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Department of Construction Technology and Management

Program: MSc. in Construction Management

A Study on Improving Project Delivery Method Selection Criteria Practice on Ethiopian Road Authority

By

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Advisor: - Wubishet Jekale (Dr. Eng.)

September, 2020

Addis Ababa, Ethiopia

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ETHIOPIN INSTITUTE OF ARCHITECTURE BUILDING CONTRUCTION AND CITY DEVELOPMENT
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To you all I wish blessings from God.

Acronyms

AHP	Analytical Hierarchical Process
CA	Contract Administration
CM	Construction Management
DB	Design Build
DBB	Design Bid Build
DM	Delivery Method
DMS	Delivery Method Selection
DSS	Decision Support System
ERA	Ethiopian Road Authority
ERCCO	Ethiopian Roads Construction Corporation
FIDIC	Federation International Des Ingénieurs Councils
GDP	Growth Domestic Product
MAUT	Multi Attribute Utility Theory
OPRC	Output Performance Rate Contract
PDM	Project Delivery Method
PM	Procurement Method
PP	Project Performance
PPP	Public Private Partnership
ROW	Right of Way
RSDP	Road Sector Development Program
VO	Variation Order

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Abstract

Construction industry in Ethiopia is one of the fast growing industries with significant share in the GDP. It has an important contribution to the economy which involves various infrastructure developments. One of the major infrastructure elements is the road sector. Ethiopian Road authority has a long history in providing road infrastructure primarily in the country.

A project delivery method (PDM) is a framework that determines the relationship and responsibilities of client, contractor and consultant. The decision to select delivery method should be based on a systematic approach that includes all available PDMs. The project under the Ethiopian Roads Authority ERA, continue to face great challenges when it comes to delivering projects by selecting the most appropriate DM for its projects. The general practice in this institution is largely depends on culture of the ERA board' reliance on their familiarity and experience with a particular method.

With this background, this study provides a comprehensive solution for this challenges of ERA. 27 criterions under four group of delivery method selection criteria are identified in this research effort. The criteria are identified through questionnaire survey from client, consultant and contractor perspectives. The result is analysed using Relative Importance Index(RII). Project actual challenges are thoroughly discussed based on 22 selected case study projects that are completed under RSDP IV and RSDP V. The analysis clarifies main challenges of ERA's projects. The major challenges identified are: Right of way, variation orders, scope change, design change and adverse weather conditions. A sufficient set of critical issues are defined in this study and advantages/disadvantages of each delivery method is thoroughly studied with respect to the issues concentrating on the effects of PDM option on the project challenges. The study covers both the available PDMs (i.e. Design-Bid-Build (DBB), Design Build (DB). The model for selecting appropriate delivery method is developed using Multi-attribute decision tools to select a PDM in this research for case study projects. The model was verified using case study project. The model provides useful information and introduces the advantages and limitations of each PDM to the decision makers. an essential well-structured decision making process is embedded in the proposed framework of this study as a result of the analysis that is reliable and sufficient to solve the problem of selecting an appropriate PDM.

Key word: - ***Delivery method selection criteria, project challenges, Multi Attribute Utility Theory***

CHAPTER 1
1. INTRODUCTION

1.1 Background to the Study

Construction in Ethiopia is one of the sectors leading the economic contribution through its own economic activity directed from the concept to implementation phase of fixed assets in the form of buildings, land improvements of an engineering nature, and other such engineering constructions as roads, bridges, dams, etc. (Association, 2006/7). It is also contributing for overall development. It has important contributions to the Ethiopian economy, as demonstrated by its share growth up to 8.5% in the GDP (Parilament, 2011/12), (wondifraw Zerihun, *et al*, 2016). The sector has registered a significant growth, over the last more than 11 years. There has been increased investment on the development and expansion of various infrastructure projects (Parilament, 2011/12).

This fundamental growth of the industry has different major problems which arise due to several causes. Some of the main challenges or problems of the industry are cost overrun, time delay, defect in quality and variation related problems (Rahel, 2016). The construction industry projects, excluding of the hydro power construction, delivery method is mainly relay on Design-Bid-Build for its long journey but recently Design-Build delivery method is practicable in Building and Road construction sectors. There are also an emerging delivery methods like OPRC and PPP which are believed to improve the major challenges of the industry in financial shortage, Quality, Time delay and Cost overrun because private organization is financing, planning and operating the public projects (Graham Miller, *et al* 2009). Even though the industry practiced DBB and DB for its sectors, there is no standard guidance on evaluating selection criteria to select the appropriate delivery method for public sectors especially for infrastructure.

The infrastructure construction as a sector takes the major contribution for the development of the industry which also shares the above-mentioned problems of the industry. Among this the road construction is one major sector which has a long history of establishment and development in providing the main and primary road infrastructure in Ethiopia before and after the establishment of Ethiopian Road authority.

The start of road construction in Ethiopia has long story in unstructured manner before the establishment of Ethiopian Road Authority in 1978. In mid-1975, ERA's Force Account Construction capacity expanded and executed major projects such as: - The rehabilitation of the Addis-Awash-Mile road with World Bank and Government funding The Construction of feeder roads and service to traffic roads such as the Bonga-Mizan, Mizan-Gore-Tepi and Gore-Gambella between 1979 to 1982 and in the period of 1984 to 1987. During this time, Nekempt-Bure, Gore-Tepi, Injibara-Beles, Holeta-Muger, Mota-Bahirdar, Mizan Tepi, Shishinda-tepi and the asphalt overlaying of the Addis-Awash-Mile road was completed successfully (ERA history documents).

The practice of ERA on project delivery, the organization has been using force account delivery method to undertake projects by the capacity of the organization from its establishment but the increasing requirements of road construction development through the involvement of road contractors led the authority to award contractors and construct many projects. From that time on wards Design-Bid-Build (DBB) delivery method becomes the sole project delivery method. This Design-Bid-Build (DBB) traditional delivery method aimed at meeting the changing demand of clients or customers. The dynamic forces are now shifted to the DB, PPP and OPRC delivery methods. Different delivery methods have brought changes not only to the process and procedure of project delivery but also the aspects of management and organization. Therefore, the concept of delivery method and areas of application should be seen from different literatures.

In 2009, ERA establish the DB directorate to initiate the DB alternative delivery method due to ERA's project evaluation report result. The report indicated that the major causes for time and cost overrun was design related problems. In order to reduce this problem transferring the design risk to the contractor was believed as a solution and DB delivery method was the better method to transfer the design risk to the contractor. Based on that DB was officially emerged as the alternative delivery method in addition to DBB and force account. The implementation of DB method also influenced by the foreign funding organizations like World Bank as a requirement for funding projects. The introduction of various project delivery method was induced by the quest for more efficient and speedier project delivery and better project performance.

From the technical assistance report by (SMEC, 2018) ERA in its Modernization Framework identified the following seven issues which have hindered its goal:

- Greater demand for transparency in Road and Project Administration
- Greater demand for minimizing Increased Cost and Time Overruns
- Adoption of greater Customer focus attitude; hence demand for an Open and broad understanding of the Sector Problems
- Greater demand for efficiency in all operations, leading to better results and quality
- Rapid improvement in ERA's Performance
- Increased use of New Management and Technological Aspects
- More efficient Data Management System

As a result of their study SMEC proposed that, there is a need to develop PDM selection suitability evaluation criteria in order to minimize ERA's issues hindering its performance to successfully achieve its Goal.

1.2 Statement of the Problem

Project delivery method is a one crucial element contributing to project success. The selection of appropriate delivery method is an important step in project execution. The criteria for choosing a suitable delivery method are based on client's objectives and priorities and influenced by project constraints.

One of the reasons for poor project performances is the use of inappropriate project delivery method without any specified selection criteria and framework based on (Eriksson and Westerberg, 2011) findings. The use of an appropriate delivery method to deliver a project has long been recognized by many researchers as an essential requirement to ensure successful performance of the project in terms of time, cost, quality and contract administration in the world for instance, a study by Agha (2016) found that using the most appropriate system and method can result in 5-10% reduction in project costs. He also said, clients may also suffer if they simply base their selection upon experience and the conservative decisions of their in-house experts or consultants. The decision to select the appropriate delivery method to implement for a construction project is crucial.

Though it does not necessary lead to a successful project but with other factors taken into consideration can influence the success of the project. Based on the research by (Hashim *et al*, 2006), the effect of delivery method on project performance in Malaysia found that, one of the principal reasons for poor project performance in the Malaysian construction industry is, project clients often do not take into consideration the right delivery method selection criteria when deciding on which DM to use. Also, argued that many projects have suffered poor performance due to clients' disregard of DM selection criteria when deciding on the right delivery system to adopt on projects at a time of delivery.

In addition, Eriksson and Westerberg (2011) indicated that, the construction industry of many countries frequently receive criticism regarding poor client satisfaction due to inadequate procurement practice relating to little or no focus on DM selection criteria when deciding on the delivery methods. When it comes to our country, while projects are outsourced; there is lack of standard framework as a guideline to consider different delivery method selection criteria for road projects. The primary thing in procurement process of projects is selecting the delivery method which the project will be delivered, and the client, designer and contractor relationship is decided. Even though project delivery method selection needs careful attention and examining of the selection factors to reduce the upcoming related performance problems, currently ERA doesn't use standard framework as a guideline for delivery method selection criteria usage for its projects. From the data's gather through; pilot questionnaires, all the procurement directorate engineers and some planning department heads who involves in delivery method selection, tends to select project delivery method with one or two criteria mainly based on urgency. They do not consider different criteria's to be considered for deciding on the appropriate delivery method and this is due to lack of governance framework to help the selection process.

Recently the technical assistance document prepared by (SMEC, 2018) states "road authorities including Ethiopian Road Authority require a systematic and objective approach on how to select a suitable delivery method from the various alternatives methods that are available.''

Therefore, the main thing here is, introducing the delivery method selection criteria practice to ERA by developing a framework through explaining the selection criteria functions, and their implications on delivery method selection practice in federal roads authority.

1.3 Research Gap

The research gap as stated in the problem statement ERA do not have Delivery Method Selection criteria framework to select appropriate DM

1.4 Objective of the research

1.4.1 General objective

The general objective of this research is to improve project delivery method selection process through introducing Project Delivery method selection criteria for federal road projects.

1.4.2 Specific objectives

The specific objectives of this research, using the ERA projects as a case study, embraced the following objectives:

1. To assess delivery method selection criteria used for Project delivery method selection of ERA.
2. To assess the relationship between delivery method selection and challenges associated with delivery methods
3. To develop an appropriate framework for selecting delivery system for federal road projects

1.5 Research Questions and Hypothesis

1.5.1 Research Questions

To achieve the outlined objectives, there will be a research questions and a hypothesis that this study sought to address.

The questions include is:

1. What are the factors used to select DM in road projects?
2. What are the problems and challenges associated with different DM practiced in ERA projects?
3. How can we select delivery method for federal road projects?

1.5.2 Hypothesis

Project delivery method selection framework can solve the problem and challenges identified in federal road projects.

Null hypothesis

Project delivery method selection framework cannot solve the problem and challenges identified in federal road projects.

1.6 Significance of the study

The outcome of this paper will clearly investigate project delivery methods, project delivery methods selection criteria, project actual challenges and proved a way on how to select appropriated project delivery method through model development. finally, creating a framework to be used for selecting appropriate delivery method for specific road projects through identification of factors affecting project selection.

1.7 Scope or Delimitation of the study

The scope of the research focuses on the DM selection criteria practice for federal road projects only.

1.8 Limitation of the study

Lack of access to project data was the major limitation especially for case study document review.

1.9 Research Methodology and Structure

The research is organized in five chapters as presented below in the following figure.

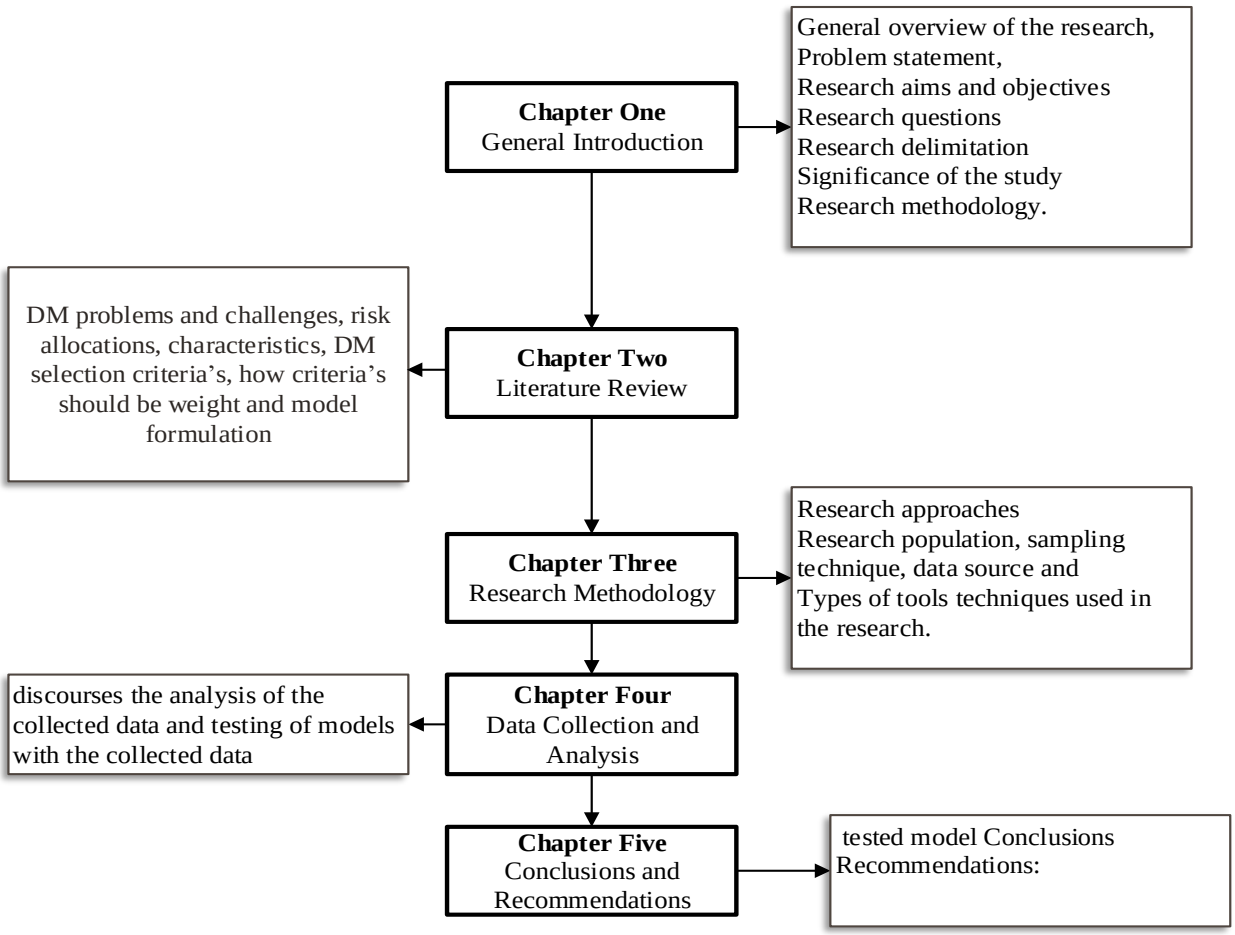

Figure 1.1:Research Methodology and Structure

CHAPTER 2
2. LITERATURE REVIEW

2.1 General

Construction Project Delivery system or Methods (PDM) define the roles, relationships and responsibilities of project team members and the sequence of the activities required to construct or provide a facility. Different scholars define project delivery methods differently though the basics and main concepts are the same therefore, only few are selected here to show what it means.

Project delivery method is the set of roles, responsibilities, relationships and sequences of activities required between team members for a specific project based on (US national institute of standards and technology, 2002). According to CMAA(2012), the choice of delivery method is crucial since project delivery method is the organization of relationships between the parties involved in the design and construction of a project. According to Rahel (2016) in her thesis she defines, the project delivery method as the process by which a project is scientifically (in accepted standard and specification) designed and construct the project. It includes project scope definition; organization of designers, contractors and various consultants; sequencing of design and construction operations; execution of design and construction.

Peter Davis, *et al* (2008) discussed that, delivery methods will direct project owners to consider and decide on arranging when the contractor shall better be engaged along the improvement process or components of the project; influencing ownership and impacts of changes and their far-reaching compensable events. With respect to additional cost and/or extension of completion time; it influences the choices of the subsequent procurement and contracting procedures including their contract types.

Construction Project Delivery Methods (PDM) define the roles, relationships and responsibilities of project team members and the order of the activities required to construct or provide a facility (Washington State Department, 2016). The above-mentioned researchers have basic similarities in specifying the delivery method as a key role in determining the relationship of client with consultant and contractor. Delivery method used as a guidance for contractual agreements between involved parties. In line with this, the key difference is each project delivery method sets different arrangements of roles and responsibilities for different parties.

The operational definition of project delivery method for this research is, delivery method is key process in creating contractual relationships and agreement for the involvement of the three major stakeholders (client, consultant and contractor) that specifies the roles and responsibilities of project team members that are arranged for the activities required to construct for a particular project based on (Washington State Department, 2016).

There are different types of delivery methods used for construction projects in the world, but different delivery methods have their own comparative advantages that identifies one from the other. Therefore, delivery method selection needs careful attention to get the appropriate DM for a single project. The following figure 2.1 described delivery methods which are widely used in the construction of the world.

2.2 Types of Delivery Methods

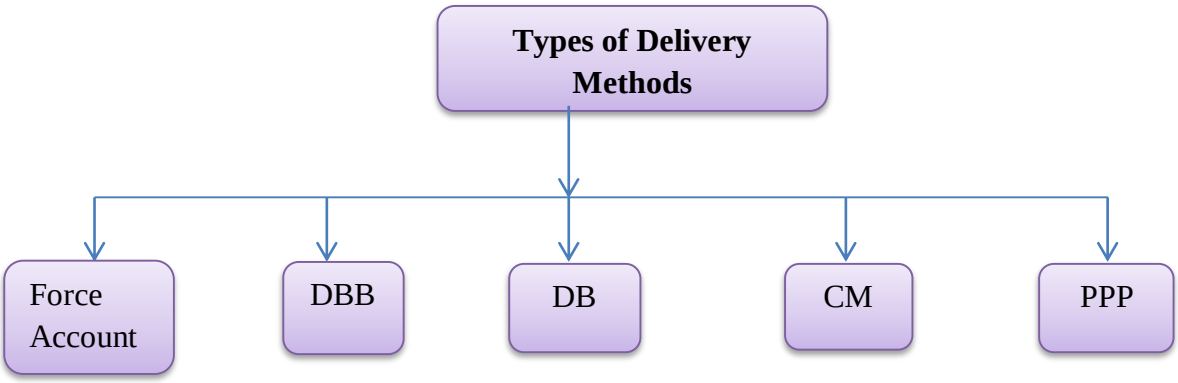

Figure 2.1: Types of delivery methods

2.2.1 Force Account

Is a method where the client decides to construct by own force. Based on the concept of make or buy decision making using transaction costs (G.KLEIN), (LIM, 2001) the client decision depends on the relative costs of internal versus external expenses to the market mechanism and project nature that entails certain costs: discovering the relevant prices, negotiating and enforcing contracts, and so on. Within the firm, the client may be able to reduce the "transaction costs" by coordinating these activities by himself. After having the decision, construction work is undertaken by the owner. According to Wubishet, (2018) and SMEC (2018), Force account project delivery methods are recommended for the following situations:

1. When the project could not attract contractors through open or restrictive competitive procurement approach due to remoteness and/or security problems and/or forcing the employer or direct award to public organization is mandatory;

2. When the project could attract contractors through competitive procurement approach, but the Price is found too high require intervention to ensure value for money; and

3. When emergency situations happened such that time becomes critical or an essence not to wait until competitive procurement approach is used to (re)develop the physical infrastructures.

