04
Organizational	0.09	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.06	0.06	0.05	0.07	0.48	0.03
Environmental	0.05	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.05	0.04	0.06	0.35	0.02
Location Factors	0.06	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.05	0.35	0.02
Social Responsibility	0.04	0.03	0.03	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.05	0.28	0.02
Political Factors	0.03	0.04	0.02	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.22	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 pairwise comparison matrix

parameters	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
profit	1.00	1.50	3.00	1.50	1.50	2.00	3.00	3.00	2.00	2.00	1.50	2.00	2.00	3.00	4.00	33.00
Risk	0.67	1.00	4.00	4.00	5.00	1.50	2.00	5.00	4.00	3.00	4.00	5.00	2.00	4.00	3.00	48.16
Measure of Worth	0.33	0.25	1.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00	2.00	2.00	1.50	4.00	38.08
Financial Standing	0.67	0.25	0.33	1.00	1.50	1.50	2.00	1.50	2.00	2.00	3.00	4.00	3.00	4.00	1.50	28.25
Resource	0.67	0.20	0.33	0.67	1.00	3.00	4.00	3.00	3.00	3.00	3.00	4.00	2.00	2.00	3.00	32.87
Economic Factors	0.50	0.67	0.25	0.67	0.33	1.00	1.50	1.50	1.50	1.50	3.00	4.00	3.00	3.00	4.00	26.42
Experience	0.33	0.50	0.33	0.50	0.25	0.67	1.00	1.50	1.50	1.50	3.00	4.00	3.00	4.00	6.00	28.08
Technical Ability	0.33	0.20	0.33	0.67	0.33	0.67	0.67	1.00	1.50	2.00	4.00	4.00	3.00	4.00	4.00	26.70
Size and Complexity	0.50	0.25	0.25	0.50	0.33	0.67	0.67	0.67	1.00	2.00	4.00	3.00	3.00	3.00	4.00	23.83
Duration	0.50	0.33	0.33	0.50	0.33	0.67	0.67	0.50	0.50	1.00	3.00	3.00	3.00	3.00	4.00	21.33
Organizational Culture	0.67	0.25	0.25	0.33	0.33	0.33	0.33	0.25	0.25	0.33	1.00	2.00	2.00	1.50	3.00	12.83
Environmental Factors	0.50	0.20	0.50	0.25	0.25	0.25	0.25	0.25	0.33	0.33	0.50	1.00	1.50	1.50	2.00	9.62
Location Factors	0.50	0.50	0.50	0.33	0.50	0.33	0.33	0.33	0.33	0.33	0.50	0.67	1.00	1.50	2.00	9.67
Social Responsibility	0.33	0.25	0.67	0.25	0.50	0.33	0.25	0.25	0.33	0.33	0.67	0.67	0.67	1.00	2.00	8.50
Political Factors	0.25	0.33	0.25	0.67	0.33	0.25	0.17	0.25	0.25	0.25	0.33	0.50	0.50	0.50	1.00	5.83
Total	7.75	6.68	12.33	14.83	15.50	17.17	19.83	22.00	22.50	22.58	35.50	39.83	31.67	37.50	47.50	

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

CR=CI/RI	0.1528

	Adgusted consistency analysis																	
parameters	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	cr wt	λ=wsv/cr wt
profit	0.11	0.23	0.35	0.12	0.14	0.14	0.20	0.19	0.11	0.10	0.05	0.05	0.06	0.08	0.08	2.02	0.11	17.83
Risk	0.08	0.16	0.46	0.31	0.47	0.10	0.13	0.31	0.23	0.16	0.13	0.13	0.06	0.10	0.06	2.90	0.16	18.50
Measure of Worth	0.04	0.04	0.12	0.23	0.28	0.27	0.20	0.19	0.23	0.16	0.13	0.05	0.06	0.04	0.08	2.12	0.12	18.29
Financial Standing	0.08	0.04	0.04	0.08	0.14	0.10	0.13	0.09	0.11	0.10	0.10	0.11	0.09	0.10	0.03	1.35	0.08	17.38
Resource	0.08	0.03	0.04	0.05	0.09	0.21	0.27	0.19	0.17	0.16	0.10	0.11	0.06	0.05	0.06	1.66	0.09	17.82
Economic Factors	0.06	0.10	0.03	0.05	0.03	0.07	0.10	0.09	0.09	0.08	0.10	0.11	0.09	0.08	0.08	1.16	0.07	16.83
Experience	0.04	0.08	0.04	0.04	0.02	0.05	0.07	0.09	0.09	0.08	0.10	0.11	0.09	0.10	0.12	1.11	0.07	16.66
Technical Ability	0.04	0.03	0.04	0.05	0.03	0.05	0.04	0.06	0.09	0.10	0.13	0.11	0.09	0.10	0.08	1.05	0.06	16.77
Size and Complexity	0.06	0.04	0.03	0.04	0.03	0.05	0.04	0.04	0.06	0.10	0.13	0.08	0.09	0.08	0.08	0.95	0.06	16.58
Duration	0.06	0.05	0.04	0.04	0.03	0.05	0.04	0.03	0.03	0.05	0.10	0.08	0.09	0.08	0.08	0.85	0.05	16.39
Organizational Culture	0.08	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.02	0.03	0.05	0.06	0.04	0.06	0.54	0.03	16.00
Environmental Factors	0.06	0.03	0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.05	0.04	0.04	0.44	0.03	16.38
Location Factors	0.06	0.08	0.06	0.03	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.51	0.03	16.66
Social Responsibility	0.04	0.04	0.08	0.02	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.44	0.03	17.19
Political Factors	0.03	0.05	0.03	0.05	0.03	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.34	0.02	16.95
Total	0.88	1.05	12.33	14.83	15.50	17.17	19.83	22.00	22.50	22.58	35.50	39.83	31.67	37.50	47.50	λmax=		17.08
weights	0.11	0.16	0.12	0.08	0.09	0.07	0.07	0.06	0.06	0.05	0.03	0.03	0.03	0.03	0.02	CI=λmax-n/(n-1)		
																	CI	0.1487
																	RI	1.59
														<1 (Acceptable)			CR=CI/RI	0.0935