2.2.2 Design-Bid-Build (DBB)

DBB is the traditional, most widely used and well understood project delivery method in the world (Agha N. I , 2016). In this method, an owner deals with the designer or a consultant for complete design services and then announces and awards a separate construction contract. The contract is based on the designer's prepared construction documents. As a result, the owner is financially liable for cost of design and changes associated with design issues. Since, the owner is responsible for the details of design, the contractor agreed to meet the quality of the construction work based on the prepared design by the designer (Ali Touran, *et al* 2009).

Mathonsi and Thwala (2012) explained that, the traditional method is called traditional because it has been in experienced for such a long time and the only choice available for most clients of the construction industry for many years. Davis et al. (2008) stated that in the traditional approach, the client accepts the design work generally separated from construction work. In other words, consultants are responsible for design and cost management. The contractor is responsible for constructing the work. Over the past several years, the construction industry has experienced different changes never observed before. The increased size and complexity of the construction projects, the financial challenges, the political and social considerations and the information technology are just some of the changes that have occurred. These changes have led to the development of alternative delivery methods other than the traditional one. Natasa and Car-Pušić (2008) stated that, many clients today are dissatisfied with the traditional approach on its operational characteristics and thus, they are actively seeking alternative delivery methods, organization and management to meet the increasingly complex demands on project specific outcomes. DBB is useful for projects that can be designed to near 100% complete. Typical and common projects will benefit the most from the use of DBB as the delivery method. Projects that involve high risk and many unknowns as well as projects that have a limited amount of time to complete the project will not achieve the benefits of DBB.

2.2.2.1 Design-Bid-Build Governance structure

The governance structure of DBB has three fragmentation of obligations in which the client formulates the contract for the design plus procurement service with the designer, construction phase with the contract administration (supervision) consultant and with the contractor. Based on (FIDIC,1999) condition of contract the 'Engineer' or CA consultant contractual rights and responsibilities generally to administer the project like approval of schedule, payment certificate, modify design errors, approve or reject test results, administer claim on behalf of the client (owner)…etc. based on specification and contract clauses. (FIDIC,1999) also stipulates contractual rights and obligations for contractor to execute the work in accordance with the contract within specified time. If he fails to do because of issues beyond his control, he will entitle to claim and compensated, if the delay is due to his fault, he will pay liquidated damage. Figure 2.2 below shows the contractual relationship between the client, consultant and contractor. It is not always the case that designer and contract administration consultant separates in some cases. The client

may agree with one consultant for all consulting works started from the design but in other cases like ERA, the client awards a designer and supervision consultant separately.

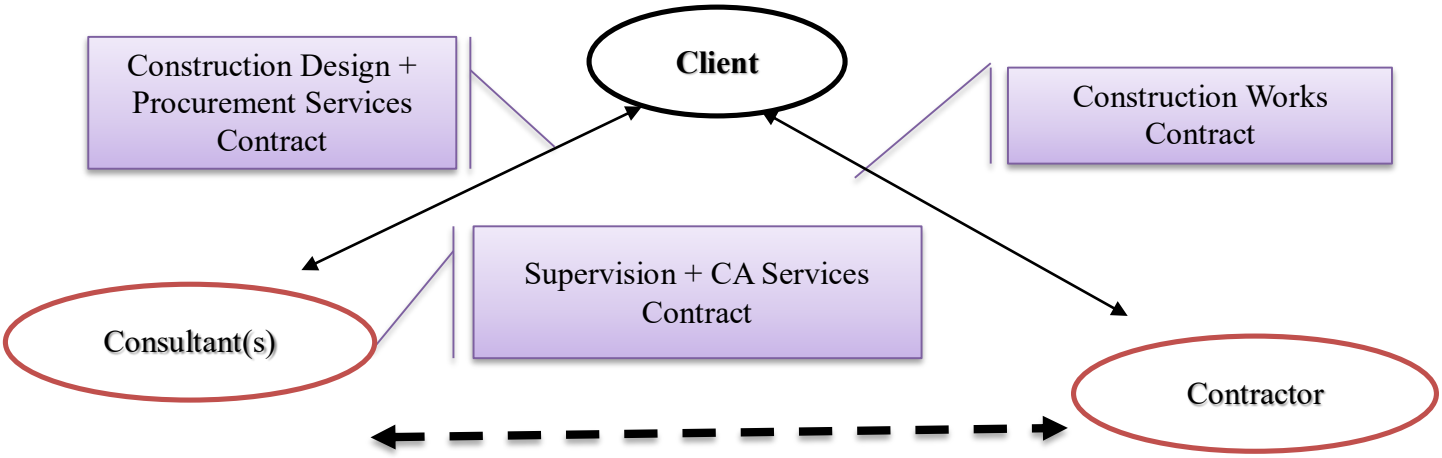

Figure 2.2:DBB governance structure

(Allan Neill, 2011) stated that, in terms of risk allocation on a DBB delivery method, the owner typically prepares the risk allocation and administration framework separate from any of the other parties involved in a project and is usually responsible for: design reviews, differences between design criteria and 100% design, errors/omissions revealed during construction, constructability of design, environmental impact reviews, coordination with other work, differing sub-surface conditions, design defects, un identified utilities affecting site, hazardous waste, third party litigation, and warranty for facility performance. These roles and responsibilities position the owner as manager of different risks associated with each of the previous aspects of a project.

Design-Bid-Build has different characteristics which identified it from any other alternative delivery methods. Based on (Kamran, 2009) literature review, some of the characters in DBB are, there is high level of competition in design and construction bids. All qualified designers are able to compete for the design without restriction. Additionally, all construction contractors who are eligible for the required criteria are also able to compete without constraint. Projects are awarded based on list evaluated competitive bidder. Design-Bid-Build has different advantages, success factors and characteristics which identifies it from other delivery methods. Based on (Wubishet, 2018) learning guideline the following are major advantages, disadvantages, success factors and characteristics.

2.2.2.2 Characteristics of Design-Bid-Build

- Enough Time and Fund Availability
- high owner involvement

- Quality shall be defined in detail
- Adequate Contractor competence
- Contractor Executes, Complete and Remedy Defects for Construction Works

2.2.2.3 Advantages of Design-Bid-Build

- Widely applicable
- Well established and easily understood
- clearly define the scope
- Provides the lowest initial price that responsible, competitive bidders can offer
- design is completed before construction
- clearly define the role for each party
- Well established and easily understood
- bill of quantities can be used for valuing variations
- The designer is experienced enough to oversee both the design and construction
- Extensive litigation has resulted in well-established legal precedents
- As construction features are typically fully specified, client with significant control over the end product (however, this may come at the expense of increased agency inspection efforts)

2.2.2.4 Disadvantages of Design-Bid-Build

Although D-B-B is the most used delivery method in construction, there has been questioning regarding the efficiency of this method some if widely identified disadvantages are listed as follows.

- Tends to yield base level quality
- Least-cost approach requires higher level of inspection by the agency
- The client bears design risk
- No built-in incentives for providing enhanced output
- Lack of input from the construction industry during the design stage exposes the agency to claims related to design and constructability issues
- Tends to create an adversarial relationship among the contracting parties, rather than foster a cooperative atmosphere in which issues can be resolved efficiently and effectively
- Fragmented contract may lead to claim & dispute
- Initial low bid might not result in ultimate lowest cost

2.2.2.5 Success factors Design-Bid-Build

- owner's Fairness, Prior Experience and Competence
- Faithful and Less Adversarial Consultant(s)
- Non-Ambiguous, Non-Discrepant Provisions

- Completeness of the tender document
- Contractor's Fairness and Competency

2.2.2.6 Suitable conditions to use Design-Bid-Build

- The service of a designer has already been procured
- The designer is experienced enough to oversee both the design and construction
- The design is substantially complete by the time the contractor is selected
- Contractor is selected on the basis of price with a general acceptance that the price may be wrong
- It is important for client to use a contract form with fair and familiar distribution of risk
- When neither the employer or his advisers raise this as an issue
- Full tender documentation exists to ensure price certainty
- The bill of quantities can be used for valuing variations
- Client desires competitive tendering
- Scope of work is clear and well defined to facilitate detailed design

2.2.2.7 Risks of using DBB

According to BCCA (2012), Design Bid Build delivery method has faced different problems or challenges commonly for the private and public sectors that leads to compressing the project schedule, if required, because fast-tracking of design and construction is not compatible with this delivery method. (BCCA, 2012) illustrates the following bullet points of risks for the owner in using DBB.

- Owners need to ensure that bid documents have few (if any) errors or omissions, to minimize cost, schedule and dispute impacts during the Project since it has high tenability to change or variation.
- DBB may require a certain level of cooperation and collaboration with each participant to reduce different disputes between them.
- The construction schedule may be compressed due to prior decisions being late. There may be insufficient time for design completion, with bids being invited prematurely in order to meet deadlines. It invites disruptive changes to defer part of the main design work until the bidding period or after contract award.
- Until the general contract is awarded, a "traditional" approach may involve construction expertise only through the Consultant. However, construction expertise can be obtained sooner by retaining a construction advisor, and the Owner may value early collaboration of builders with design professionals in order to enhance the constructability of the project. This is best achieved as a concerted effort as opposed to an occasional request for advice about specific issues.

2.2.3 Design-Build (DB)

The term "Design and Build" refers to "the delivery strategy that requires the contractor carrying out the design works as well as the construction and completion of the work" (Yusof, 2006). Mathonsi and Thwala (2012) explained that, the design and construct delivery method is a method where one party, generally the contractor, takes responsibility for the design and construction of the project mostly. The client deals only with one construction firm. According to Davis et al, (2008), in the design and construct delivery method, a contractor is responsible for some or all of the design. Similarly, El Wardani (2004) clarifies that, in the design and construct contract, there is generally a single point of responsibility for both the design and construction works. Thus, the client has the advantage of contractually agree only with one firm and therefore, only one firm to blame if things go differently. It is also mentioned that, the employer's requirements are specified in such a way that the design input and liability of the contractor are clear.

Design-build is a project delivery method in which the owner procures design and construction services in the same contract from a single legal contractor. Ali Touran, *et al* (2009) states that, in DB, the client identifies the project's intended outcomes, and defines clearly the requests of the technical proposals. In return, bidders prepare a technical and price proposal showing the methodology on how the design and construction work is going to be implemented. All construction and tender evaluation can be more difficult than in DBB due to different technical proposals (Lahdenperä, 2004). There are different types of DB delivery methods which are widely practiced in the world as shown in the following diagram and table respectively.

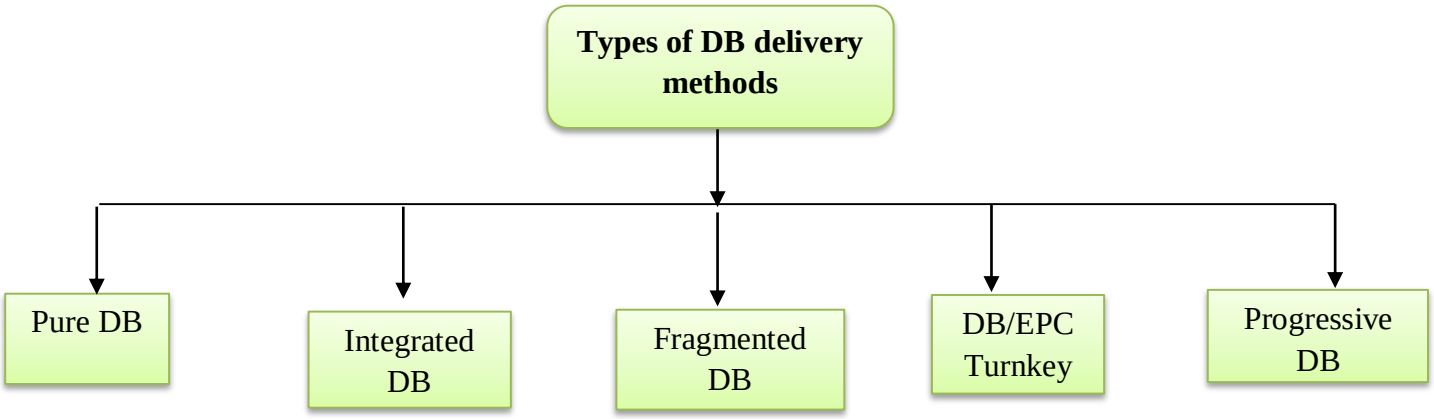

Figure 2.3:Types of DB delivery methods

Table 2.1:Types of DB, source from Wubishet (2018) lecture notes

Types of DB project Delivery Methods	
Pure/True DB	Complete and Self-Contained approach applied in comparatively simple and low risky projects where all the necessary construction design services and works reside within a design builder as sole responsible using sufficient resources including maximum benefits from Contractors Constructability, Value Engineering / Management Creativity and Innovation Inputs into the design services
Integrated DB	Contractor or Design led DB where the Core designers and specialized contractors are in partnership within one organization in which either of the Construction Design Services (Most Cases) or Construction Works are bought in to form a suitable partnership
Fragmented/Enhanced/Novation DB	To be Rescinded latter, Construction Design Services including the Design Brief need to be developed with a Consultant which may (Bridging) or may not (Novation) become a part in the Design Build Team practiced in the following two forms: **1.DB Bridging (USA) / DB Novation (UK) or Consultant Switch**: is an enhanced DB PDM where the Schematic design (that is 10 to 30% of the design Services) is developed by the Client and the Preliminary and Final Design Services and the Construction Works are to be undertaken by the DB Contractor / Team **2.DB Develop and Construct**: Client using Consultant prepare Preliminary Design and DB Contractor/ Team to undertake Working Drawing and Construction Works and can be termed as Extended DBB (Hybrid Form of BD and DBB)
DB /EPC Turnkey	Applied to large scale, long duration and technical complexity, that is; widely Used in Projects for the Manufacturing Industry, Power Development and High-Rise Building with substantial design services and works requiring integration of all project stages including installation and commissioning for Turning the Key to operate (Total Contracting).
Progressive DB	Progressive DB: A recent development using stepped processes using primarily a qualification based or best value

	selection approach (Quality and Cost Based Selection) whereby the delivery of the project is made in two distinct phases progressively ((a) Preliminary or Pre-Construction Phase; and (b) Final design & Construction and Commissioning Phase) in order to define the design and the contract price with the team.in most cases, the Owner allows Early Design Builder Involvement before the design has been developed in order to benefit from the Contractor inputs.

From the above stated types of DB delivery methods, Progressive DB is new concept so, it is eliminated from consideration while studying DB characteristics and in our country especially in road construction projects DB novation is been practiced based on (SMEC, 2018) report.

2.2.3.1 Design-Bid Governance structure

The governance structure of DB has two contracts which are, the client formulates the contract with the 'client representative' or supervision consultant and with the general contractor (FIDIC, 1995) orange book for Design-Bid and Turnkey projects. Based on (FIDIC,1995) condition of contract clause 3.2, the 'Engineer/client representative' or CA consultant has, contractual rights and responsibilities generally to administer the project like vale, cost, Extension of time and administer claim on behalf of the client (owner)…etc.

FIDIC, (1995) also stipulates 'the Contractor shall design, execute and complete the Works, including providing construction documents, within the time for completion, and shall remedy any defects within the Contract Periods'. Clause 4.1, If he fails to do because of issues beyond his control, he will entitle to claim and compensated, if the delay is due to his fault, he will pay liquidated damage. The figure below shows the contractual relationship between the client, CA consultant and contractor.

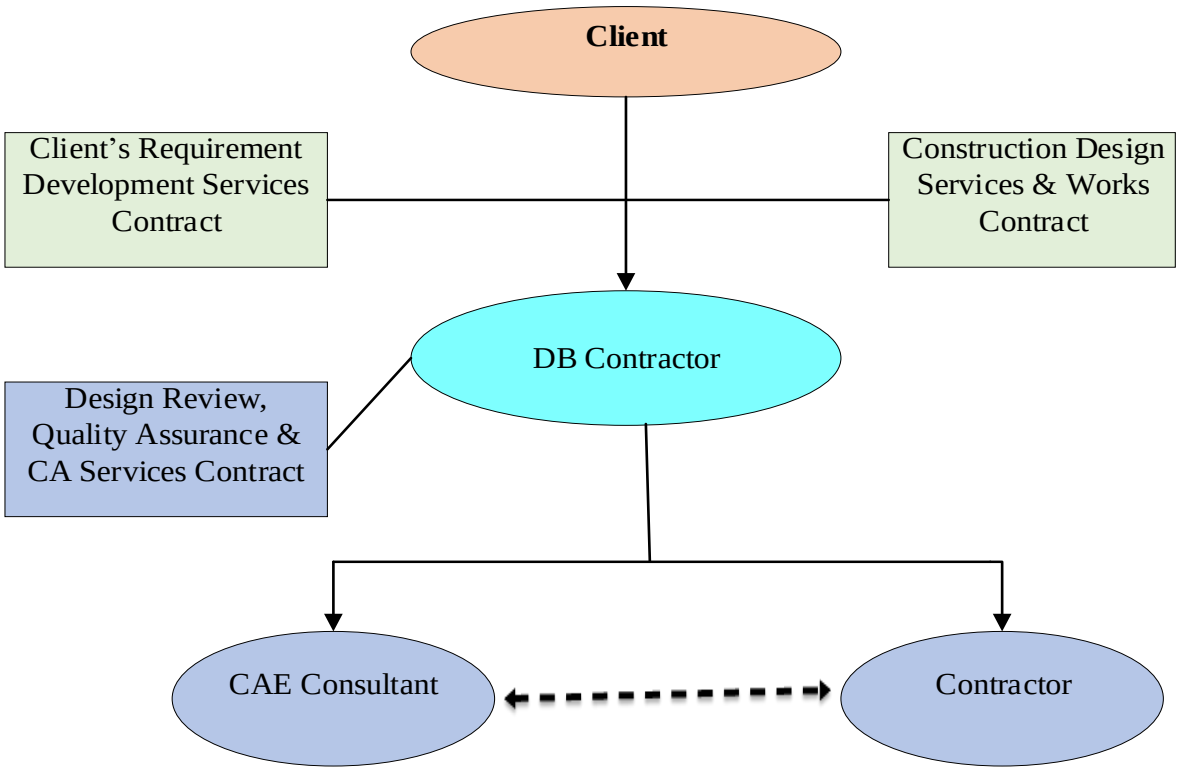

Figure 2.4:DB governance structure

(Allan Neill, 2011) stipulates, in terms of risk allocation on a DB delivery method, the owner typically prepares the risk allocation framework separate from any of the other parties involved in a project. And he is usually responsible for: design reviews, differences between design criteria and 100% design, errors/omissions revealed during construction, constructability of design, environmental impact reviews, coordination with other work, differing sub-surface conditions, design defects, unidentified utilities affecting site, hazardous waste, third party litigation, and warranty for facility performance. These stated responsibilities are managed by the owner. Based on (Wubishet, 2018) learning guideline the following are major advantages, disadvantages, success factors and characteristics of DB.

2.2.3.2 Advantages of Design-Build

- Client not familiar with the construction process
- Project is technically complex
- Client desires a single point of responsibility
- Low likelihood of variations to the project
- Innovation and quality improvements through: Alternative designs and construction methods
- A quick start works on site

2.2.3.3 Disadvantages of Design-Build

- Reduced opportunities for smaller local contractors
- Increased risk of contractor results in higher cost
- Less client control over final design
- Accelerated construction can potentially overextend the workforce
- Elimination of traditional well-known check and balance

2.2.3.4 Success factors of Design-Build

- Completeness of Employer's Requirements
- Contractor's Fairness, Prior Experience and Competency
- Non- Ambiguous, Non -Discrepant Provisions
- Less Project Occurrences and / or Impacts of Uncertainty, Complexity, Non-Predictability, Unforeseen Events for the Employer

2.2.3.5 Characteristics of Design-Build

When considering this delivery method against project needs the following typical characteristics should be considered (Center for Excellence, 2010). It helps to commence the work prior to finalizing the design

- Tight time-lines that requires high certainty in final cost and completion date
- Design and construction risks are best managed by the contractor
- Client is looking for design and construction innovation
- Contractor Designs, Executes, Complete and Remedy Defects for Construction Works
- Quality and cost- based selection used

2.2.3.6 Suitable conditions of Design-Build

This delivery method is advisable to use when: -

- There is a requirement of a single point of accountability for design and construction
- Client not familiar with the construction process
- Project is technically complexity
- The employer desires a quick start to work on site
- There is a low likelihood of variations to the project
- There is a requirement to potentially reduce the overall project cost by giving the contractor the opportunity to contribute construction experience into the design, resulting in innovation and efficiencies.

2.2.3.7 Risks and challenges of Design-Build

Risks should be allocated to the party best able to handle them. In the Design-Build contracts the contractor is responsible for the hole design and construction works. The client is always responsible for risks associated with concept design and construction standards, community and political acceptance, environmental impact remediation (except construction impact), and right of way matters. The contractor is required to manage risks associated with design, construction, design changes, changes in quantities, community relations, traffic management and environmental issues. In DB contracts extensive risk transfer is generally considered appropriate, it is not advisable to the client to transfer all risks to the contractor since the contractor will assume high cost for the risks (Lahdenperä, 2004). While in some cases clients have been worried about the contractors' ability to price risks. Contractors also thinks, the cost of risks is so high that it cannot be fully included in the bid price. For instance, risks related to excavation volumes may be extreme and might be better managed by sharing them between the contractor and the client. Additionally, the client makes a risk analysis for every large project in order to assess whether transfer of certain risks provides value for money.

However, currently the contractors are trying to transfer risks back to the client. Generally, the client thinks that the contractor should bear the risk of unforeseen ground conditions, while contractors feel that this is an unreasonably high risk with their tight margins and does not really bring best value to the client. According to the contractors, the client should also retain risks on issues arising due to his prescriptive specifications.

Since the design-build contractor is working in starting from the design, DB offers the opportunity to save time and money. Yet, the advantages of the system are compensated by a substantial loss of control and involvement by the client. Accordingly, it is difficult for the client to confirm that it is receiving the best value for its money without having a fully transparent work process (CMAA, 2012). The client should give prior attention in considering DB is that, the client should carefully consider the level of participation DB requires for a successful project. First, the client should recognize the effort and completeness of the concept or initial design which forms the basis of its contract with the DB contractor (Putkey, 2009). BCCA (2012) guidline, stipulates the following conditions where Design Build should not be used.

- The Owner does not disclose all evaluation criteria for prequalification and proposal submissions to all bidders, or is not prepared to provide the evaluation results to bidders;

2.2.4 Construction management (CM)

Construction Management is a project delivery method, in which an Owner contracts with a single entity to provide site management advice, organizational and practical services and will be accountable for the hole construction work (BCCA, 2012). CM approaches gives the responsibility for site management services, such management services may include preparation of cost models, advice on the time and cost consequences of design and construction decisions, scheduling, cost control, coordination of construction

contract negotiations and awards, timely purchasing of critical materials and long-lead-time items, and coordination of construction activities (Bolumole, 2017). Construction Management has two major types CM at fee and CM at risk. Agency CM (CM at fee) is not a project delivery method as the CM is not contractually responsible for delivering the project. Its role is purely consultative and is usually not at risk for the cost and schedule of building the project.

The characteristics identify CM at-Risk:

- Three prime players—owner, consultant, CM at-Risk
- Two separate contracts—owner to consultant and owner to CM at-Risk
- Final provider selection based on Qualifications Based Selection or Best Value: Fees

2.2.5 Public Private Partnership (PPP)

PPP Project Delivery Method is a project delivery method allowing partnership agreement to be established between a government entity and a private organization for developing and operating a public asset and/or providing a public service (Graham Miller, *et al* 2009). In PPP the private contractor is responsible for risk and management responsibility than all other delivery methods. PPP typically make the private sector parties that build public infrastructure financially responsible for its condition and performance throughout the assets life-time. Such asset related services include clearing, security, catering, facilities management, service delivery, operations, maintenance and the like (Center for Excellence, 2010). In a typical PPP project, the public body will:

- Prepare an output-based specification rather than a prescriptive specification
- Engage a provider to deliver services over a long term
- Require the provider to design, finance, construct, maintain and operate the facility. The private party provides ancillary services and assumes the risk for those functions
- Make no payments to the provider before the facility has commenced operation
- Provides payment over the contract's term based on services delivered against the achievement over its lifetime and operated efficiently
- Eventually take back ownership of the asset at a specified handover quality or standard

In PPP the government's responsibilities for administering the project are very different to all other delivery methods. The government becomes a purchaser of asset-based services and paid for the work according to performance. It allocates certain risks to the private party and locks in whole-of-life budgets and quality standards which allows to focus on its core business.

2.2.6 Output-Performance-Based-Road Contract (OPRC)

The essence of the OPRC concept is that the Contractor carry out all required maintenance work to a road or roads to keep them at a specified required standard (worldbank, 2009). There is no measurement of the

volume of works carried out and the client does not provide a schedule to contractor to tell what should be done or when it should be done. The Contractor is free to establish the work required as and when it suits him subject only to maintaining the road at the specified standard. The Contractor is responsible for quality control, both of the overall standards of maintenance and of the details of materials used and work performed. The contractors output and performance is measured by cross checking the work with a specific set of measurable values related to road condition (Policy Challenges in the Implementation , june 2016).

Output and Performance-based Contracting for Roads (OPRC) differs significantly from method-based contracts that have been traditionally used to maintain roads. Figure 2.5 below illustrates the difference between OPRC and other methods.

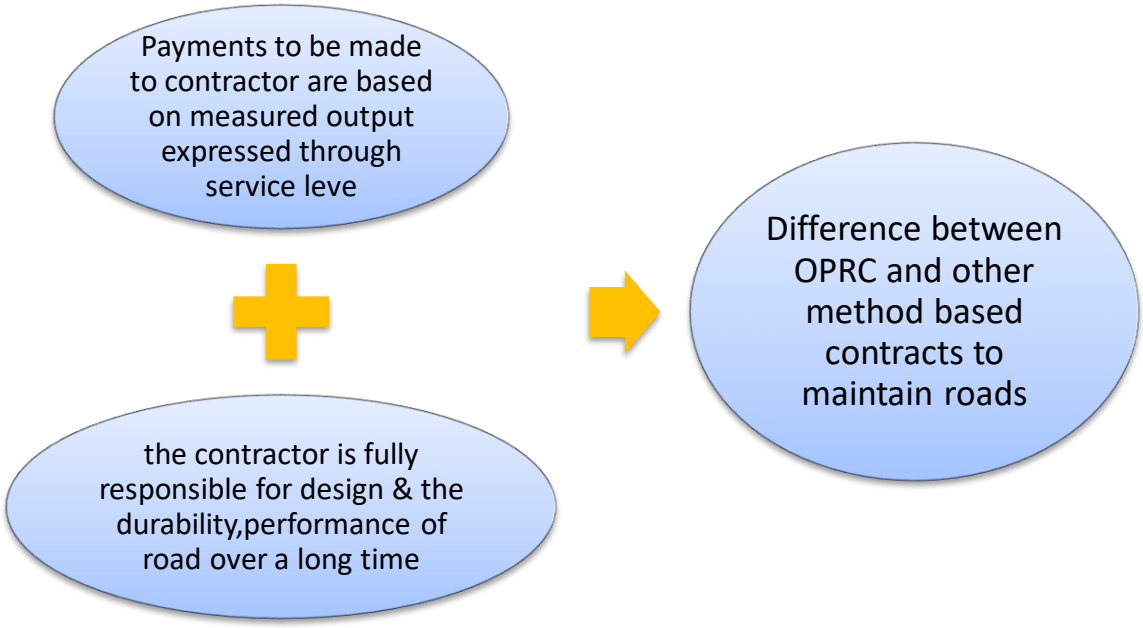

Figure 2.5:Difference between OPRC and other methods

OPRC helps through minimization of significant variation orders than other delivery methods, because, the contractor is accountable for design preparation and implement the works through actions and services levels that are necessary in order to achieve and maintain the service levels stated in the contract. The Service Levels provided to the contractor are defined from a road user's perspective and may include factors such as average travel speeds, riding comfort, safety features, etc. (worldbank, 2009).

In worldwide, Construction Management, Out Put Performance Rate Based Contract and Public Private Partnership project delivery methods are very popular. In our country CM is not yet emerged but

PPP for building project and OPRC for road is started for the first time. As stated in the background of the study, ERA has been using Force Account and DBB for its long journey in providing the road infrastructure for the country. But write now ERA is implementing DBB and DB for all its projects. Therefore, the scope of this research relay only on DBB and DB delivery methods.

2.3 Delivery method trends in ERA Projects

Delivery method needs to be selected to meet the client and project objectives. Different selection criteria are widely accepted in the world to facilitate the selection process. In Ethiopian road authority there have been using force account and design bid build delivery methods for the majority of its projects in the road construction (ERA history). ERA's major road projects under road sector programs (RSDPI-RSDPIII) are completed by using mainly design bid build delivery method.

According to (Rahel, 2016) in her thesis explained, the design bid build delivery method has been using as a sole delivery method for all project types for ERA's projects. based on (Lema, 2006) after 1983, it was a significant time by introducing the DB delivery method for the first time in the country. There were 14 contracts signed. All of the fourteen DB projects that ERA had awarded to the contractors were rural road projects intended to connect different rural towns in different parts of the country. But none of them were successful. Maximum of 84% and minimum 27% of the work were completed at the end of contract period. Some of the contracts were terminated after the construction had begun but some other contractors were managed to complete the project but they couldn't survive in the industry ever afterwards due to lack of the organizational capacity in both contractor's side and ERA side. proper analysis was not investigated before the implementations of the projects. There are different challenges faced during the first implementation of DB. (Rahel, 2016) and (Lema, 2006) have stated some of the major problems encountered like , Lack of the required experience and expertise with the local contractors, client itself was not having the required experience for the DB delivery method, lack of well-established pre-contract planning, local contractors lacked proficient design staff, sometimes the local contractor's tendency to underbid' the works, over-extension of contractors, no clear guidelines for procurement of goods and services, financial incapability of local contractors, and inadequate equipment.

As stated in the background study, ERA has established DB directorate and started using Design Build in 2009. Lots of projects were delivered by using DB delivery method. But recently the DB directorate is rearranged and distributed to six regional directorates because, through administering large number of DB projects the basic experience is gained and ERA's especial attention is moved towards PPP which is the newly emerged delivery method for our construction industry.

2.4 Common Challenges of Projects during construction

Road projects have different nature than building and other construction sectors and each road project has unique nature which differentiate one project from the other. Road construction projects faces different

challenge based on the nature of the project, the client involvement, location of the project and the type of delivery method. Some of the major challenges are right of way, design change, scope change, adverse weather condition and variation orders. These problems are the major causes of claim in our road construction (Girmay, 2003). The following are some of the major challenges in road construction.

2.4.1 Right of way

One of the major causes of claims in the Ethiopian construction industry, particularly in road projects has been rights of way related issues or failure to give right to possession of site. According to (Girmay, 2003) delayed possession of site primarily a result of late removal of power poles, tele lines, water supply lines, community settlement, trees, handing over of borrow pit areas, quarry & asphalt plant sites. (Haile, 2016) stated, one of the major causes of Ethiopian road projects is right of way related problems which include: late site hand over after the contract award, delay of local administration/federal government decision, and untimely resolution of problems regarding right of way case. Right-of-Way activities can require an extended time commitment and affect project delivery schedules.

World Bank, (2018) in its implimentation report on Ethiopian road construction stated that, solving ROW issues before starting the construction work reduces delay time and cost increase related to it. ROW needs relocation of utilities such as pipeline, electric poles, and removal of building within the area. The delay in removal of obstructions is not only a problem of ERA but in most cases even though ERA paid for relocation of utilities, the agencies responsible for such relocation delayed removing them. This extended the road construction period. The report also mentioned that, ERA was very innovative in using specialized agents to ensure relocation of utilities were done on time. Based on the above issues, it is crucial that right-of-way issues should be identified and take necessary actions early in the project development process. The initial stage revolves around activities to set up the project and identify both the scope and stakeholders in the project. Identify the type and extent of right of way needed for the project and assess the capabilities of the cooperating agency that will be responsible for right of way and utility work.

2.4.2 Design change and incomplete design

Construction has usually separated planning and design from construction work which have resulted in some scope and design related changes during the construction. Design considerations may lack the issue of buildability, productive economy or performance of the work when it is prepared separately (Mughees Aslam *et al*, 2019). The design deficiency or incompleteness of the design can be another reason for the design change. According to (Harthy *et al*, 2006), the root causes of design changes are design deficiencies and incompleteness occurred during the design development stage. Design change has an impact on project schedule and caused cost overrun (Werku Koshe, 2016) in their studies in cause of delay in Ethiopian construction projects finds out that, design change is one of the primary causes for project delay. (Haile, 2016), studied on Ethiopian road project performance between domestic and chines contractors

and he reveals that, the principal cause of project delay is design related problems like faulty design, design change and modification and delay in approval of modified design.

2.4.3 Variation orders and excess in quantity

Variation order is the deviation experienced in any project from the original contract or work scope that contracting parties mutually agreed at contracting time. Variation Order (VO) is common event in construction projects. It implicates changes in the original scope of work from the contract. The primary step in handling variation is studying the cause and effects of variation orders. (Aftab Hameed Memon, 2014) stipulates that, there are different factors that cause Variation Order. And variations can cause claim and disputes between the parties involved in construction projects. Thus, it is very vital to control variation orders in a construction project. Amiruddin Ismail *et al*, (2012) a study in the effect of variation order for road construction in south Iran states that, the Variation order contains a set of instruction which allows changes or modifications to be made to an earlier agreement in terms of volume or nature of task to be carried out. variation order is common in all types of construction projects and plays a significant role in affecting the project cost and time of the projects. (Nurul, 2007) studied variation control affecting construction works in Malaysia and finds, 32% of variations comes from errors in bill of quantities, re-measurement of the work contributes 25%, change due to local authority requirements has a contribution of 19% to variation since requirements are not properly followed, clients request takes 10% of the variations, change in design shares 9%. Project complexity is one phenomenon contributing for variation. (Keane et al., 2010) states, complexity gives rise mostly to undesirable situation like variations with their consequent effects, and if there is a number of variation orders on a project, the chance or likelihood of project delay and cost increase.

2.4.3.1 Causes of variation orders

Various authors had identified different causes of variation orders in construction project both on the private and public projects. The various causes of variations identified over the years shows that variation has become one major project challenges for the majority of construction projects, and it creates disputes among involving stakeholders. (Tadesse, 2009) studied cause of variations in Ethiopian federal road projects, identified more than 20 factors but the major ones he identified are right of way problems, lack of proper planning, lack of contractors' proper evaluation of tender documents at tendering phase, contractors' financial problems and lack of prompt decision making (quick responses) are the top five causes. (Haile, 2016) finds out that, Variation order like: - new additional work order due to the public request, quantity increment because of faulty design and additional work due to design change and modification. The major causes of variation orders are: a change of schedule after the construction work began cause change in resource mobilization and utilization. It will force some resource to be idle. The change in schedule alters the project cost (Fisk, 1997; O'Brien, 1998). Change in scope of the project can be changed due to many reasons like deficiency of the planning process and less involvement of the client during the design and planning phase. Scope change is one major factor cause variation orders to projects

(Arain et al., 2004). Change in design is also another factor causing variation order. It occurred either if there is deficiency in design such as unclear working drawing or the change in scope is occurred. Design change is principal cause of variation (Fisk, 1997).

2.4.3.2 Effects of variation order

Variation orders consequent various effects on the project's performances and project duration. Variation order also cause a change in the project cost in some cases variation order will result in cost decrease of the project but most of the time it results the project cost. Variation order is issued by the change order which is a document describing the scope of the change and its impact on both cost and / or time. The parties will agree on the changed items or additional items from the contract in both the quantity and cost of the items. But if no agreement is reached between the parties of the project on the change, it turns into a claim or dispute that may negatively affect the execution of the project and affect the project performance (Alia Alaryan *et al*, 2014). Some of the major effects of variation order are:

- **Source of claim:** (Abebe Dinku, 2003) and (Girmay, 2003) studied causes of claim in some selected road projects and found out that variation is one major factor which cause claim in Ethiopian road construction. Variation also cause requirement of new or additional amount of material and equipment's which results in logistics delays. (Ranasinghe, 2013) stated that, variation order is a source of claim since it affect the project schedule and cost which affect the performance of the contractor. But its influence on project performance vary from one project to another based on the nature of work, the complexity of the project, and the type of delivery method.
- **Delay in completion time:** Variations usually affects the project progress, leading to delay in achieving the contract project duration. Kumaraswamy *et al*, (1998) studied delay problems in construction projects of Hong Kong stated, 50% of the projects surveyed were delayed because of variations.
- **Increase in project cost**: One of the most common effects of variation is increase in the project cost. (Tadesse, 2009) in his study reveals that, the second most impact of variation in Ethiopian road construction is project cost increase next to delay in project duration. Any modification or addition in the design during execution of the project may results in demolition or rework of any project component and leads to project cost increase (Clough and Sears, 1994).