PROJECT COMPARISIONS

	Profit	Measure of WORTH	Project Risk	Financial standing	Resource		profit	p1	p2	p3	p4	p5	CR WT
							p1	1	0.70	0.62	1.39	1.35	0.18
Project 1	15.25%	3.7	1	1	143654554		p2	1.4	1.0	0.9	2.0	1.9	0.26
Project 2	21.83%	1.98	3	1	106355689.7		p3	1.6	1.1	1.0	2.3	2.2	0.29
Project 3	24.73%	5.02	3	1	323626315.1		p4	0.7	0.5	0.4	1.0	1.0	0.13
Project 4	10.95%	4.9	1	1	113214084.6		p5	0.7	0.5	0.5	1.0	1.0	0.13
Project 5	11.27%	1.858	1	1	125481595.5		Total	5.51036	3.8489	3.39802	7.67425	7.45634	1
RESOURCE	p1	p2	p3	p4	p5	CR WT	RISK	p1	p2	p3	p4	p5	CR WT
p1	1.0	1.4	0.4	1.3	1.1	0.18	p1	1	0.333333	0.333333	1	1	0.11
p2	0.7	1.0	0.3	0.9	0.8	0.13	p2	3	1	1	3	3	0.33
p3	2.3	3.0	1.0	2.9	2.6	0.40	p3	3	1	1	3	3	0.33
p4	0.8	1.1	0.3	1.0	0.9	0.14	p4	1	0.333333	0.333333	1	1	0.11
p5	0.9	1.2	0.4	1.1	1.0	0.15	p5	1	0.333333	0.333333	1	1	0.11
Total	5.65476	7.63788	2.51009	7.17519	6.47372	1	Total	9	3	3	9	9	1
Financial standing	p1	p2	p3	p4	p5	CR WT	B/C	p1	p2	p3	p4	p5	CR WT
p1	1	1	1	1	1	0.20	p1	1.0	1.9	0.7	0.8	2.0	0.21
p2	1	1	1	1	1	0.20	p2	0.5	1.0	0.4	0.4	1.1	0.11
p3	1	1	1	1	1	0.20	p3	1.4	2.5	1.0	1.0	2.7	0.29
p4	1	1	1	1	1	0.20	p4	1.3	2.5	1.0	1.0	2.6	0.28
p5	1	1	1	1	1	0.20	p5	0.5	0.9	0.4	0.4	1.0	0.11
Total	5	5	5	5	5	1	Total	4.71838	8.81717	3.47769	3.56286	9.39612	1

NORMALIZATION and PRIORITY CALCULATIONS

profit	p1	p2	p3	p4	p5	cr wt
p1	0.18148	0.18148	0.18148	0.18148	0.18148	0.18148
p2	0.25981	0.25981	0.25981	0.25981	0.25981	0.25981
p3	0.29429	0.29429	0.29429	0.29429	0.29429	0.29429
p4	0.13031	0.13031	0.13031	0.13031	0.13031	0.13031
p5	0.13411	0.13411	0.13411	0.13411	0.13411	0.13411
	1	1	1	1	1	

RESOUR(	p1	p2	p3	p4	p5	CR WT
p1	0.18	0.18	0.18	0.18	0.18	0.176842
p2	0.13	0.13	0.13	0.13	0.13	0.130926
p3	0.40	0.40	0.40	0.40	0.40	0.398392
p4	0.14	0.14	0.14	0.14	0.14	0.139369
p5	0.15	0.15	0.15	0.15	0.15	0.154471
	5.654761	7.637882	2.510093	7.175187	6.473716	1