2.4.4 Scope change

According to PMBOK 6th edition, "Project Scope is the process of developing a detailed description of the project and product. The key benefit of this process is that it describes the product, service, or result boundaries and acceptance criteria" (PMBOK, 2017). Change of plan or scope of project is one of the most significant causes of variation in construction projects. (Zewdu, 2015) in his research states, scope change is the significant factor for variation orders. It leads to project time delay and cost increase in Ethiopian road construction. (World Bank, 2018) in its implimentation report stated that, one of the cause

for project delay and cost increase in Ethiopian road project is the scope change in the implementation stage by the client.

2.4.5 Adverse climatic condition

Rainfall affects the construction activity. Delay in maintaining the project duration is one major risks of the contractor. Project delay is not always a problem of the contractor. Some delays, such as those caused by weather conditions, are beyond the contractor's control, (Anteneh, 2015) stated that, weather condition is one of the major cause of delay and increase in project cost. Since in most construction projects adverse weather affects the project performance. Adverse weather condition can disturb or abort the works, cause decrease in production rate and quality of works. It may pause the construction process for many days after it has stopped raining depending on the soil moisture. So the work shall be done again. weather delays cause increase in cost since, labor and equipment's lay idle. (Haile, 2016) in his research paper stipulates, unexpected ground conditions such as: adverse climate condition (rain), unforeseen site condition, changes in sub-soil conditions is the cause for 25 % of project delay in Ethiopian construction projects. Adverse weather condition hinders the project completion date (Halpin 2005). Gören (1998) reveals that, if the impacts of adverse climatic conditions are taken into consideration properly while preparing the working schedule, its effect can be prevented. Generally, delays due to weather conditions are considered as excusable but not compensable this means the contractor is entitled to time extension, but not additional cost. It may have a knock-on effect and may result in slowing down the progress or even stops road construction activities.

Generally, Design Bid Build delivery method is well experienced and popular in the road construction history of Ethiopia since, the majority of ERA's projects is being delivered by using DBB. Administering DBB road projects has different challenges due to many reasons. Based on ERA modernization manual on contract administration, DBB projects have suffered on incomplete design, inadequate quantity estimation practice, frequent variation orders, claims raised from the above reasons. These challenges are critically affecting the implementation process of Design Bid Build road projects in general. Specific challenges of those projects will be seen in detail through document analysis in the analysis part of this research paper.

When we come to Design Build delivery method, in ERA it is now becoming one of popular delivery method through its implementation in different types of road projects. Majorly it transfers the design risk to the contractor with initial concept design up to 30% prepared by the consultant before the tendering stage. This leads the contractor to prepare the rest of the project design. Contractors are forced to fix their project cost based on the concept design prepared which challenges them with excess quantity increment after signing the contract. This practice is challenging both the client and the contractor because if the estimated quantity is raised the contractor will cover additional costs than he expects and led the contractor to be terminated from the industry but if the quantity is less the client should pay the agreed amount. This

practice generally makes the DB projects initial costs very high. But Specific challenges of those projects will be seen in detail through document analysis in the analysis part of this research paper.

2.5 Delivery methods and their impacts on project performance

The main significance of studying different project delivery method is because PDM has influence on the project performance and successful completion of the projects based on different literatures. Different studies have showed the wide varieties of influences of delivery methods on project performance but most of them are relied on the key performance measurement indicators which are quality, cost and time. I tried to see some of them as follows: -

According to (Ademola Eyitope O. , 2012) journal prepared on Critical Selection Criteria for Appropriate Procurement Strategy for Project Delivery in Nigeria, he stated that, The selected system under an appropriate contract type and control will help to avoid problems and attainment of project objectives–time, cost and quality through allocation of different risks, roles and responsibilities he also tried to collect the selection factors which will affect the choice of the delivery method.

Mekonnen (2013) on his research on effectiveness of DBB and DB projects showed that, DB projects generally showed shorter project time than DBB the reason stated is, the design period is overlapped with the construction time, the shorter project completion led the cost reduction than DBB. The project cost is also known at the start of the project. He also clearly indicates that the choice of project delivery method affects project performance. Significant difference in the project performance was found between DB system and traditional DBB contracting methods.

His generalization on DB preference is depend on the questionnaire he distributed, and Five case studies taken from both DBB and DB project delivery methods. His basic performance evaluation lies on contract completion time and costs but in my perception, it is not appropriate to evaluate the performance on the basis of mentioned indicators only without considering quality of work, project size, nature and other factors which have impact on project time and cost like price escalation and right of way problems which will have significant impact on the project.

(Lema, 2006) conducted a research on alternative project delivery methods for public Constructions in Oromia Region. According to his study, using alternative delivery methods is crucial and the priority of consideration in using alternative delivery methods is given to reduction of project time, cost certainty and the third one is reducing owner burden Ensuring quality become the least in criterion. Based on his study findings, DBB method achieve the project schedule more effectively than DB. According to his study also, DBB is better in project cost reduction and check and balance due to designer's separation from the contractor. The quality issue also the same as well. His analysis and generalization were based on the questionnaire he distributed in the Oromia regions as a result most of his respondents used DBB and they prefer DBB from the DB because they thought that local contractors didn't have the capacity in

all aspects to implement DB. With having such data's, I don't think it's enough to generalize in the preference of DBB over the DB. Per Erik Eriksson, in his study on the effects of procurement on project performance through comparative study analysis stated that, clients tend to choose a procurement method they have the habit of using it. Traditional DBB will create adversial relationship between parties which will affect the construction process and the DB delivery method also have a low quality output than DBB. He also tries to recommend in order to get a better performance using DBB is better but with the early involvement of the contractor in the design stage to reduce variation. (El-Sayegh, 2007) concluded after analyzing the United Arab Emirates construction industry practice from his study on the effectiveness of project delivery methods is that, Design-Build methods are more effective in meeting most project objectives followed by construction management at risk, and the traditional design-bid-build. Design-build is relatively more effective in ensuring the shortest project duration than construction management methods. The traditional delivery methods are not effective in ensuring the shortest duration. Construction management method is the most effective in confirming staying within budget. The results also showed that the Design-Bid-Build methods provide the greatest flexibility to incorporate changes during the design and construction of the project.

This all above different results of the researchers in project performances delivery method showed that the choice of one delivery should not be random and needs detail analyzing of the project objectives. There are criteria needed to be considered and influence the selection of delivery methods when having more than one alternative delivery method. Those criterions are presented below to realistically analyze them.

2.6 Selection of Delivery Methods

Project delivery method selection happens early in the project life cycle, but it affects the project schedule, cost, and quality control. It also affects the relations between the parties involved in the project. Nevertheless, project delivery method selection is not fundamentally different from many other decisions (Kamran, 2009). Different client has different needs and requirements for their desires creates difference in construction projects so significantly, project nature is also varying from project to project leads to a situation where no single system of delivery method can be suitable for every project as a result careful selection process of PDM is crucial for every project (Agha, 2016).

Using the DMS criteria is helpful in identifying which delivery method will suits with the project requirements since there is no one best delivery method which serves all kinds of the project requirements (Construction division, 2016). Based on (Washington State Department, 2016) Proper Selection of PDM has different benefits which helps for successful completion of the project. Some of them are: achieving best price or value, achieving critical schedule requirement including milestones, achieving best quality, achieving maximum scope, alignment with the Employer's / Employer's representative's capability, alignment with the project specific attributes and utilize PDM benefits to predicted project risks.

Ahadamsi, (2016), concluded on his journal paper is that, when different delivery methods are available with their individual unique features, obliged clients in using systematic decition making and helps to get benefited the most from one delivery method. Such challenges have largely resulted in the need to conduct a selection process in a methodical and systematic manner and also stated different factors need to be considered before any decition is to be made.

2.6.1 Delivery method Selection Criteria

Several previous studies have identified number of factors influencing the selection of delivery methods in construction. The selection criteria for project DM will influence which procurement system should be used in a project (Love, *et al*). Knowing delivery method selection criteria is the base for selecting the appropriate delivery method (El-Sayegh). If the selected project is based on the conditions of the specific projects, it will contribute much to the successful completion of the project (Ali Hosseini, *et al*,2015). Different researchers around the world have identified Project delivery method selection criteria in different times. Most of the criteria they found are similar so, presenting all researchers findings would create repetition therefore, some of the findings are presented below.

The journal paper by (Ali Hosseini *et al*, 2015) for infrastructure PDM selection, has found out 22 selection criteria based on the analysis from different literature. He compares the findings with document analysis from different projects and discussed that it can be said that, each project may find one PDM that, in some sense, is more appropriate than others. there is a need to specify the project requirements, client's needs and nature of the external environment. No PDM is likely to be better than the others for all projects. The criteria identified are categorized in to three which are, Project characteristics, owner characteristics and external environment. The criteria under each group are listed as follows: -

Project characteristics; Delivery speed, Schedule delay, Cost growth, Cost Certainty, Quality performance, Project type, Project scale, Project cost, Complexity, Scope definability, Flexibility, change order, innovation.

Owners characteristics; Dispute, Owner willingness to be involved, Owner willingness to take risk (Risk allocation), Owners available HR.

External environment; Contractor's capability and availability, Market competitiveness, Regulatory feasibility, Technology availability, Political impact.

A journal of information management and business by (Odhigu Festus Onosakponome *et al*, 2011) on cost benefit analysis of procurement systems and the performance of construction projects in east Malaysia have analyzed, the impacts of procurement method on the performance of construction projects by distributing around 90 questionnaires to different participants of construction projects and argued that the selection of delivery method for construction projects should be based on the philosophies that support

best value for money. From the respondent's majority of them believed that, choice of delivery method influences project objectives. DB type of delivery method somehow improve the quality of works. Based on its findings the paper outlines the following criteria for selection of the appropriate delivery method Time/Speed, Quality level, Risk allocation/avoidance, Flexibility to change, Responsibility, Complexity of project, Price competition, Cost & time certainty, Disputes and arbitration, Project type, Clients experience, Project site location, Project size, Political constraints, Regulatory impact, Market competitiveness, Client technical capacity, Experienced contractor availability, Client willingness to actively involvement, Client requirement for value for money, Material availability and Client trust in other parties.

Ademola Eyitope *et al*., (2012) mentioned that, there are different criteria which can be used for the selection of a specifif PDM but the major ones are categorized int o four groups and presented below.
Table 2.2:Ademola Eyitope et al., 2012 group of selection criteria

Project technicality	**Project business case and financing**	**Project risk management**	**Public policy requirement**
Type/Complexity of the project Expected performance quality Design and product specifications Completion time.	Availability /Funding structure Number of competitors Price certainty and market structure	Controllable variation Responsibility division and integration Risk sharing and allocation.	Specific government directive Trend in client's familiarity Political reasons and interference

Peter Davis *et al*., (2008) argued that, the decision as to which prodelivery method to adopt is a difficult and challenging task for clients of construction projects and had an analysis on how and why' delivery methods are selected by public sector clients in Queensland (QLD) and Western Australia (WA). According to the paper, clients who have better experience in the industry has a better chance in identifying the suitable PDM for each projects but their attitude to risk has a great impact on their selection. The major challenge for clients when selecting a delivery method is identifying the criteria for the project which leeds to the deduction on the selection process. Selection necessiates to be carried out in a disciplined and objective way within the framework of the clients overall strategic project objectives. Since the range in choice of delivery method is now so wide and projects are becoming so complex as a result of technological advncements. The paper major finding is PDM selection criteria from different literatture and focused group interview to experianced proffessionals in the area. The criteria are Project time and cost risk profile, Project value, Project complexity, Market forces, Location (area/geography), Client knowledge, maturity and control, Refurbishment/new project, Political considerations,industry culture and Project quality.

A Technical Assistance report by (SMEC, 2018) have identified different selection criteria for infrastructure projects through three categories as shown in the following table.

Table 2.3:Delivery method selection criteria by SMEC,2018

Employer related factors	**Project related factors**	**Context related factors**	**Relationship related factors**
Institutional experience Perception towards successful performance Staff experience Customer satisfaction Avoid or minimize time & cost overrun Transparency Possibility for innovation Employer involvement Control over the process	Risk or uncertainty predictability Early scope determination Early cost estimation definition Cost certainty Design change flexibility Quality certainty Project Stability Degree of inter relatedness	Budget constraint Technological competency Consultant & contractor's competency Disadvantaged Enterprises Impact.	Relevance need identification Clarity of roles and responsibilities Difficulty in ROW obstruction removal Partnership r/ship Claim and dispute administration

Agha O. I., (2013), focused in identification of the factors which identifies the selection of delivery method for Gaza Strip. He tried to analize different selection criteria from different literature and selected the major ones and categorized into six groups: "client group"; "cost group";"time group"; "risk group"; "project characteristics group"; and " external environment group". from his collection.

Factors related to client: - Client's nature and culture (public or private), Client reputation, Client's experience in procurement methods, Client's trust in other parties, flexibility for changes and variations, Client's financial capability, Accountability, The degree of desired client involvement, Availability of qualified personnel (procurement staff).

Factors related to cost: - Price competition, Design cost, Consultant fees, Price certainly prior to commencement, Cost control.

Factors related to time: - Speed, minimize design time, time constrains, Time control, Project time schedule, Completion time, Delivery schedule.

Factors related to risk: - Risk avoidance/allocation, Responsibility, Disputes & arbitration, Geotechnical investigation.

Factors related to project characteristics: - Degree of project complexity, type and nature, funding method, project site location, project size, project payments modality, quality level of project, project

methodology, expected performance of project, available resources of project, constructability of design, project completion at estimated time, project completion at estimated cost.

Factors related to External environment, Procurement policy, Market completion/structure Market competitiveness, Economic conditions, Political considerations, Social factors, Environment impact, Other party's involvement/role/participant, Commercial conditions, Legal issues/factors, Availability of procurement system in the local market, Number of competitors, Technology, stakeholder integration, Worker conditions, Material availability. He also tries to underline on the importance of knowing the criteria for each construction project based on the above group of catagories to the project sucesss and avoiding problems related to it.

(Kamran, 2009), showed that, there are different criteria which needs to be examined prior to selecting the project delivery method and those criteria are arranged based on Project-level issues, agency-level issues, public policy/regulatory issues, life cycle issues, and other issues. Project-related parameters are those parameters that pertain to the duration, estimated cost, quality level, project risks, limits on schedule growth, and project complexity. Agency-related parameters are about the owner agency such as experience and competence of agency's employees, flexibility needs in construction phase, level of risk assumption, importance of preconstruction services, and quality level expectations. Public policy and regulatory parameters mainly cover the legal and contracting issues, for example, the authority of using a delivery method in a state, the level of competition in the market, and various permits needed for the project. Life-cycle issues cover the costs of maintaining and decommissioning the facility as well as the ability to minimize energy and environmental effects of the project. He also reveals that an appropriate project delivery method can contribute in achieving the project goals before trying to select project delivery methods and a well-structured decision-making framework is crucial. (Sameh Monir, 2007) identified several criteria which can impact the selection of PDM through eight divisions.

Time related factors: - Ensuring the shortest completion time for the whole design and construction and ensuring completion on schedule.

Cost related: - Ensuring the lowest cost and ensuring completion with budget.

Scope related; - Capitalizing on a well-defined scope, the potential for changes during construction, owners desire for flexibility to make changes.

Quality related factors; - Attaining the highest overall quality.

Owner organization related; - The owner's desire for single project contract, The owner's desired level of control, The need for construction professional input during design, The level of in-house management experience.

Funding/Cash flow related factors: - The desire for early estimates, Delaying or minimizing expenditure rate, the need for financing.

Project characteristics related factors: - The importance of the project, project complexity, owner's familiarity with the project.

Risk and relationship related factors: - The amount of risk, Minimizing adversarial relationships

From the above stated criteria, they have identified that quality is the main factor followed by the owner's desire for single project contract, desired level of control, desire for early estimates and the desire to control cost growth through their distributed questionnaires and analysis result.

Shamil Naoum, (2012) reveals that, the the selection of the most appropriate delivery method somehow can make or break the project, hence it is important for both clients and project participants. And have used 11 PDM selection criteria for the model prearation and ranked them based on the their relative importance to each delivery method. Those criteria are time, cost, project complexity, quality budget certianity, time certainity, price competion, division of responsibility, risk.

Based on (Mathonsi, 2012) a study in south africa construction industry, PDM selection criteria are divided in to two categories, external factors and internal factors. External factors are Factors from the external environment and it comprised the following variables: market competition, information technology, regulatory environment, natural causes and globalisation. The internal factors were further grouped into client characteristics and project characteristics. Client characteristic factors were found to consist of artificial factors (variables) such as client's level of knowledge, political and social consideration, familiarity with procurement system, competition, funding arrangements, government (public)/private sector project, and risk allocation. Project characteristics were found to be artificial factors (variables) such as size and technical complexity of the project, influence of the life cycle of the project, expedited project delivery, time, quality, and price certainty.

Shiyamini Ratnasabapathy,(2007) have studid the sirilankan construction industry pproject delivery method selection criteria to develope a decision support system to select the appropriate delivery method. The criteria they have identified through their research are categorized in to client requirement, project characteristics and external environment. Under the client requirement category the major factor are: risk management, time availability and predictability, price certainity, price competioin, Accountability, Flexiability for change, quality of work, responsibility and parties involvement and familiarity. Project charateristics include project cost and funding method, project complexity, project type, time constraints, degree of flexiability and payment modality. On the other hand external invironment contains market competition, economic condition and the fisical policy, technology, socio cultural suitabilityand regulatory invironment.on their finding all the factors have remarkable influence on the selection process with their own different significance based on the participants perspective.

After studying many previous studies in this chapter, the factors affecting the selection of delivery method were categorized into four groups for this research. The group of factors are: "client characteristics"; "risk factors"; "project characteristics "; and " external environment characteristics". The selection of an appropriate delivery method in the construction projects in the Ethiopian Road Authority will be analyzed based on the following major criteria which are presented as an applicable tool. In order to determine their impacts on the selection process of delivery method. Regarding the practical approaches that could be used in the delivery method selection process, the previous studies indicate that, there are many methods that can be used as a delivery methods and indicate many approaches to select an appropriate delivery method. The effectiveness of these approaches depends on different factors which directly affect the selection of the best delivery method. The following table illustrates the factors that are identified as influencing the selection of delivery method for this research paper. As a result of the literature review. The factors are categorized into four groups.

Table 2.4:Selected PDM criteria

Client characteristics	**Project characteristics**	**Risk factors**	**External environment characteristics**
Control over the process	Early time estimation definition	Risk or uncertainty	Political reasons and interference
Client reputation	Early cost estimation definition	Responsibility	Contractor's capability and availability
Client's experience in procurement methods	Scope definability	Budget constraint	Market competitiveness
Flexibility for changes and variations	Quality certainty	Claim and dispute administration	Regulatory feasibility
The degree of desired client involvement	Cost certainty		Technology availability
Avoid or minimize time & cost overrun	Price competition		
Transparency	Design change		
Staff experience	Flexibility to change		
Possibility for innovation	Early scope determination		
Complexity of the project	Speed of time		
The importance of the project			

Based on this selection criteria, the following table tabulate the major benefits and dis benefits of DBB and DB adapted from (Washington State Department, 2016) table summarization.

Table 2.5:Comparison of DBB and DB with the selected deliver method selection criteria's

Item	DESIGN-BID-BUILD (DBB)	DESIGN-BUILD (DB)
Cost		
Advantage	❖ Competitive bidding provides a low-cost bid for construction to a fully defined scope of work ❖ Increase certainty about cost estimates for Construction because project fully designed before bidding ❖ Construction costs and/or unit prices are contractually set before construction begin	❖ Contractor input into design should moderate cost ❖ Design-Builder can provide a cost-efficient response to Project Goals ❖ Costs are contractually set early in design process with design-build proposal ❖ Allows a variable scope to bid to match a fixed budget ❖ Potential lower average cost growth ❖ Funding can be obligated in a very short timeframe ❖ Potential for fewer cost change orders as the Design-Builder is responsible for design errors and the associated costs
Dis Advantage	❖ Cost accuracy is limited until design is completed ❖ Construction costs are not locked in until design is 100% complete ❖ Cost reductions due to contractor innovation and constructability is difficult to obtain	❖ Risks related to design-build, lump sum cost without 100% design complete, can impact final cost due to unknowns at the time of the RFP
Schedule		
Advantages	❖ Schedule can be more predictable and more manageable with a complete design ❖ Milestones can be easier to define with a complete design ❖ Projects can more easily be "shelved" with a complete design ❖ Shortest procurement period (Bid period is typically shorter than the RFQ/RFP processes) ❖ Elements of design can be advanced prior to permitting, construction, etc. ❖ Time to communicate/discuss design with stakeholders	❖ Potential to accelerate schedule through parallel design-build process ❖ Shifting schedule risk to DB team ❖ Obligates construction funds more quickly ❖ Industry input into design and schedule ❖ Fewer chances for disputes between client and Design-Builders ❖ More efficient procurement of long-lead items ❖ Ability to start construction before entire design, ROW, etc. is complete (i.e., phased design)

		❖ Allows innovation in resource loading and scheduling by DB team ❖ Schedule delays due to design error the responsibility of the Design Builder
Dis Advantages	❖ Requires time to perform a linear design-bid-construction process ❖ Design and construction schedules can be unrealistic due to lack industry input ❖ Low bid selection may lead to potential delays and other adverse outcomes.	❖ Request for proposal development and procurement can be intensive ❖ Undefined events or conditions found after procurement, but during design can impact schedule and cost ❖ Time required to define technical requirements and expectations through RFP development can be intensive ❖ Time required to gain acceptance of quality program Requires client and stakeholder commitments to an expeditious review of design
Project Complexity and Innovation		
Advantages	❖ Clients can have more control of design of complex projects and consultant expertise can select innovation independently of contractor abilities ❖ Opportunities for value engineering studies during design, more time for design solutions ❖ Aids in consistency and maintainability ❖ Full control in selection of design expertise ❖ Complex design can be resolved and competitively bid	❖ Designer and contractor collaborate to optimize means and methods and enhance innovation ❖ Opportunity for innovation through draft RFP and best value ❖ Can use best-value procurement to select Design-Builder with best qualifications ❖ Constructability and VE inherent in process ❖ Early team integration ❖ Sole point of responsibility for design and construction
Dis Advantages	❖ Innovations can add cost or time and restrain contractor's benefits ❖ No contractor input to optimize costs ❖ Limited flexibility for integrated design and construction solutions (limited to constructability) ❖ Difficult to assess construction time and cost due to innovation	❖ Requires desired solutions to complex designs to be well defined through technical ❖ requirements (difficult to do) ❖ Qualitative designs are difficult to define (example. aesthetics) ❖ Risk of time or cost constraints on designer inhibiting innovation ❖ Some design solutions might be too innovative or unacceptable

		❖ Quality assurance for innovative processes are difficult to define in RFP
Staff Experience and Availability		
Advantages	❖ Clients, contractors and consultants have high level of experience with the traditional system ❖ Designers can be more interchangeable between projects ❖ Smaller number of technical staffs required through use of consultant designer	❖ Less client staff required due to the sole source nature of DB ❖ Opportunity to grow for client staff by learning a new process
Dis Advantages	❖ Can require a high level of client staffing of technical resources ❖ Staff's responsibilities are spread out over a longer design period ❖ Can require staff to have full breadth of technical expertise	❖ Limitation of availability of staff with skills, knowledge and personality to manage DB projects ❖ Existing staff may need additional training to address their changing roles ❖ Need to "mass" management and technical resources at critical points in process (i.e., RFP development, design reviews, etc.)
Level of Control		
Advantages	❖ Full control over a linear design and construction process ❖ Oversight roles are well understood ❖ Contract documents are typically completed in a single package before construction begins ❖ Multiple checking points through three linear phases: ❖ Maximum control over design	❖ A single entity responsible for project design and construction ❖ Allows overlap between design and construction ❖ Getting input from construction to enhance constructability and innovation ❖ Overall project planning and scheduling is established by one entity
Dis Advantages	❖ Requires a high-level of oversight ❖ Increased likelihood of claims due to design ❖ Limited control over an integrated design/construction process	❖ Can require high level of design oversight ❖ Can require high level of quality assurance oversight ❖ Limitation on staff with DB oversight experience ❖ Less control over design ❖ Control over design relies on proper development of technical requirements

2.6.2 Approaches of selecting Delivery method

Several researchers have tried to develop different guidelines, frameworks and models on how to select the appropriate PDM by using different systematic ways. Some of them are widely used in the world. for instance, (Kamran, 2009), (Ali Touran, *et al*. 2009), (Saaty T. L., 1990) prepared different matrix approach to select the appropriate PDM. The following figure shows widely used models.

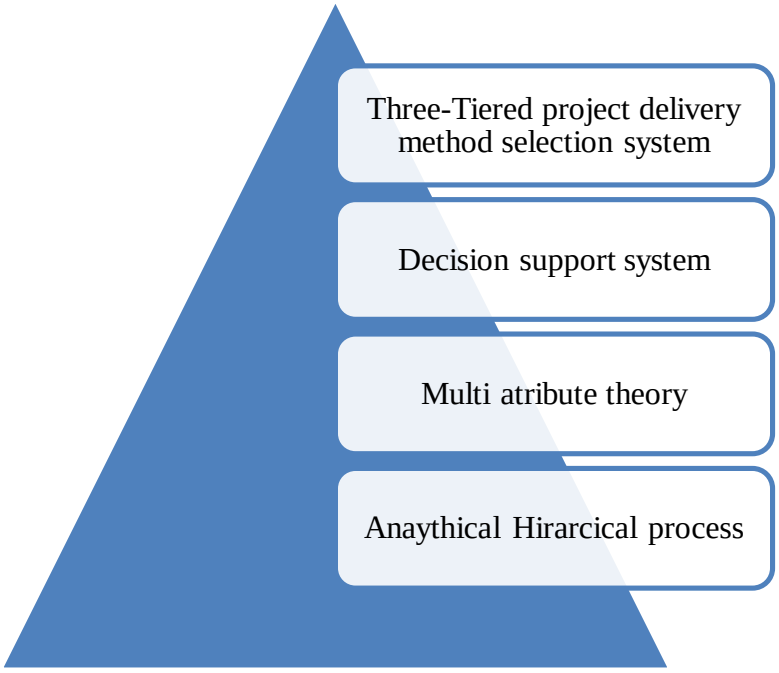

Figure 2.6:Delivery method selection models

2.6.2.1 Three-Tiered project delivery method selection system

This selection framework is developed by (Ali Touran *et al*., 2009) as a guidebook for the selection of different project delivery methods for the transit industry in USA. It is widely acceptable guideline in the world and easier to use. The matrix approach has three different steps which is Tier 1 analytical delivery decision approach, Tier 2 weighted matrix delivery decision approach and Tier 3 Optimal risk-based approach. This matrix approach is the most widely used approaches of project delivery method selection.

2.6.2.1.1 Tier 1 analytical delivery decision approach

Tier 1 analytical delivery decision approach creates a room for a systematical decision making for selecting individual project delivery methods. As stated in the guidebook of Washington, Tier 1 approach has three primary objectives.

- Present a structured framework to assist major issues involved in the project delivery decision,

- Assist clients in determining whether there is a dominant or obvious choice of project delivery method, and
- Provide a structure for documenting the project delivery decision in the form of a Project Delivery Decision Report.

Tier 1 approach depends on advantage and disadvantages analysis of delivery methods based on project critical considerations. It helps the decision makers to understand the benefit of each delivery methods. The result of Tier 1 analysis may not result in deciding which delivery method is appropriate rather it provides the foundation for the next step. (Ali Touran D. D., 2009) recommends the following six steps to be followed while using tier 1 approach.

- Step 1 Create Project Description
- Step 2 Define Project Goals
- Step 3 Review Go/No Go Decision Points
- Step 4 Review Project Delivery Method Advantages and Disadvantages
- Step 5 Choose Most Appropriate Project Delivery Method
- Step 6 Document Results

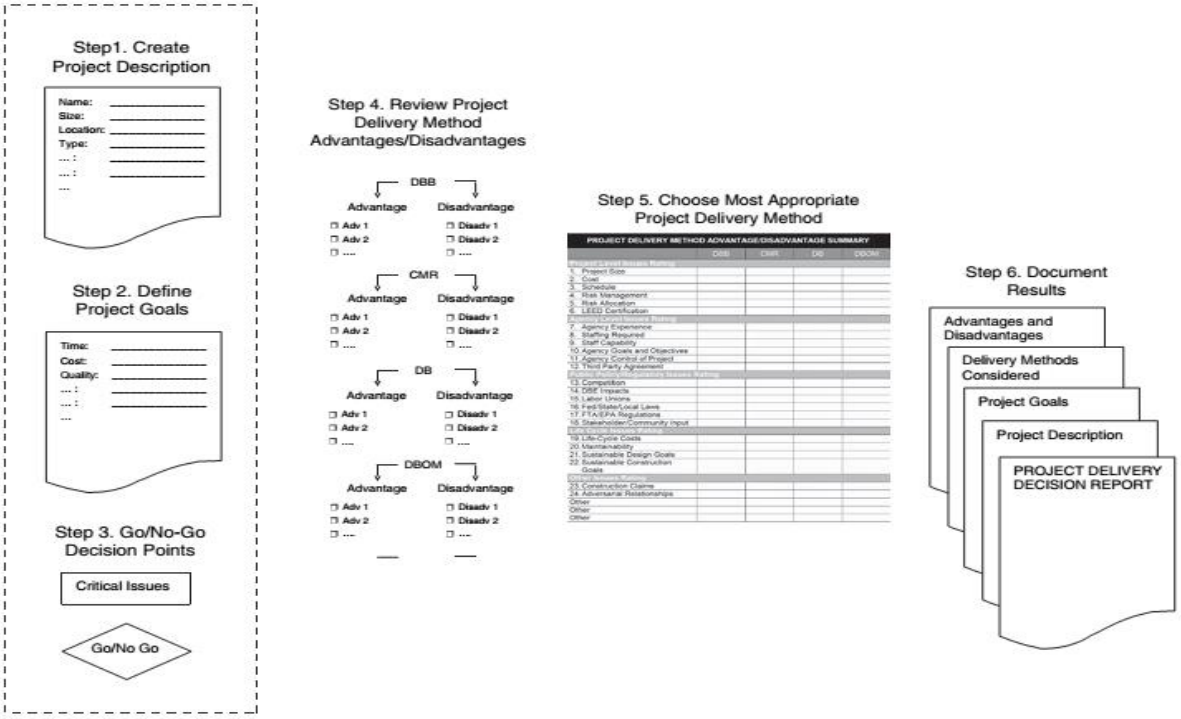

Figure 2.7:Tier 1 approach steps. adapted from TCRP guidebook prepared by Ali Touran D. D., 2009

Projects always differs in their scope of work, duration, budget, people involved, and nature. This difference affects the delivery method selection since they have different roles for project success clients should choose the most appropriate delivery method on the basis of the project requirements and the

opportunities that each delivery method can provide for them. The above mentioned six steps guides the process of Tier 1 decision making. The project description provides detail of project goals. The first step would be the creation of a project description. (Kamran, 2009) explains that, the objective of creating a project description is to briefly express details to document for the project delivery decision. (Ali Touran D. D., 2009) suggests the following checklist to include important project characteristics and provide full information about the project.

Project Description

- Project Name
- Location
- Estimated Budget
- Estimated Project Delivery Period
- Required Delivery Date
- Source(s) of Project Funding
- Project Type
- Project Corridor or Site Dimensions
- Major Features of Work
- Major Schedule Milestones
- Major Project Stakeholders
- Major Challenges
  - With Right of Way, Utilities, and/or Environmental Approvals
  - During Construction Phase
  - During Operation and Maintenance
- Main Identified Sources of Risks
- Sustainable Design and Construction Requirements

This approach gives guidance on how clients define their project specific goals. A well-defined project goal is the crucial for excluding those delivery methods that are not feasible. It is also mandatory for identification of potential advantages and disadvantages of delivery methods.

2.6.2.1.2 Tier 2 Weighted-matrix delivery decision approach

Tier 2 weighted-matrix delivery decision approach is the second option after analyzing Tier 1 approach. The decision maker if not satisfied with the result of Tier 1 then Tier 2 will be applied. In Tier 2 approach the decision is based on critically study different delivery methods that are identified eligible for further analysis from the Tier 1 result. The decision tool is basically either AHP or weighted matrix like MAUT. Weighted matrix delivery decision approach uses the concept of relative importance or weight of delivery method selection criteria (Chang, 2004). (Ali Touran D. D., 2009) stated that the Tier 2 approach has three major primary objectives.

- Present a structured framework to assist clients in prioritizing their unique project goals and delivery selection issues;
- Assist owners in aligning their unique goals and issues with the most appropriate project delivery method; and
- Further document the project delivery decision in the Project Delivery Decision Report established in Tier 1

They also prevail in their guidebook to have five independent steps in Tier 2 approach

- Step 1 Define Selection Factors
- Step 2 Weight Selection Factors
- Step 3 Score Project Delivery Methods
- Step 4 Choose Most Appropriate Project Delivery Method
- Step 5 Document Results

Tier 2 approach, defines the set of delivery method selection criteria. The criteria are concise with the pre-defined project. the next process is weighting the set of criteria based on their suitability for each delivery method. And giving Score to the project delivery method with respect to each selection criterion is followed. After having the weighted criteria and PDM score, application of weighted-decision matrix determines the appropriate delivery method through multiplication of the weight of selection criteria with delivery method score. The maximum score will specify the best choice.

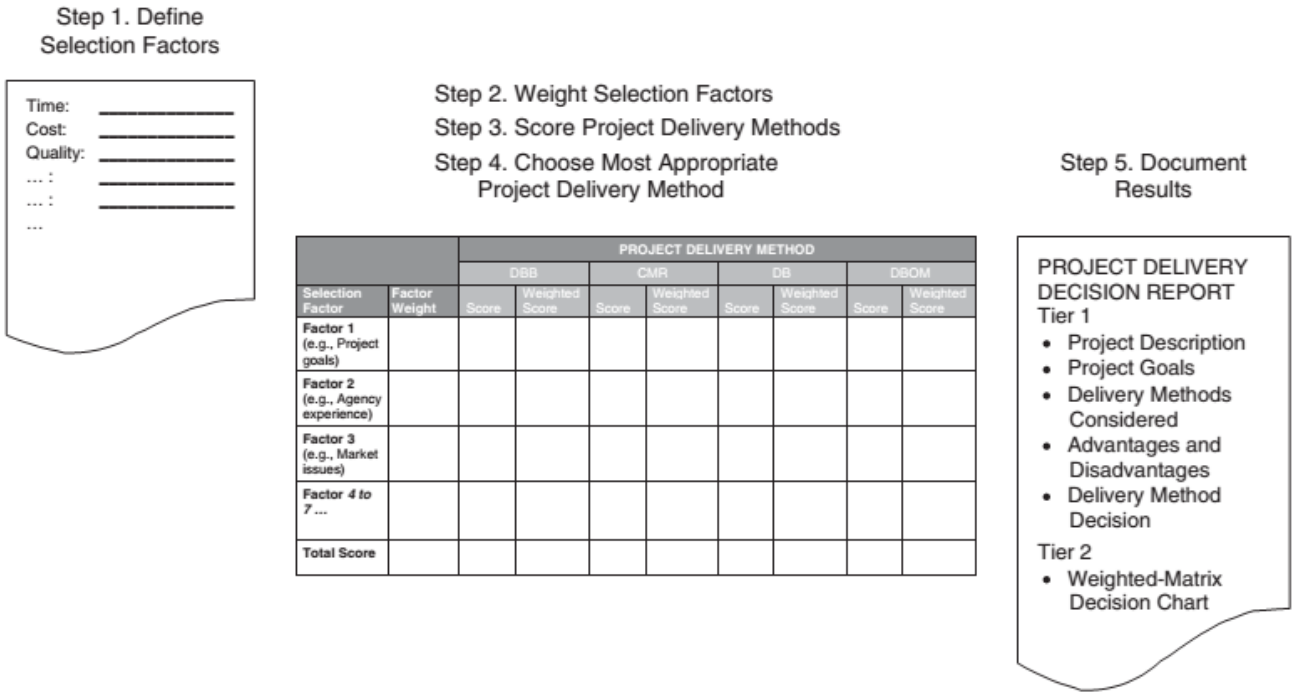

Figure 2.8:Tier 2 approach steps. adapted from TCRP guidebook prepared by Ali Touran D. D., 2009

Table 2.6:Weighted matrix template adapted from TCRP guidebook prepared by Ali Touran D. D., 2009

		DBB		CMR		DB	
Selection Factor	Factor Weight	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Factor 1							
Factor 2							
Factor 3							
Factor *4 to 7* …							
Total Score							

At this stage, based on this template choosing the appropriate delivery method is a matter of reviewing the total score and get the right decision. There are several ways to give weight to the factors and each of them should be given weight based on their importance. Equal weight should not be given to factors weight because it may not lead to the appropriate choice. There are different ways for weighted matrix method like Delphi method, pairwise comparison, rank order centroid, and ratio method to get criteria appropriate weight.