B/C	p1	p2	p3	p4	p5	CR WT
p1	0.211937	0.211937	0.211937	0.211937	0.211937	0.2119
p2	0.113415	0.113415	0.113415	0.113415	0.113415	0.1134
p3	0.287547	0.287547	0.287547	0.287547	0.287547	0.2875
p4	0.280674	0.280674	0.280674	0.280674	0.280674	0.2807
p5	0.106427	0.106427	0.106427	0.106427	0.106427	0.1064

Financial Standing	p1	p2	p3	p4	p5	CR WT
p1	0.2	0.2	0.2	0.2	0.2	0.2
p2	0.2	0.2	0.2	0.2	0.2	0.2
p3	0.2	0.2	0.2	0.2	0.2	0.2
p4	0.2	0.2	0.2	0.2	0.2	0.2
p5	0.2	0.2	0.2	0.2	0.2	0.2
	1	1	1	1	1	1

RISK	p1	p2	p3	p4	p5	CR WT
p1	0.111111	0.111111	0.111111	0.111111	0.111111	0.111111
p2	0.333333	0.333333	0.333333	0.333333	0.333333	0.333333
p3	0.333333	0.333333	0.333333	0.333333	0.333333	0.333333
p4	0.111111	0.111111	0.111111	0.111111	0.111111	0.111111
p5	0.111111	0.111111	0.111111	0.111111	0.111111	0.111111
	1	1	1	1	1	1

CONSISTENCY CALCULATIONS

profit	p1	p2	p3	p4	p5	CR WT
p1	1	0.70	0.62	1.39	1.35	0.18
p2	1.4	1.0	0.9	2.0	1.9	0.26
p3	1.6	1.1	1.0	2.3	2.2	0.29
p4	0.7	0.5	0.4	1.0	1.0	0.13
p5	0.7	0.5	0.5	1.0	1.0	0.13
λ max= 5.1		CI=0.01407		CR= 0.01256<0.1		

B/C	p1	p2	p3	p4	p5	CR WT
p1	1.0	1.9	0.7	0.8	2.0	0.21
p2	0.5	1.0	0.4	0.4	1.1	0.11
p3	1.4	2.5	1.0	1.0	2.7	0.29
p4	1.3	2.5	1.0	1.0	2.6	0.28
p5	0.5	0.9	0.4	0.4	1.0	0.11
λ max= 4.28		CI=-0.177		CR= -0.15<0.1		

RISK	p1	p2	p3	p4	p5	CR WT
p1	1	0.3333	0.33	1	1	0.11
p2	3	1	1	3	3	0.33
p3	3	1	1	3	3	0.33
p4	1	0.3333	0.33	1	1	0.11
p5	1	0.3333	0.33	1	1	0.11
λ max= 5.05		CI=0.0126		CR= 0.01127<0.1		

RESOURCE	p1	p2	p3	p4	p5	CR WT
p1	1.0	1.4	0.4	1.3	1.1	0.18
p2	0.7	1.0	0.3	0.9	0.8	0.13
p3	2.3	3.0	1.0	2.9	2.6	0.40
p4	0.8	1.1	0.3	1.0	0.9	0.14
p5	0.9	1.2	0.4	1.1	1.0	0.15
λ max= 5.1		CI=0.0272		CR= 0.00242<0.1		

Financial standing	p1	p2	p3	p4	p5	CR WT
p1	1	1	1	1	1	0.20
p2	1	1	1	1	1	0.20
p3	1	1	1	1	1	0.20
p4	1	1	1	1	1	0.20
p5	1	1	1	1	1	0.20
λ max= 5.144		CI=0.03618		CR= 0.0323<0.1		

Appendix C. Road construction projects in Adama and their allocated Budget

No.	Projet Name	Allocated budjet for 2015/16	Town	Client	Consultant Name & Grade	Contractor Name & Grade
1	Asfaaltii road Back of Aba Geda	262,396,767.8	Adama	ACM	ECO	ANWAR SEID
2	Moenco Bridge	127,623,48.54	Adama	ACM	TCD	IDRIS AHMED
3	Gravel road express way 0+00-1+700km & Around Bole prep. school	143,654,554.3	Adama	ACM		KIDKON
4	Gravel road from ASella Asfalt to Ali Birra road	106,355,689.7	Adama	ACM		KIDKON
5	Gravel Road from Flora recreation to deka Adi kebele	113,214,084.6	Adama	ACM		KIDKON
6	Gravel road from jemal store to Around sheria court and sekelo and Rob gebeya	909,763,75.18	Adama	ACM		TUTAD
7	Gravel road infront of Goro school and Tractor factory to 40m Asefalt	462,991,034.68	Adama	ACM		DACHO D.
8	Asfaaltii road Sheria court to Dagega Kebele	139,436,111.2	Adama	ACM	TCD	ANWAR SEID
9	Gravel road Etur to Awash RIVER	335,346,021.49	Adama	ACM		GGC GC
10	Asphalt maintenance	126,837,410	Adama	ACM		Dursif EMI
11	Asphalt maintenance	134,346,277.5	Adama	ACM		SUBI EMI
12	Asphalt maintenance	158,714,379.8	Adama	ACM		Robibon
13	Asphalt road G. Wako Gutu to Sheria court	290,408,080.2	Adama	ACM	TCD	ANWAR SEID
14	Asphalt road Express way to Etur	268,563,655.2	Adama	ACM	ECO	GGC GC
15	Gravel road Express way to Boku spring	323,626,315.1	Adama	ACM		KIDKON GC
16	Gravel road Moenco to 40m and Finfine asphalt to Sire Aba bune secandary school	125,481,595.5	Adama	ACM	ECO	AKLESIYA GC