A. Determination of weights

The government of Australia uses the weighting and rating model for project delivery method selection for their infrastructure projects. According to (Center for Excellence, 2010) the guide book prepared by the Australian government, the criteria are first identified based on the client requirements and project characteristics, second the criteria are rated and weighted for each delivery method options then the highest score will be selected as the appropriate PDM from the alternatives.

The Washington state department and Transport Cooperative Research Program (TCRP) recommends the same weighting and rating method of delivery method selection models in Tier 2 selection approach through the guidebook for the evaluation of project delivery methods. The methods of weighting criteria identified and used are Delphi method, pairwise comparison, rank order centroid, and ratio method.

Another guidebook prepared by Tina Koppinen and Pertti Lahdenperä in 2004, on the basic experiences of PDM and their practical applicability on their road sector, shows even though there are wide variety in trend of PDM the basic selection of alternative delivery method is the same. The detail

assessment was made basically in four countries which are Finland, United Kingdom, Australia and USA and also there are some other countries which are included in the study like New Zealand, Hong Kong and Canada.

In his journal Roszkowska, (2013) emplies that, in multi-criterial models the weights of criteria play a very significant role and they have diverse clarifications depending on context decision making, on multi-criteria analysis methods. However, they usually provide the information about the relative importance of the considered criteria.

This all references shows that ranking criteria, weighting the delivery method available choices criteria weighting and selecting the appropriate deliver method who gets the highest score is being practiced in large number of countries. Therefore, as a best practice the above mentioned four ranking methods will be applicable for this particular research for the criteria or factors identified in the Ethiopian Road Authority for selecting of appropriate project delivery method for each project based on specific project characteristics. As mentioned in the above statements, weighted matrix approach needs weighting and ranking of factors to determine the appropriate score for each delivery method and the above mentioned four methods (Delphi method, pairwise comparison, rank order centroid, and ratio method) are mostly used methods. These methods will help the decision makers to develop more consistent and transparent weights. The formula and techniques of the methods are explained below.

i. Delphi Method

The Delphi method is an iterative procedure used to pull together the judgments of experts using a series of questionnaires combined with their feedbacks. The original Delphi method was developed by Norman Dalkey of the RAND corporation in the 1950's for U.S sponsored military project (Gregory J. Skulmoski, 2007). The panel consists of a number of experts chosen based on their experience and knowledge required to decide on importance of selection criteria. The Delphi practice is based on the detail discussion of experts on the aim of the project specific goals. In this technique the panel members are asked to give the weights of the criteria through thorough discussion on the importance of delivery method selection criteria. Delphi studies have been useful in educational settings in forming guidelines, standards, and in predicting trends (Green, 2014). The Delphi method should be conducted by a director (facilitator) who has independent communication with each panel member.

ii. Pairwise comparison

In the pairwise comparison method, the decision maker compares each criterion with the rest of the criteria and give a preferential level to the item in each pairwise comparison (Chang, 2004). For example, if the item at hand is as important as the second one, the preferential level would be one, and if it is extremely more important, its level should be 10. After conducting all of the comparisons and determining the preferential levels, the numbers will be added up and normalized. The results are the weights for each

item. The following table can be used as a guide for giving preferential level score to an item while comparing it with another one.For example, let us assume that shortening the schedule, project cost and agency control of the project are the most important parameters in the project delivery selection decision.

Following the pairwise comparison, the decision maker should prefer one of these factors (*e.g.*, shortening schedule) and compare it with the remaining factors and give a preferential level to it. For example, shortening schedule is more important compared to project cost; in this case it will be given 5 as the level of importance. The decision maker should continue the pair-wise comparison and give weights to each of them.

iii. Rank Order Centroid (ROC)

Rank order centroid method is a way of giving weight to a number of criteria ranked according to their importance. The decision makers usually can rank certain criteria much easier than giving weight to them. the rank ordering weighting methods provide approximations of "True" weights of criteria when rank ordering is known. Such assumptions complete rank ordering being provided by decision makers. Using the rank method is better than giving direct weights to each selection criteria. Since the rank is easier for the decision makers than giving weight and creates better environment for discussion based on the rank given to each criteria. ROC method takes those ranks as inputs and converts them to weights for each of the items. The conversion is based on the following formula:

$$W_i = (1/M)\sum_{n=i}^{M} 1/n$$

Where *M* is the number of items and *Wi* is the weight for *ith* item. For example, if there are 4 items for giving weights, the item ranked first will be weighted (1/1 + 1/2 + 1/3 + 1/4) / 4 = 0.52, the second will be (1/2 + 1/3 + 1/4) / 4 = 0.27, the third (1/3 + 1/4) / 4 = 0.15, and the last has a weight of (1/4) / 4 = 0.06. As it is shown in this example, the ROC is simple and easy to follow but it gives weights which are highly dispersed.

iv. Ratio method

Ratio method is another simple way of calculating weights for a number of items. (Kamran, 2009) presents the ratio method with practical example in his dissertation explained that, a decision maker should first rank all the items according to their importance. The next step is giving weight to each item based on its rank. The lowest ranked item will be given a weight of 10. The weight of the rest of the items should be given as multiples of 10. The last step is normalizing these raw weights. (Kamran, 2009) also stated that the gap between the weight of each criterion should not be based on the value of 10. The value or weight given to each criterion is dependent on the decision makers perspectives on the importance of the factors. Normalized weights are simply calculated by dividing the raw weight of each item over the total weights of all items.

2.6.2.1.3 Tier 3 Optimal Risk based Approach

Project risk is a condition includes various aspects of project consideration which contains potential adverse conditions to cause undesired impact on the project development. Proper risk identification and taking risk management practice reduce its impacts. The type of project delivery method will have a substantial impact on risk allocation because the risk responsibilities are determined by the contract (Kamran, 2009).

Tier 3 approach is applied if the appropriate delivery method choice is not clearly specified through Tier 2 analysis. according to (Ali Touran D. D., 2009), tier 3 approach consists of two phases. The first phase involves a qualitative analysis which involves developing a risk allocation matrix that clearly shows an owner's risk under competing delivery methods. Through reviewing of risks, the owner will have a chance to decide whether a specific delivery method is more appropriate than others. If a qualitative analysis does not provide an ultimate answer to the delivery selection, phase two of quantitative analysis should be proceed. The quantitative approach emphasizes the effect of project delivery method on project cost and schedule.

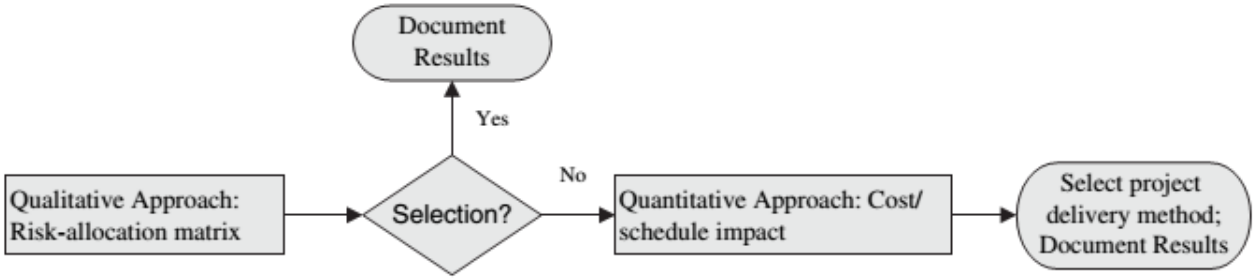

Figure 2.9:Overview of risk-based approach, taken from TCRP Guidebook

A. Qualitative approach

It is recommended to look for appropriate delivery method choice when the design of the project is in its preliminary stage. If the project goes into the Final Design, the decision maker will have not the opportunity use alternative delivery methods and will be limited to the traditional DBB approach because once the detail design is completed the chance of searching for another delivery method is decreased like DB. Since in DB the main advantage of using it is transferring the design risk to the contractor.

If the decision on PDM cannot be made in the first two Tires, the client would conduct preliminary risk analysis in order to be able to make the choice on PDM. The result of preliminary risk analysis is a risk allocation matrix. To each risk factor, a rating will be assigned as to the effect of the PDM on the treatment of that risk factor, from the perspective of the owner.

(Ali Touran D. D., 2009) illustrates hypothetical example to explain the way how qualitative analysis can be implemented for PDM selection. Therefore, the example was taken for this research to show qualitative risk- based approach. For instance, the use of a DBB has a favorable effect for "Permits/approvals" risk from the client point of view. It is decided that the client is the best party to obtain these permits and that the client can most effectively do this under a DBB approach. A rating of "+" is assigned for such a case. The same risk factor, under a DB delivery method is unfavorable from the client point of view, because the client feels that the DB constructor is not the best party to obtain various permits and approvals (such as environmental permits). A rating of "—" is assigned for such a case. As another example, the risk associated with "Design Defects" has a rating of "—" for the client under the DBB arrangement because in this delivery method the client is responsible for the accuracy of design. A DB approach on the other hand gains a "+" rating for the client because it transfers this risk to the constructor. In summary, the ratings always evaluate a risk from the standpoint of the client.

If the choice of a PDM has no effect on a particular risk factor, then a rating of "0" will be assigned. After the matrix is developed and rated, the evaluation team can review the outcome and see if any PDM seems superior in terms of its capacity in dealing with the risk factors.

Table 2.7:Qualitative risk analysis sample example

Risk Factor	DBB		DB	
	Responsible	Rating	Responsible	Rating
Permits/Approval	Owner	+	Constructor/Owner	-
Different Site Conditions	Owner	0	Constructor/Owner	+
Design Defects	Owner	-	Constructor	+
QA/QC	Constructor/Owner	0	Constructor	+
Exchange Rate Risk	Owner	-	Owner	-
Other risk factors				

Analysis of the risk allocation matrix and rating the risk factors can be for each PDM should be undertake in a realistic time. If the result indicates a clear PDM choice, then the decision is finalized and

the results will be documented. If the qualitative analysis does not clearly show the appropriate project delivery method then the detail quantitative analysis is the next step.

B. Quantitative Approach

The quantitative analysis is endeavored when the qualitative analysis does not result the clear choice of PDM. The quantitative approach process is started by reviewing all the risk factors and selecting those risk factors. The approach investigates the impacts of major risk events in accordance of different delivery method on the project cost. The quantitative approach is suggested to be used at the decision of the preliminary engineering phase (Kamran, 2009) since the client is expected to have a probabilistic risk analysis on project cost and schedule. The project cost distribution and the list of ranked risks will serve as inputs to the process of selecting the best PDM. For each ranked risk a distribution of risk costs is usually estimated. The highest ranked risks are those with large expected values and large ranges (an indication of high variability of the risk factor).

Only the risk factors that are profound to the project delivery method will be selected for further analysis. For each of these risk factors, the range of cost will be predictable under assumed project delivery method. The quantitative approach is a powerful tool for matching competing PDMs. It focuses on those differences between the PDMs that affect cost and schedule. It provides a reliable way of assessing each PDM based on the major risk factors affecting the project. The problem of this approach is its dependency on the availability of the expensive risk analysis results and the higher skill level required for pricing out each risk under various PDMs. A properly selected PDM is an operational risk mitigation tool that can support to keep reduced project costs and minimize project delays.

2.6.2.2 Decision Support System

A Decision Support System is a system based tool used for selecting project deliver method. It helps the decision maker by providing sufficient relevant knowledge and a framework for decision. A DSS can be as simple as a list of critical factors to be considered or as complicated as a complex software package. “Decision Support Systems consist of a class of information systems that draws on transaction processing systems and interrelates with the other parts of the whole information systems to support the decision-making (Power, 2002). DSS can be divided into five categories: data-driven DSS, model-driven DSS, knowledge-driven DSS, document-driven DSS, and communications-driven DSS. Building a new DSS entails an improvement and change in one of the following: 1) the user interface, 2) the database, 3) the model and analytical tool, and 4) the DSS architecture and network (Power, 2002).

DSS are for problems with multiple objectives and some are for problems with a single objective. Owners have a number of objectives in terms of cost, schedule, quality, level of control when deciding on project delivery method, *i.e.* PDM selection is a problem with multiple objectives. One way of dealing with the issue of PDM selection is to consider the uncertainty and use probability distributions for

modeling utility functions which will make the decision making more complex. When the effect of a PDM is not clear, the owner assumes a certain level of impact by each PDM, therefore the problem of PDM selection is treated as a problem under certainty (Kamran, 2009). Selection of the appropriate project delivery method is a complex decision-making process. It is a multi-criteria decision and should be made as early in the design phase as possible; preferably during the project scoping process and certainly before the final construction cost estimates are ready.

2.6.2.3 Multi Atribute Utility Theory

Agha N. I.,(2017), states that a MAUT is a methodology that can be used as a tool to measure impartiality in particular area of managemen. the MAUT is considered the primary technique appropriate for examining the criteria which affect the selection of PDM.They also stated that, the MAUT is used mainly to solve complex problems that involve the examintion of several criteria in relation to different outcomes. The decision makers investigates the values of the potential outcomes based on utility, i.e., the relative desirability of each possible outcome.

Fellows et al. (1983) states that, it is used for examining the criteria of clients, the preferences of procurement experts and the weights of each criterion by the consultants for each delivery method in the most systematic way. Through representing the relative utility of each client requisite and the delivery method against a numerical scale, it is possible to obtain a set of utility factors.

O. Moselhi,(2013) also provided that the multi-tiered process signifies a series of steps, arranged to obtain certain project requirements to simplify the selection process. The process involves identification of criteria as an input for evaluating the choice of PDM. Ojo and Aina (2010) illustrate that the MAUT involves these four steps:

1. The client weights the relative importance of each significant factor that affects the selection of the procurement method.

2. Rationalised priority ratings are calculated by dividing each of the priority ratings by the sum of all the ratings and are then entered into the decision chart. The sum of the rationalised priority ratings should always be equal to 1.

3. Each rationalised priority rating is taken in turn and multiplied by each of the utility factors and the results are then entered into the appropriate columns

4. The totals of each of the result columns under each procurement method are calculated and ranked in descending order.

The most appropriate procurement method is the method with the highest total.

2.6.3 Analytical Hierarchical Process

The decision making using AHP is based on analyzing environmental, social, political impacts of different choices through from experience (Saaty T. L., 1990). AHP method was developed by Dr. Thomas Saaty in 1980 as a tool to help with solving technical and managerial problems. It is one of the most widely used technique for appropriate delivery method selection. Kamran, (2009), AHP application is being modified starting from the first development by different researchers including Dr. Saaty. It aims at measuring relative importance for a certain set of alternatives on a ratio scale, based on the result of the decision-maker. Palcic, (2009) mentioned that the analytic hierarchy process (AHP) includes both the rating and comparison methods. Rationality requires developing a reliable hierarchic structure or feedback network that includes criteria of various types of influence, stakeholders, and decision alternatives to determine the best choice. The AHP utilizes mathematical procedures with matrices to calculate the relative importance of the selection criteria and it includes a method of computing the level of consistency of the judgments (Saaty, 2003). The theory also includes several approximate techniques of calculating importance based on pair wise comparisons (Saaty,1980). The AHP has found its widest applications in multi criteria decision making, planning and resource allocation and in conflict resolution (Saaty R. , 1987).

2.7 Challenges of using delivery method selection criteria

Using of PDM selection criteria differs from one client to the other based on the criteria identification capacity and adaptability trend exists. According to (SMEC, 2018) some of the challenges in utilizing the criteria are:

- Lack of knowledge on selection criteria's and their potential benefits in identifying the proper delivery method
- Resistant to change the adopted delivery method and trend in delivering the projects
- Lack of knowing about the possible effects of the improper selection of delivery methods
- Lack of frameworks which govern how criteria's will be used and determine on the possible outcomes

Selecting the appropriate delivery method of projects by using the delivery method selection criteria will play a vital role in the road infrastructure construction sector because it has the major contribution for the development of the construction industry.

2.8 Conceptual framework

The conceptual framework of this thesis, tries to put the relationship between the delivery method selection criteria and selected project delivery method and its influence on the project success as shown in the following figure.2.10

Based on the relationship tabulated here the DM selection criteria are independent factors which affect the dependent factor which is the selected PDM and problem and challenges of DM is one factor which affect the DM effectiveness and project success.

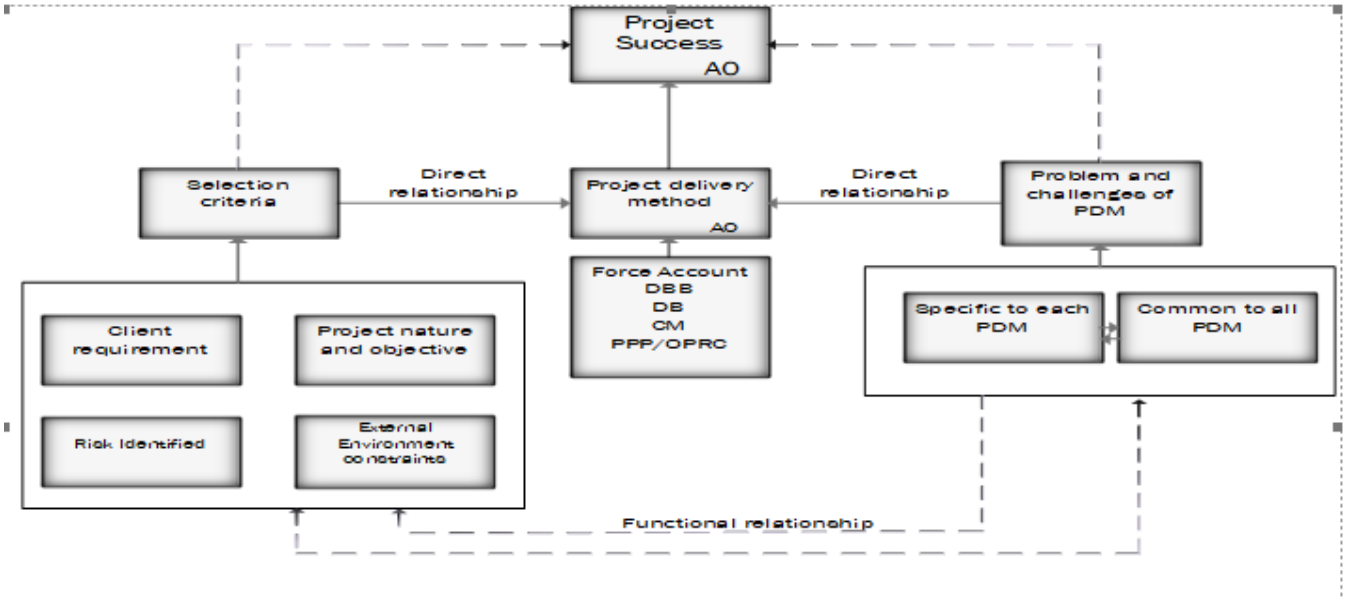

Figure 2.10:Conceptual framework

CHAPTER 3
3. METHODOLOGY

3.1 Introduction

Research methodology is a set of systematically organized study used for solving the research problem (Kothari, 2004). It is also a process that involves selection and utilization of different techniques for research problems by following a stepped, reasonable, organized and regression method, through data gathering and analyzing to draw a valid deduction from them. Abiy Zegeye *et al*, (2009) preparatory module for graduate program for AAU, describes methodology as "the theory of how inquiry should proceed" that "involves analysis of the principles and procedures in a particular field of inquiry." It involves the researchers' expectations about the nature of reality and the nature of knowing and knowledge. This chapter includes the methodology used in this research. It provides research type, methods selected and the information about the research design from three research instruments.

Instrument One: - Questionnaire, is designed for answering research question one, to identify delivery method selection criteria which uses in Ethiopian Road Authority. This part will provide information on questionnaire design, population, sample size, various approaches to data collection and data analysis technique. It also identifies the, validity content, and reliability of the questionnaire. The criteria are presents from literature review, different previous studies focused on identifying and ranking the factors affecting the selection of delivery method.

Instrument Two: - Document analysis from selected projects, this instrument is used for answering question number two which is, what are the problem and challenges of different delivery methods used for Ethiopian road authority. This part of the methodology will present, the rational for selection of case study projects, data gathering and analysis mechanisms to compare and contrast the challenges of projects with their respected delivery methods advantages and disadvantages to draw a valid conclusion.

Instrument Three: - Model development, this instrument is used for the third research question and the hypothesis raised how we can select appropriate delivery method for Ethiopian Roads Authority projects. This part of the methodology will present the type of selection model used, validation methods and proposed framework to draw a valid output.

3.2. Research Types

There are different types of research classifications. According to Abiy Zegeye *et al*, (2009) preparatory module for graduate program for AAU, it is difficult to propose a single classification method that fits different perspectives. It should also be noted that there is no clear dividing line between one method and the other. There are always commonalities in a sense that one method somehow includes the other. Accordingly, this research is designed to be: Descriptive and Explanatory since it aims to explore and analyze the different delivery methods selection criteria used for selecting appropriate delivery methods. it has an applied nature since it is designed to solve practical problems than acquiring knowledge. In terms of the research approaches, it follows both qualitative and quantitative approaches. In terms of data source, this research utilizes both primary data and Secondary Data sources. The following diagram illustrates the research methodology followed for this particular research.

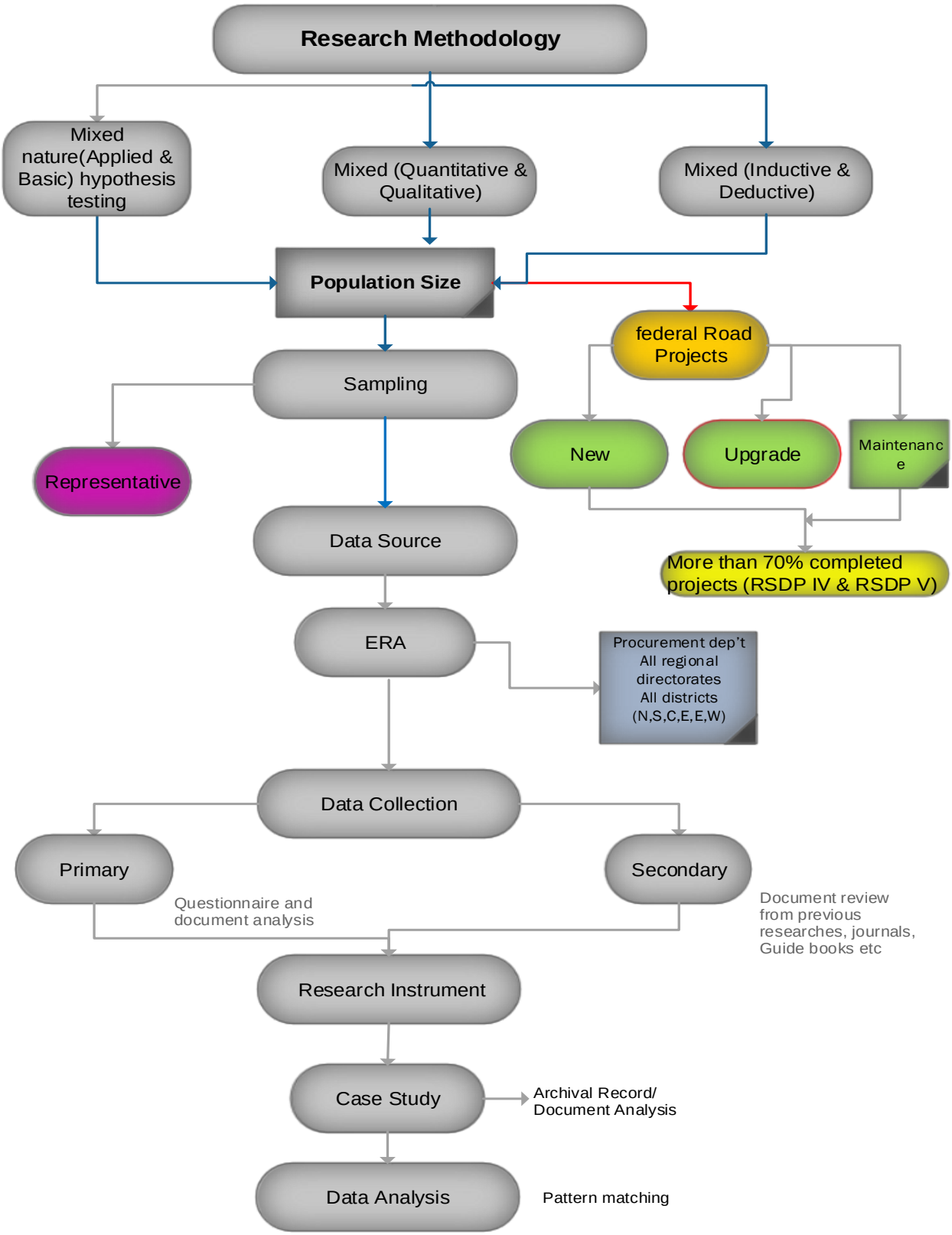

Figure 3.1:Research Methodology diagram

3.2.1. Justification of Research methods

According to Yin, (2003) a case study research is used for exploratory, descriptive as well as explanatory studies. This research describe type of PDM, selection criteria, selection mechanisms, dependent and independent variables. It explains the relationship between variables, how they can be weighted. Therefore, the main research design for analysis and discussion will fall to case study mainly concentrated in ERA's projects. This research paper aims to solve the problem of selecting different DM using systematic way through research questions and hypothesis testing. This purpose gives the research basic (hypothesis testing) and applied (problem solving) mixed nature. The main reason for using both inductive and deductive approaches for this research is basically initiated from an existing problem from research questions inductively and the proof disproof of hypothesis will go deductively therefore the combination of the two instruments will be used.

The methodological approach used in undertaking this research involves both qualitative and quantitative approaches which is very important to achieve the objectives of the research, to get the better output of mixing both approaches instead of using only one. Because the research questions raised from the specific objectives will be qualitatively analyzed because a critical review of literature related to this research area will first undertake to provide the theoretical background and context of the research. This review covered: (i) Project DM currently in use in ERA, and factors influencing their appropriate use; (ii) the main criteria for selecting DM; (iii) different selection models used for DM selection (iv) challenges of project implementation.

3.2.2 Data Source and Data collection mechanism

The primary data sources for this research was principally from ERA, consultants and contractors for the questionnaire designed. As it's discussed earlier in the background study, the research focuses on project delivery method selection practice of ERA. Different directorates and regions of ERA shall be the primary sources like, Procurement directorate for selection of PDM, Contract Administration (Project management directorate) and Regional directorates (East, West, South, North, Express & Central) for rating selection factors and to score the delivery methods suitability for each criterion. Consultant and contractors who are willing and actively involving in current projects of ERA are asked to rate the selection factors and to score the delivery methods suitability for each criterion. Another primary data source was selected projects, extension of time approval analysis documents, variation order assessment and approval documents, progress reports and different contractual request and approval documents. To extract each project actual challenges or reasons that cause EOT and cost escalation of the project beyond its estimated contract time and cost. The analysis of different projects needs more in-depth understanding of the cases to identify specific problems and challenges of projects related to its delivery method faced during progress as a unit, and through comparison of similarities and differences of the individual project cases with their identified problems and challenges.

Secondary sources are data's which are collected by other persons and found out relevance for this research. Secondary sources will be different manuals, guidelines, thesis papers and journals which used for identifying factors which affect the selection of PDM and the relationship between different identified variables and different models used for selection of appropriate DM.

There are two main types of data collection mechanism followed for this research., primary data and secondary data. The primary data was collected through questionnaire and document analysis from the selected case study projects. Secondary data were collected from different thesis, journals and different written documents prepared by other researchers in the research area for literature review and as a supporting document for the analysis and to draw a valid conclusion.

3.2.3. Population and Sampling

The population size for this research is focused on client, consultant and contractors for the questionnaire and ERA's road projects for document analysis.

For the questionnaire designed, the population size includes

From ERA: - there are 7 regional and procurement directorates, 23 team leaders in the current organization structure of ERA. All regional directorates and team leaders were addressed. In addition, 5 senior advisors for the director general are included.

From Contractors and Consultants: - only GC-1 contractors are selected for the analysis. Since, they have a lot of experience in the road sector and may have a better chance in participating in DB contracts. There are 26 GC-1 contractors currently, who are actively involving in the road projects of ERA. There are 28 active consultants currently based on the data gathered from ERA.

The Population size for document analysis is focused on federal road projects in general and specifically for new and upgrading federal projects in all districts which are over 70% completed in the RSDP IV and RSDP V since July 2010G.C. The total population size is 63 projects. The projects are selected from both types of delivery methods which are currently used in federal road projects.

3.2.3.1 Sample size determination

The sample size determination is used for case study projects. for the questionnaire designed the research uses parametric data since most of the population numbers are addressed.

For the questionnaire designed, from ERA: - All 35 (regional directorates and team leaders) population size was addressed. From contractors and consultants: - 21 contractors and 22 consultants were addressed. Since almost all population is addressed for the questionnaire distribution it is not required to determine the sample size of the population.

For the case study projects, sampling is the process of selecting representative units of a population for the study in research investigation. Based on the data gathered from ERA, the total number of projects from RSDP IV and RSDP V, more than 70% complete are 61 from both DBB and DB type of delivery methods.

To select appropriate sample size, from the projects, I used the following statistical equations based on (Genn,Israel) sample size determination formulas:
Where:

no - Sample size

Z - Z value (e.g. 1.96 for 95% confidence level)

P - Percentage picking a choice, expressed as a decimal (0.50 used for sample size needed).

q- 1-p

e- Margin of error (+5%)

$$n_0 = \frac{Z^2 pq}{e^2}$$

no = $\frac{(1.96^2)\,(0.5)\,(0.5)}{(0.05)^2}$ = 385

If the sample size is small then we use the following formula to decide on the number of sample

n = $\frac{\text{no}}{1+(\text{no}-1)/\text{N}} = \frac{385}{1+(385-1)/61}$ = 52 projects is going to be analyzed

The result of simple size determination formula is 52 projects but 22 projects were analyzed for extracting actual challenges of projects. The number of the project is determined by the data availability for analysis. Especially for DB projects data gathering was difficult because recently ERA dispersed DB directorate to all regional directorates which creates information barrier.

3.3 Questionnaire Design

A questionnaire survey is designed to obtain further information in order to support the research study objectives and it is also designed based on identified selection factors that will affect the selection of best delivery method in construction projects in ERA. To assist formulation of a framework for the selection of delivery method. In this study, the questions of the research questionnaire are constructed based on literature review stated in previous chapter (Chapter 2) and interviews with senior client's representatives

to obtain different thoughts, which can be useful for creating questions. The questionnaire consists one part: contains, respondents rank of the main factors affecting the selection of delivery method and respondents score given to both DBB and DB suitability with each selection criteria.

3.3.1 Validity test

Taherdoost, (2016) explaines validity as the degree to which an instrument measures what it is imagined planned to measure. According to (Roberta Heale, 2015) Validity is defined as the level to which a concept is accurately measured in a quantitative study. Validity has several considerations and assessment approaches. Statistical validity is used to evaluate instrument validity, which include criterion validity and construct validity. To ensure the validity of the questionnaire, statistical tests is applied. The first test is Criterion-related validity test (Pearson test) which measures the correlation coefficient between each paragraph in one field and the whole field that used to test the validity of the questionnaire.

3.3.1.1 Instrument validity

The questionnaire was reviewed by some senior experts in ERA and my advisor. They were requested to identify the internal validity and to what extent it was suitable to be used as an instrument to realize the goals and aims of this research.

3.3.1.2 Structure and criteria validity test

Structure validity is statistical tool that used to test the validity of the questionnaire structure by testing the validity of the whole questionnaire. It measures the correlation coefficient between one criterion and all criteria of the questionnaire that have the same level of Likert scale. Criterion validity is the extent to which a measure is related to an outcome (Taherdoost, 2016) it measures internal consistency of the questionnaire. It is used to forecast future or current performance (Roberta Heale, 2015). The research questions consisted of 27 selection criteria.

3.3.2 The reliability Test

The reliability of an instrument is the degree of consistency which measures the attribute; it is supposed to be measuring (Mohajan, 2017). Reliability is the consistency of research measurement, or the degree to which an instrument measures the same way each time it is used under the same condition with the same subjects. It can be equated with the stability, consistency, or dependability of a measuring tool (Roberta Heale, 2015). The value of the reliability coefficient theoretically can range between -1.00 and +1.00. For most purposes, reliability coefficients above 0.7 are considered satisfactory (Taherdoost, 2016). The reliability coefficient of the scale was established by Cronbach alfa using SPSS package. The formula that determines alpha is simple and makes use of the items (variables), k, in the scale and the average of the inter-item correlations, r

$$\alpha = \frac{kr}{1+(k-1)r}$$

The Cronbach's coefficient alpha was calculated for each field of the questionnaire. The most identical values of alpha indicate that the mean and variances in the original scales do not differ much, and thus standardization does not make a great difference in alpha. Table 3.1 and table 3.2 shows the values of Cronbach's Alpha for each factor of the questionnaire and the entire questionnaire. For the fields, values of Cronbach's Alpha were in the range from 0.84 and 0.88

Table 3.1: Reliability test of group of selection factors

Group of Selection factors	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Factors related to Client characteristics	25.54	6.53	0.75	0.84
Risk related factors	25.47	6.69	0.78	0.84
Factors related to Project characteristics	25.52	6.85	0.70	0.85
Factors related to External environment	25.76	6.30	0.69	0.85
Design bid	22.16	5.38	0.73	0.85
Design bid build	21.88	5.70	0.62	0.87

Table 3.2:Reliability test of selection factors

Selection factors	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
The degree of desired client involvement	99.36	139.76	0.51	0.86
Client experience in procurement method	100.22	135.13	0.39	0.88
Flexibility for changes and variations	100.36	131.95	0.49	0.86
Avoid or minimize time & cost overrun	99.81	136.53	0.39	0.89
Transparency of work process	100.13	138.21	0.45	0.77
Staff experience	100	138.76	0.50	0.85
Possibility for innovation	100.54	138.54	0.42	0.86
The importance of the project	99.90	143.32	0.20	0.89
Scope definability	99.54	140.83	0.42	0.88
Early time estimation definition	100.45	143.97	0.18	0.89
Quality certainty	100.27	140.20	0.47	0.78
Cost certainty	99.5	138.83	0.48	0.88
Complexity of the project	99.68	137.75	0.46	0.88

Price competition	99.95	131.47	0.64	0.78
design change	100.31	130.13	0.74	0.87
Early scope determination	99.86	136.50	0.58	0.87
Early cost estimation definition	100.41	138.53	0.43	0.88
Urgency of time	100.09	137.99	0.38	0.89
Likelihood of construction risk or uncertainty	99.72	139.73	0.46	0.88
Budget constraint	99.77	133.80	0.52	0.89
Risk transfer or sharing	100.5	141.69	0.25	0.78
Claim and dispute administration	99.90	137.70	0.37	0.86
Political reasons and interference	99.59	142.72	0.12	0.89
Market competitiveness	100.45	129.97	0.81	0.87
Contractor's capability and availability	100.05	135.37	0.50	0.88
Regulatory body interference	100.63	138.33	0.50	0.78
Technology availability	100.59	135.87	0.63	0.82

Based on the result the Cronbach alpha value is > 0.7 which is acceptable. The result of this statistical analysis shows that each selection criteria are reliable for the use of those factors to select the appropriate delivery methods for federal road projects of Ethiopia.

3.3.3 Method of data analysis

In order to be able to select the appropriate method of analysis for questionnaire, the level of measurement must be understood. For each type of measurement, there is/are an appropriate method/s that can be applied and not others. In this research, ordinal scales were used. Ordinal scale is a ranking or a rating data that normally uses integers in ascending or descending order. The numbers assigned to the important (1, 2, 3, 4, 5) do not indicate that the interval between scales are equal, nor do they indicate absolute quantities. They are merely numerical labels based on Likert Scale. After collecting the data from questionnaire which distributed to client representatives, consultants and contractors, the data was analyzed and the result documented, the analysis concentrate on two directions which the first one is to identify and rank of the factors that affecting the selection of delivery method in construction projects in ERA, and the second one is to develop strategies to build a model to select the best delivery method in road construction projects. Furthermore, the data was analyzed using SPSS package and Microsoft Excel.

3.4 Case Study projects selection

The second step of the research was to select a number of road projects and conduct case study analyses on them. The main objectives of the case studies were to find out the state of practice in the industry and to understand the processes and challenges of projects. According to Yin (1984), case studies are “the preferred strategy when *how* or *why* questions are being posed. A case study essentially tries to illuminate

a decision or set of decisions: The main principles of data collection in a case study were followed. These principles were a) using multiple sources of evidence, b) creating a case study data base, and c) maintaining a chain of evidence. Yin (1984) emphasizes on the importance of planning the process of accessing and collecting data as an essential preparation for efficiently and accurately collecting cogent information. The analyzed case study projects include seven Design-Build (DB) projects and Nineteen Design-Bid-Build (DBB).