17	Asfaaltii road	535,985,954.45	Adama	ACM	ECO	Aniwar seid GC
18	Coble Stone Road	4,532,798.86	Adama	ACM		OLIF
19	Coble Stone Road	4,532,798.86	Adama	ACM		FALMII
20	Coble Stone Road	4,139,920.85	Adama	ACM		BURQAA
21	Coble Stone Road	4,532,798.86	Adama	ACM		IRREE
22	Coble Stone Road	4,532,798.86	Adama	ACM		MO'AB
23	Coble Stone Road	5,502,281.55	Adama	ACM		Hunde R&B
24	Coble Stone Road	5,502,281.55	Adama	ACM		Birmaji R&B
25	Walk way	6,245,050.7	Adama	ACM		Hiriya R&B
26	Walk way	7,035,757.59	Adama	ACM		Walif Gachena
27	Walk way	8,449,403.87	Adama	ACM		Walabuma R&B
28	Walk way	11,705,190.14	Adama	ACM		Hawinet R&B
29	Walk way	12,02,3097.1	Adama	ACM		Kanko R&B
30	Walk way	12,023,097.1	Adama	ACM		Walif R&B

Appendix D. Respondent's response data

Respondents Data (1-45)																																															
`		Codin	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	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Profit	Risk	R1	1	2	3	7	3	1	1	5	1	3	3	1	3	1	1	3	1	3	1	1	1	1	1	3	5	1	1	2	1	3	1	3	1	1	3	3	3	1	1	3	1	3	5	3	3
	Measure of Worth	R2	3	2	3	3	3	3	5	2	3	2	3	1	5	5	5	5	3	5	5	2	3	2	3	9	7	7	3	5	7	3	3	1	7	7	7	7	7	7	3	7	2	3	1	3	3
	Financial Standing	R3	1	5	3	5	1	1	1	1	3	1	3	1	1	1	1	5	1	1	5	3	1	1	3	3	5	5	1	1	3	1	3	1	1	3	3	1	3	3	1	1	1	3	3	3	1
	Resource	R4	1	3	4	5	1	2	1	3	1	2	3	1	1	1	3	3	1	2	5	5	3	2	5	7	5	5	5	3	1	1	1	3	3	1	1	3	1	1	3	1	3	1	1	3	3
	Economic Factors	R5	1	5	3	5	3	7	5	5	3	5	3	5	3	3	7	3	3	3	3	5	5	5	7	3	5	1	1	7	1	5	5	1	3	3	1	1	3	1	1	3	1	1	1	3	3
	Experience	R6	3	5	7	7	8	7	3	3	9	6	5	3	6	1	9	5	5	6	3	7	5	9	9	5	3	5	7	1	5	1	1	7	7	3	1	7	5	1	2	3	3	3	3	1	1
	Technical Ability	R7	3	7	5	9	8	5	9	3	7	5	1	7	3	3	7	3	5	7	1	7	5	5	9	5	3	7	1	3	1	7	3	1	1	3	5	3	3	5	7	3	3	5	7	3	1
	Size and Complexity	R8	3	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	7	3	1	5	7	3	1	7	5	3	1	1	3	1	3	1	3	1	1	3
	Duration	R9	1	7	9	9	1	6	7	3	9	9	7	7	8	1	9	1	3	9	3	7	7	6	9	9	3	3	1	3	1	3	3	7	2	1	3	1	3	1	5	7	1	2	3	5	7
	Organizational Culture	R10	7	3	2	9	2	1	1	9	1	0.3	5	1	0.3	5	3	5	0.2	1	1	1	0.3	3	7	1	7	3	3	3	3	3	3	3	1	1	1	7	1	3	1	1	3	3	1	5	1
	Environmental Factors	R11	7	7	1	5	9	1	1	9	1	0.2	5	1	1	3	1	9	0.3	1	3	1	0.3	0.3	6	1	7	9	9	7	7	7	7	7	7	9	9	5	5	5	1	3	7	5	5	7	9
	Location Factors	R12	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	5	2	9	9	2	1	9	3	1	7	1	1	3	3	3	1	2	3	3	3
	Social Responsibility	R13	7	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	1	5	5	9	5	3	7	5	3	3	7	0.2	3	7	5	5	3	5	9	5
	Political Factors	R14	9	7	7	7	9	7	3	9	8	5	7	1	5	5	7	7	5	7	5	7	5	8	2	5	7	9	7	3	9	8	5	7	5	5	5	7	7	5	7	5	7	5	9	2	5
Risk	Measure of Worth	R15	5	7	5	5	4	5	7	9	6	3	7	5	5	3	5	0.1	3	5	5	5	3	5	2	3	9	4	5	7	9	6	3	7	5	5	3	5	0.1	3	5	5	5	3	5	2	3
	Financial Standing	R16	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	9	5	7	7	5	3	7	7	5	5	5	5	3	7	7	5	3	3	7	3
	Resource	R17	1	7	7	5	1	8	5	7	8	5	7	5	6	7	9	7	7	7	5	7	8	3	7	7	9	1	8	5	7	8	5	7	5	6	7	9	7	7	7	5	7	8	3	7	7
	Economic Factors	R18	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	9	2	3	5	1	1	7	3	1	7	1	5	1	2	1	1	1	1	5	1
	Experience	R19	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	9	5	1	5	3	3	7	1	2	7	5	5	3	2	1	3	3	2	5	5
	Technical Ability	R20	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	9	5	7	5	6	5	5	7	4	7	4	1	5	5	3	5	5	5	5	5
	Size and Complexity	R21	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	1	7	3	5	8	7	5	3	7	5	7	3	7	7	3	7	7	9	3	7
	Duration	R22	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	1	5	9	5	5	3	3	5	6	5	5	5	6	5	3	5	5	3	3	5
	Organizational Culture	R23	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	6	5	7	5	5	3	7	7	6	1	5	7	6	3	5	5	5	3	3	5
	Environmental Factors	R24	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	1	7	5	5	8	8	7	3	9	7	7	5	9	7	3	9	8	3	3	9
	Location Factors	R25	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	9	3	1	3	2	3	1	1	3	7	3	3	3	4	7	3	3	3	7	5
	Social Responsibility	R26	9	5	5	7	9	7	5	7	5	7	5	5	4	5	5	5	5	7	5	5	5	5	4	5	1	9	7	5	7	5	7	5	5	4	5	5	5	5	7	5	5	5	5	4	5
	Political Factors	R27	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	1	9	1	7	7	7	5	3	6	7	7	1	7	7	5	7	7	7	4	7
Measure of Worth	Financial Standing	R28	9	5	5	5	1	7	5	3	5	5	5	5	5	1	5	5	5	7	5	5	5	5	2	7	1	1	7	5	3	5	5	5	5	5	1	5	5	5	7	5	5	5	5	2	7
	Resource	R29	1	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	3	7	7	9	3	5	5	7	5	7	6	0.2	6	5	7	5	5	5	2	5
	Economic Factors	R30	1	7	7	5	1	8	5	9	7	7	3	7	7	1	9	3	8	9	9	7	7	8	2	7	5	1	8	5	9	7	7	3	7	7	1	9	3	8	9	9	7	7	8	2	7
	Experience	R31	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	1	5	7	9	3	3	7	5	3	7	3	5	3	3	9	3	3	3	3	5
	Technical Ability	R32	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	1	6	3	9	9	5	7	3	3	9	5	3	5	6	1	5	5	5	2	7
	Size and Complexity	R33	9	7	7	9	9	7	7	7	7	3	7	5	3	7	3	5	3	4	1	3	5	3	2	7	7	9	7	7	7	7	3	7	5	3	7	3	5	3	4	1	3	5	3	2	7
	Duration	R34	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	5	7	7	9	5	3	7	7	3	7	3	5	3	5	3	3	5	3	2	5
	Organizational Culture	R35	1	7	9	5	1	9	5	9	9	6	7	7	5	7	7	7	2	7	7	7	6	6	2	9	9	1	9	5	9	9	6	7	7	5	7	7	7	2	7	7	7	6	6	2	9
	Environmental Factors	R36	1	5	7	9	2	3	1	3	3	1	2	1	1	7	7	3	2	5	9	5	3	3	5	5	5	2	3	1	3	3	1	2	1	1	7	7	3	2	5	9	5	3	3	5	5
	Location Factors	R37	1	3	5	9	2	1	5	3	5	1	2	3	1	7	5	7	1	3	9	3	1	1	5	3	3	2	1	5	3	5	1	2	3	1	7	5	7	1	3	9	3	1	1	5	3
	Social Responsibility	R38	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	2	1	7	9	3	1	2	1	1	7	5	5	1	1	7	3	1	1	5	3
	Political Factors	R39	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	4	5	5	9	7	2	2	1	3	7	7	7	4	6	9	5	4	4	5	5

Respondents Data (1-45)																																															
`		Codin	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	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Financial Standing	Resource	R40	7	1	2	9	9	1	5	3	1	0.2	1	5	0.3	7	1	5	3	5	7	5	0.3	1	5	3	3	9	1	5	3	1	0.2	1	5	0.3	7	1	5	3	5	7	5	0.3	1	5	3
	Economic Factors	R41	1	1	1	9	7	1	7	3	1	1	5	3	0.3	7	1	7	1	3	9	5	0.3	1	2	1	7	7	1	7	3	1	1	5	3	0.3	7	1	7	1	3	9	5	0.3	1	2	1
	Experience	R42	1	1	3	9	5	5	5	3	3	5	7	1	1	7	3	5	2	5	9	7	3	2	2	5	8	5	5	5	3	3	5	7	1	1	7	3	5	2	5	9	7	3	2	2	5
	Technical Ability	R43	9	3	1	7	9	3	1	3	1	1	2	3	0.3	1	1	7	1	1	7	3	1	1	2	1	9	9	3	1	3	1	1	2	3	0.3	1	1	7	1	1	7	3	1	1	2	1
	Size and Complexity	R44	7	3	5	7	1	5	1	3	3	5	2	1	1	3	5	5	3	5	9	5	3	2	2	7	7	1	5	1	3	3	5	2	1	1	3	5	5	3	5	9	5	3	2	2	7
	Duration	R45	9	3	5	9	3	5	3	9	1	3	7	1	1	5	1	9	1	1	9	5	3	1	5	5	5	3	5	3	9	1	3	7	1	1	5	1	9	1	1	9	5	3	1	5	5
	Organizational Culture	R46	1	5	7	7	8	7	3	3	9	6	1	3	6	1	9	5	5	6	3	7	5	9	9	5	3	8	7	3	3	9	6	1	3	6	1	9	5	5	6	3	7	5	9	9	5
	Environmental Factors	R47	9	7	5	9	8	5	9	3	7	4	1	7	4	3	7	3	5	7	1	7	5	5	9	5	3	8	5	9	3	7	4	1	7	4	3	7	3	5	7	1	7	5	5	9	5
	Location Factors	R48	1	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	1	5	7	3	7	5	1	9	4	3	5	0.2	5	5	3	5	5	5	9	7
	Social Responsibility	R49	9	7	9	9	1	6	7	3	9	9	7	7	8	1	9	1	3	9	3	7	7	6	9	9	3	1	6	7	3	9	9	7	7	8	1	9	1	3	9	3	7	7	6	9	9
	Political Factors	R50	1	3	2	9	2	1	1	9	1	0.3	5	1	0.3	5	3	5	0.2	1	1	1	0.3	0.2	7	1	7	2	1	1	9	1	0.3	5	1	0.3	5	3	5	0.2	1	1	1	0.3	0	7	1
Resource	Economic Factors	R51	1	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	3	7	7	9	3	5	5	7	5	7	6	0.2	6	5	7	5	5	5	2	5
	Experience	R52	1	7	7	5	1	8	5	9	7	7	3	7	7	1	9	3	8	9	9	7	7	8	2	7	5	1	8	5	9	7	7	3	7	7	1	9	3	8	9	9	7	7	8	2	7
	Technical Ability	R53	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	1	5	7	9	3	3	7	5	3	7	3	5	3	3	9	3	3	3	3	5
	Size and Complexity	R54	1	7	9	9	1	6	3	9	9	5	7	3	3	9	5	3	5	6	1	5	5	5	2	7	5	1	6	3	9	9	5	7	3	3	9	5	3	5	6	1	5	5	5	2	7
	Duration	R55	9	7	7	9	9	7	7	7	7	3	7	5	3	7	3	5	3	4	1	3	5	3	2	7	7	9	7	7	7	7	3	7	5	3	7	3	5	3	4	1	3	5	3	2	7
	Organizational Culture	R56	7	7	5	5	5	7	7	9	5	3	7	7	3	7	3	5	3	5	3	3	5	3	2	5	9	5	7	7	9	5	3	7	7	3	7	3	5	3	5	3	3	5	3	2	5
	Environmental Factors	R57	3	7	9	5	1	9	5	9	9	6	7	7	5	7	7	7	2	7	7	7	6	6	2	9	9	1	9	5	9	9	6	7	7	5	7	7	7	2	7	7	7	6	6	2	9
	Location Factors	R58	3	5	7	9	2	3	1	3	3	1	2	1	1	7	7	3	2	5	9	5	3	3	5	5	5	2	3	1	3	3	1	2	1	1	7	7	3	2	5	9	5	3	3	5	5
	Social Responsibility	R59	7	3	5	9	2	1	5	3	5	1	2	3	1	7	5	7	1	3	9	3	1	1	5	3	3	2	1	5	3	5	1	2	3	1	7	5	7	1	3	9	3	1	1	5	3
	Political Factors	R60	5	7	9	9	1	6	3	9	9	5	7	3	3	9	5	3	5	6	1	5	5	5	2	7	5	1	6	3	9	9	5	7	3	3	9	5	3	5	6	1	5	5	5	2	7
Economic Factors	Experience	R61	1	1	3	3	3	1	1	5	3	1	3	1	1	1	2	5	0.3	3	9	3	0.3	1	4	3	5	3	1	1	5	3	1	3	1	1	1	2	5	0.3	3	9	3	0.3	1	4	3
	Technical Ability	R62	1	1	3	7	3	1	1	5	1	0.3	3	1	0.3	1	1	3	0.2	1	7	1	0.2	0.3	4	3	5	3	1	1	5	1	0.3	3	1	0.3	1	1	3	0.2	1	7	1	0.2	0	4	3
	Size and Complexity	R63	3	5	3	7	1	1	1	5	3	0.2	3	1	0.3	1	1	5	1	1	5	3	0.3	0.3	9	3	5	1	1	1	5	3	0.2	3	1	0.3	1	1	5	1	1	5	3	0.3	0	9	3
	Duration	R64	3	3	4	5	1	2	1	3	5	2	3	1	1	1	3	9	1	2	5	5	3	2	5	7	5	1	2	1	3	5	2	3	1	1	1	3	9	1	2	5	5	3	2	5	7
	Organizational Culture	R65	5	5	3	7	6	7	5	5	4	5	3	5	4	3	7	3	3	4	3	5	5	5	7	7	5	6	7	5	5	4	5	3	5	4	3	7	3	3	4	3	5	5	5	7	7
	Environmental Factors	R66	7	5	7	7	8	7	3	3	9	6	1	3	6	1	9	5	5	6	3	7	5	9	9	5	3	8	7	3	3	9	6	1	3	6	1	9	5	5	6	3	7	5	9	9	5
	Location Factors	R67	7	7	5	9	8	5	9	3	7	4	1	7	4	3	7	3	5	7	1	7	5	5	9	5	3	8	5	9	3	7	4	1	7	4	3	7	3	5	7	1	7	5	5	9	5
	Social Responsibility	R68	9	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	1	5	7	3	7	5	1	9	4	3	5	0.2	5	5	3	5	5	5	9	7
	Political Factors	R69	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	1	6	7	3	9	9	7	7	8	1	9	1	3	9	3	7	7	6	9	9
Experience	Technical Ability	R70	1	3	2	9	2	1	1	9	1	0.3	5	1	0.3	5	3	5	0.2	1	1	1	0.3	0.2	7	1	7	2	1	1	9	1	0.3	5	1	0.3	5	3	5	0.2	1	1	1	0.3	0	7	1
	Size and Complexity	R71	1	7	1	5	9	1	1	9	1	0.2	5	1	1	3	1	9	0.3	1	3	1	0.3	0.3	6	1	7	9	1	1	9	1	0.2	5	1	1	3	1	9	0.3	1	3	1	0.3	0	6	1
	Duration	R72	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	9	2	1	9	3	1	7	1	1	3	2	3	1	2	3	3	3	1	9	3
	Organizational Culture	R73	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	1	5	5	9	5	3	7	5	3	3	7	0.2	3	7	5	5	3	5	9	5
	Environmental Factors	R74	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	9	7	3	9	8	5	7	1	5	5	7	7	5	7	5	7	5	8	2	5
	Location Factors	R75	5	7	5	5	4	5	7	9	6	3	7	5	5	3	5	0.1	3	5	5	5	3	5	2	3	9	4	5	7	9	6	3	7	5	5	3	5	0.1	3	5	5	5	3	5	2	3
	Social Responsibility	R76	5	7	3	5	9	5	7	7	5	3	7	7	5	5	5	5	3	7	7	5	3	3	7	3	9	9	5	7	7	5	3	7	7	5	5	5	5	3	7	7	5	3	3	7	3
	Political Factors	R77	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	1	8	5	7	8	5	7	5	6	7	9	7	7	7	5	7	8	3	7	7
Technical Ability	Size and Complexity	R78	3	7	1	9	9	2	3	5	1	1	7	3	1	7	1	5	1	2	1	1	1	1	5	1	9	9	2	3	5	1	1	7	3	1	7	1	5	1	2	1	1	1	1	5	1
	Duration	R79	1	7	4	9	9	5	1	5	3	3	7	1	2	7	5	5	3	2	1	3	3	2	5	5	7	9	5	1	5	3	3	7	1	2	7	5	5	3	2	1	3	3	2	5	5
	Organizational Culture	R80	1	7	5	7	9	5	7	5	6	5	5	7	4	7	4	1	5	5	3	5	5	5	5	5	9	9	5	7	5	6	5	5	7	4	7	4	1	5	5	3	5	5	5	5	5
	Environmental Factors	R81	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	1	7	3	5	8	7	5	3	7	5	7	3	7	7	3	7	7	9	3	7
	Location Factors	R82	5	7	7	7	1	5	9	5	5	3	3	5	6	5	5	5	6	5	3	5	5	3	3	5	7	1	5	9	5	5	3	3	5	6	5	5	5	6	5	3	5	5	3	3	5
	Social Responsibility	R83	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	6	5	7	5	5	3	7	7	6	1	5	7	6	3	5	5	5	3	3	5
	Political Factors	R84	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	1	7	5	5	8	8	7	3	9	7	7	5	9	7	3	9	8	3	3	9

Respondents Data (1-45)

`		Codin	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	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Size and Complexity	Duration	R85	1	5	3	9	9	3	1	3	2	3	1	1	3	7	3	3	3	4	7	3	3	3	7	5	1	9	3	1	3	2	3	1	1	3	7	3	3	3	4	7	3	3	3	7	5
	Organizational Culture	R86	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	9	7	5	7	5	7	5	5	4	5	5	5	5	7	5	5	5	5	4	5
	Environmental Factors	R87	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	1	9	1	7	7	7	5	3	6	7	7	1	7	7	5	7	7	7	4	7
	Location Factors	R88	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	1	7	5	3	5	5	5	5	5	1	5	5	5	7	5	5	5	5	2	7
	Social Responsibility	R89	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	3	7	7	9	3	5	5	7	5	7	6	0.2	6	5	7	5	5	5	2	5
	Political Factors	R90	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	1	8	5	9	7	7	3	7	7	1	9	3	8	9	9	7	7	8	2	7
Duration	Organizational Culture	R91	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	1	5	7	9	3	3	7	5	3	7	3	5	3	3	9	3	3	3	3	5
	Environmental Factors	R92	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	1	6	3	9	9	5	7	3	3	9	5	3	5	6	1	5	5	5	2	7
	Location Factors	R93	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	9	7	7	7	7	3	7	5	3	7	3	5	3	4	1	3	7	3	2	7
	Social Responsibility	R94	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	5	7	7	9	5	3	7	7	3	7	3	5	3	5	3	3	5	3	2	5
	Political Factors	R95	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	1	9	5	9	9	6	7	7	5	7	7	7	2	7	7	7	6	6	2	9
Organizational Cultur	Environmental Factors	R96	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	2	3	1	3	3	1	2	1	1	7	7	3	2	5	9	5	3	3	5	5
	Location Factors	R97	3	3	5	9	1	1	5	3	5	1	2	3	1	7	5	7	1	3	9	3	1	1	5	3	3	2	1	5	3	5	1	2	3	1	7	5	7	1	3	9	3	3	1	5	3
	Social Responsibility	R98	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	2	1	7	9	3	1	2	1	1	7	5	5	1	1	7	3	1	1	5	3
	Political Factors	R99	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	4	5	5	9	7	2	2	1	3	7	7	7	4	6	9	5	4	4	5	5
Environmental Factc	Location Factors	R100	1	1	2	9	9	1	5	3	1	0.2	1	5	0.3	7	1	5	3	5	7	5	0.3	1	5	3	3	9	1	5	3	1	0.2	1	5	0.3	7	1	5	3	5	7	5	0.3	1	5	3
	Social Responsibility	R101	1	1	1	9	7	1	7	3	1	1	5	3	0.3	7	1	7	1	3	9	5	0.3	1	2	1	7	7	1	7	3	1	1	5	3	0.3	7	1	7	1	3	9	5	0.3	1	2	1
	Political Factors	R102	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	5	5	5	3	3	5	7	1	1	7	3	5	2	5	9	7	3	2	2	5
Location Factors	Social Responsibility	R103	2	3	1	7	9	3	1	3	1	1	2	3	0.3	1	1	7	1	1	7	3	1	1	2	1	9	9	3	1	3	1	1	2	3	0.3	1	1	7	1	1	7	3	1	1	2	1
	Political Factors	R104	3	3	5	7	1	5	1	3	3	5	2	1	1	3	5	5	3	5	9	5	3	2	2	7	7	1	5	1	3	3	5	2	1	1	3	5	5	3	5	9	5	3	2	2	7
Social Responsibility	Political Factors	R105	3	9	5	5	3	5	3	9	1	3	7	1	1	5	1	9	1	1	9	5	3	1	5	5	5	3	5	3	9	1	3	7	1	1	5	1	9	1	1	9	5	3	1	5	5