3.4.1 Data Analysis mechanism of Case study projects

As stated in the introduction part of this chapter one of the research instrument is document review for extracting project challenges that are faced during course of construction. The data analysis mechanism used is first reviewing of projects each documents like EoT requested by the contractor with its reasons, approval of requested EoT, variation order documents with its justification why it is needed and with its cost increase or decrease implications, monthly and quarterly progress reports to extract problems encountered during that period and deferent other claim heads accepted by the client. After collecting all these documents, the second step is extracting the main cause of each claim heads because challenges are the reasons that cause EoT, VO and cost escalation. The final step is comparing and contrasting the challenges with advantages and disadvantages of DB and DBB to identify which delivery method better suits and decrease which challenges. This results together with questionnaire analysis is used as an input for the proposed model.

3.5 Delivery method selection Model

The third step of this research was to develop a framework based on the model of Multi Attribute Utility Theory. It has a wide range of practicality for different delivery methods but the model for this particular research will be applied on DBB and DB delivery methods using influential factors on selecting PDM for a project a structured step-by-step approach toward selecting the best and most appropriate delivery method.

3.5.1 Model Validation

The final step was validation of the suggested model of MAUT. the validation of the model is used for proof or disproof of the proposed hypothesis. The mode used to select appropriate delivery method is validated using one case study project from the analyzed case study projects. the project is selected based on the challenges faced during its implementation.

CHAPTER 4
4. RESULT AND DISCUSSION

4.1 Introduction

This chapter have three parts of findings and discussion which discuss the data gathered for the answer which are raised in chapter 1. As a research question and hypothesis by using three different research instruments. The first research question asked what the factors are we can use for selecting the appropriate delivery methods for Ethiopian Road authority's projects. This research questions were answered by the results that have been deduced from a survey questionnaire. The survey contains total of 78 questionnaires, 35 from Ethiopian road authority, 21 consultant respondents from engineer's consulting offices, and 22 GC-1 contractors involved in ERA's projects. The questionnaire was designed to identify and rank the most common factors affecting the selection of delivery method for Ethiopian road authority projects. The selected factors were used for developing the framework to select the appropriate PDM and problems.

The second research question raised what challenges ERA's projects are facing during construction stage in order to identify which challenge we can avoid by selecting appropriate delivery method instead of random selection by familiarity. This research question will be answered through document analysis of 22 projects from both types of delivery methods. Through reviewing every contractual correspondence from contractors and client side. challenges of projects will be identified and analyzed with the help of literature review to verify the developed framework. The projects selected for analysis were from RSDP IV and V. most projects are above 70% completed and some projects are fully completed from both DBB and DB types of delivery methods.

The third research question and the hypothesis raised how we can select appropriate delivery method for Ethiopian Roads Authority projects. After knowing which criteria to be used in our country context and what challenges of projects should we reduce through the right selection of delivery methods. This research question and hypothetical framework will be answered through developing delivery method selection framework and testing of the model to verify that it helps to reduce the challenges of projects related to delivery method. Therefore, the following three parts of the chapter is going to discuss findings of each research instrument based on the order of the research questions.

4.2 Results and discussion of delivery method selection criteria

This part of the analysis is discussed the results of survey from total of 78 questionnaires, 33 from Ethiopian road authority, 21 consultant respondents from engineer's consulting offices, and 22 GC-1 contractors involved actively in ERA's projects.

4.2.1 Position of respondents

Table 10 shows the frequency and percent of job title of the respondents from ERA, that are 21.21 % Procurement and regional directorate directors, 3.03% Director General 3.03% of respondents were Contract Administration deputy director senior advisor, and 69.69% of respondents were team leaders. It can be seen that all respondents have a good procurement and project administration experience which supports the quality of gained information.

Table 4.1:The frequency and percent of job title of the respondents from ERA

Position of respondents	**Frequency**	**Percent (%)**
Director General	1	3.03
Director general and Contract Administration deputy director senior advisors	3	9.09
senior advisors	1	3.03
Procurement and regional directorate directors	7	21.21
Team leaders	23	69.69
Total	**35**	**100.0**

When we come to the consultants and contractors, the respondents were contract managers, construction department heads. General managers, project managers and senior engineers. Table 4.2 shows the frequency and percent of job title of the respondents from consultants and contractors' company.

Table 4.2:The frequency and percent of job title of the respondents from consultants and contractors' company.

Position of respondents	**Frequency**	**Percent (%)**
General and deputy managers	10	23.25
Contract Administration engineers	7	16.27
Construction department heads	8	18.66
Project managers	8	18.66
Senior engineers	10	23.25
Total	**43**	**100.0**

Respondents were asked to rank 27 delivery method selection criteria and to score the alternative delivery methods by using Likert scale. For the criteria the respondents were asked to rate importance of the criteria by using (1= Very Low, 2= Low, 3= Medium, 4= High, 5= Very High). for the delivery methods they score the suitability of the criteria for the delivery method by using the following table.

Table 4.3:The suitability score of selection criteria for each delivery method

Score	Definition
10	Very high suitability for the selection factor
8	High suitability for the selection factor
6	Medium suitability for the selection factor
4	Low suitability for the selection factor
2	Very low suitability for the selection factor
9,7,5,3,1	Intermediate values between two adjacent judgments.

4.2.2 Statistical analysis tools

For this research the data analysis technique is both qualitative and quantitative data analysis methods. The data analysis will be made by utilizing (SPSS 16) and Microsoft Excel 2016. For analyzing the data's, the following statistical tools is used: 1) Pearson correlation coefficient for validity 2) Relative Importance Index (RII).

4.2.2.1 Validity Test

Validity is the strength of our conclusions, inferences or propositions. (Taherdoost, 2016). To ensure the validity of the questionnaire, structure validity test (Pearson test) that used to test the validity of the questionnaire structure by testing the validity of each field and the validity of the whole questionnaire. It measures the correlation coefficient between one filed and all the fields of the questionnaire that have the same level of similar scale. This part of the analysis will discuss about the significant correlation between selection criteria and with the respected delivery method.

Table 4.5 shows that the correlation coefficient is statistically significant at $\alpha = 0.05$ among the factors groups: "factors related to client characteristics", "factors related to project characteristics", "factors related to Risk factors" and "factors related to external environment" groups because the p-value (Sig.) is less than 0.05. the result indicates that there is a statistically significant correlation at $\alpha = 0.05$ among all the groups.

Table 4.4: The correlation coefficient between group of selection factors

Factors		Client related factors	Project related factors	Risk related factors	External environment related factors
Client related factors	Pearson Correlation	1	.693**	.643**	.442*
	Sig. (2-tailed)		0	0.001	0.04
Project related factors	Pearson Correlation	.693**	1	.732**	.633**
	Sig. (2-tailed)	0		0	0.002
Risk related factors	Pearson Correlation	.643**	.732**	1	.833**
	Sig. (2-tailed)	0.001	0		0
External environment related factors	Pearson Correlation	.442*	.633**	.833**	1
	Sig. (2-tailed)	0.04	0.002	0	0
**. Correlation is significant at the 0.05 level (2-tailed).					

As shown in the Table 4.5, the correlation relationship between group of factors the result indicates there is a perfectly positive relationship which means one group of factor has a significant positive impact on the other which shows the importance of each group of factors.

Table 4.5:The correlation relation between group of factors and delivery methods

Factors		Client related factors	Project related factors	Risk related factors	External environment related factors	Design bid build	Design build
Client related factors	Pearson Correlation	1	.693**	.643**	.442*	.550**	.756**
	Sig. (2-tailed)		0	0.001	0.04	0.008	0
Project related factors	Pearson Correlation	.693**	1	.732**	.633**	0.379	.578**
	Sig. (2-tailed)	0		0	0.002	0.002	0.005
Risk related factors	Pearson Correlation	.643**	.732**	1	.833**	.475*	.589**
	Sig. (2-tailed)	0.001	0		0	0.026	0.004
External environment related factors	Pearson Correlation	.442*	.633**	.833**	1	.540**	.489*
	Sig. (2-tailed)	0.04	0.002	0		0.01	0.021
Design bid build	Pearson Correlation	.550**	0.379	.475*	.540**	1	.597**
	Sig. (2-tailed)	0.008	0.0082	0.026	0.01		0.003
Design build	Pearson Correlation	.756**	.578**	.589**	.489*	.597**	1
	Sig. (2-tailed)	0	0.005	0.004	0.021	0.003	0
*. Correlation is significant at the 0.05 level (2-tailed).							

As shown in the Table 4.5 and Table 4.6, the correlation relationship between group of factors and alternative delivery methods the result indicates, there is a perfectly positive relationship which means each group of factor has a significant positive impact on the alternative delivery methods which shows the importance of each group of factors for the selection of appropriate delivery method for road construction of the country.

4.2.2.2 Relative Importance Index

The relative importance index methods are used to decide the importance ranks of all factors. Relative Importance Index is a type of relative importance analyses. The relative importance index method (RII) is used here to determine clients, consultants and contractor's opinions of the relative importance of the selection criteria for selecting an appropriate delivery method in ERA. The relative importance index is computed as (Sambasivan and Soon, 2007). For this research the criterion who gets relative weight or importance index below 50% will be eliminated from the evaluation process.

$$RII = \frac{\sum W}{AXN}$$

where:

W = the weighting given to each factor by the respondents and ranges from 1 to 5

A = the highest weight (i.e.5 in this case)

N = the total number of respondents The RII value had a range from 0 to 1 (0 not inclusive), higher the value of RII, more agree for the paragraph.

This part consists of results and discussion of factors that affect the selection of delivery method in ERA. These factors were grouped into four groups. The first group is related to client characteristics factors. The second group is related to project characteristics. The third group is related to Risk factors. The last group is related to the external environment factors. The results of this part of study provide an indication of the relative importance index and rank of the major groups affecting the selection of delivery method given by client, consultants and contractors respectively. The relative importance index (RII) and rank of each of the factors affecting the selection of procurement method in construction projects in ERA are presented in Table 4.4.

Table 4.6:Relative importance index (RII) value of selection criteria

NO	Selection Factors	Client			Consultant			Contractor		
		RII	Rank	P-Value	RII	Rank	P-Value	RII	Rank	P-Value
1	Complexity of the project	90.91	1	0.00	89.52	1	0.000	84.55	3.00	0.000
2	Likelihood of construction risk or uncertainty	87.88	2	0.00	88.57	2	0.000	81.82	5.00	0.000

3	Political reasons and interference	87.27	3	0.00	87.62	3	0.000	85.45	2.00	0.000
4	The degree of desired client involvement	85.45	4	0.00	86.67	4	0.000	83.64	4.00	0.000
5	Flexibility for changes and variations	84.85	5	0.00	84.76	5	0.000	88.18	1.00	0.000
6	The importance of the project	82.42	6	0.01	81.90	6	0.000	80.91	6.00	0.000
7	Risk transfer or sharing	81.82	7	0.000	80.00	8	0.000	80.00	7.00	0.000
8	Claim and dispute administration	81.21	8	0.000	76.19	12	0.000	78.18	9.00	0.000
9	Transparency of work process	80.61	9	0.010	79.05	9	0.000	77.20	11.00	0.000
10	Staff experience	80.00	10	0.001	80.95	7	0.000	72.73	16.00	0.000
11	Early cost estimation definition	78.79	11	0.000	61.90	27	0.000	67.27	22.00	0.000
12	Early scope determination	78.18	12	0.000	78.10	10	0.000	79.09	8.00	0.000
13	design change	77.58	13	0.000	71.43	17	0.000	64.55	26.00	0.000
14	Avoid or minimize time & cost overrun	76.97	14	0.000	72.38	16	0.000	69.09	20.00	0.000
15	Urgency of time	76.36	15	0.000	68.57	20	0.000	68.18	21.00	0.000
16	Cost certainty	75.76	16	0.000	77.14	11	0.000	65.45	25.00	0.000
17	Scope definability	75.15	17	0.000	70.48	18	0.000	75.45	13.00	0.000
18	Client experience in procurement method	73.94	19	0.000	65.71	23	0.000	70.91	18.00	0.000
19	Early time estimation definition	73.33	20	0.000	75.24	13	0.000	73.64	15.00	0.000
20	Quality certainty	72.73	21	0.000	69.52	19	0.000	66.36	23.00	0.000
21	Price competition	70.91	22	0.000	74.29	14	0.000	70.00	19.00	0.000
22	Contractor's capability and availability	70.30	23	0.000	67.62	21	0.000	76.36	12.00	0.000
23	Technology availability	68.48	24	0.000	60.95	28	0.000	63.64	27.00	0.000
24	Market competitiveness	67.27	25	0.000	63.81	25	0.000	74.55	14.00	0.000

25	Possibility for innovation	66.67	26	0.000	62.86	26	0.000	66.00	24.00	0.000
26	Budget constraint	65.45	27	0.000	66.67	22	0.000	77.27	10.00	0.000
27	Regulatory body interference	64.85	28	0.000	64.76	24	0.000	62.73	28.00	0.000

From Table 4.4, all the factors get ranked above 60% by all respondents therefore, all of them are important for the decision-making process through selecting the appropriate project delivery method for a specific project.

According to ERA's professionals and consulting offices respondents; it was obtained from Table 15 that the complexity of the project was the most important factor as it has the first rank among all factors with relative important index (RII) equal 90.91% and 89.52% respectively for contractors respondents it is ranked as the third important factor with relative important index (RII) equal 84.55% it has given greater value by all parties as it affects directly on the selection of delivery method. This factor was considered as critical factor by (Peter Love, 2008)who illustrated that this factor should be taking into consideration for Australian and Queensland clients when they select delivery method. (Yap Zhi Shan1, 2019) is also ranked Complexity of the project as the second important factor for the selection of appropriate PDM based on the findings in Malaysian construction. Ali Hosseinia, (2015) studied the selection criteria for infrastructure projects and stated complexity of the project is one of the basic criterions in selecting among alternative PDMs and Eyitope et al., (2012) who agree to the importance of considering the degree of project complexity factor in the selection process of PDM. Likelihood of construction risk or uncertainty is the selection criteria which is ranked second by the client and third by consultant respondents with relative important index (RII) equal 87.88% and 88.57% respectively but from the contractor's perspective it is ranked fifth with relative important index (RII) equal to 81.82%. This factor was considered as one of the important criteria to select the appropriate PDM by (Yap Zhi Shan1, 2019) and (Ali Hosseinia, 2015) in their researches. Another group of researchers (Love P. E., 1998) identified Likelihood of construction risk or uncertainty as the major criteria to test their client requirement and preference in selecting the appropriate PDM in their studies in Australia.

Political reasons and interference are ranked third by the client respondents and gets second priority by the contractor respondents, but consultant respondents ranked as the fourth most important factor according to our construction culture. This factor is also acknowledged by Ademola Eyitope O. a., (2012) as the third important factor under their public policy requirement group of criteria W.D Thwala, (2012) finds out that political considerations is the fourth most important factor for the selection of delivery method in South African construction (Peter Love, 2008) is also stated that this factor is considered as the one of the sixth important criteria for Australian construction. The degree of desired client involvement ranked fourth by client respondents and contractors with relative important index (RII) equal 85.45% and 83.64% respectively, but consultants gave the second rank. This criterion or factor is more valuable for the client and contractor based on the result since the client involvement level determines the type of

contractual relationship created between them and also determines the degree of their responsibilities. Flexibility for change and variation is ranked as the fifth selection factor by the client and consultants with relative important index (RII) equal 84.85% and 84.76% respectively, and contractors ranked as the first important criterion with relative important index (RII) equal 88.1% based on the contractor's perspectives the flexibility of one delivery method for any changes is the major issue on selecting the type of delivery method this. The importance of the project is ranked as the six important factors based on the client, consultants and contractors' respondents. On this criterion all are agreed on the same level of influence of the criterion on selection of the delivery method of Ethiopian road construction with relative important index (RII) equal 82.42%, 81.9% and 80.9% respectively, with this result they are agreed with (El-Sayegh, Significant Factors Affecting the Selection of the Approporiate Project Delivery Method, 2007) who also ranked this factor as the six important factor among the corresponding factors. The seventh criterion is risk transfer or sharing by client respondent with relative important index (RII) equal 81.82% and contractors 80.0% respectively and ranked as the eighth important criterion with relative important index (RII) equal 80.0%. Maizon et al., (2006) are in the exact agreement with this result as they ranked risk avoidance factor in the eighth position factor in the Malaysian construction industry while Husam & Sedki (2009) are very close with this result as they ranked the risk avoidance factor in the tenth position in the Malaysian construction industry. In opposite, Odhigu et al., (2011) and Eyitope et al., (2012) are relatively far from this result as they ranked this sub-factor in the third rank position.

Claim and dispute administration criterion was ranked eighth by client respondents with relative important index (RII) equal 81.21% and consultants gave the twelve position with relative important index (RII) equal 76.19% on the other hand contractors were ranked as ninth important factor with relative important index (RII) equal 78.18% this result shows the difference between perspectives of the three groups of respondents but as we can see claim and dispute administration is more a challenge for client since it administers a large number of projects at a time. Therefore, choosing the appropriate delivery method reduces claim and dispute issues in administering the projects. Transparency of work process is the ninth selection factor for client and consultants with relative important index (RII) equal 80.61%and 79.05% respectively, and on the contractor's perspective it is ranked as the eleventh level with relative important index (RII) equal 77.7%. staff experience is ranked as the tenth important factor by the client respondents with relative important index (RII) equal 80%, the respondents from consultants ranked this factor as seventh with relative important index (RII) equals 80.95% and the contractors were ranked as sixteen important factor with relative important index (RII) equals 72.73%. (El-Sayegh, 2007) ranked this factor as eighteen important factor and signifies the management and staff of the client should have enough experience in administering the type of delivery method Shiyamini et al., (2007), Maizon et al., (2006), Mortledge et al., (2006), and Franco et al., (2002) illustrated that this factor is one of the most important factors influencing the selection of delivery methods. Early cost estimation definition is ranked eleventh by the client side with relative important index (RII) equals 78.79%, but consultants and contractors have far result with client they ranked the factor as twenty-seven and twenty-two level of importance with relative important index (RII) equals 61.9% and 67.27% respectively. Early scope determination is ranked as twelve important factors by client respondents with relative important index (RII) equals 78.18% and

the consultants and contractors have relatively similar rank result with relative important index (RII) equals 78.1% and 79.09% respectively. Design change is ranked as the thirteenth important factor by the client respondents with relative important index (RII) equals 77.5% and consultants have ranked the factor as seventeenth level of importance with relative important index (RII) equals 71.43%, contractors also ranked the factor twenty-sixth important one with relative important index (RII) equals 64.55%. Avoid time and cost overrun is ranked as the fourteenth important factor for the selection of the delivery method by the client respondents with relative important index (RII) equals 76.97%, on the other hand consultants and contractors rankled this factor as the sixteenth and twentieth important factor based on their rank with relative importance index (RII) 72.368% and 69.09%, avoiding time and cost overrun is one of the major concern of administering projects. Urgency of time is the fifteenth ranked factor among the factors by the clients with relative important index (RII) equals 76.36% but consultants and contractors ranked as twentieth and twenty-one important factor with relative important index (RII) equals 68.52% and 68.18% respectively. Urgency of time is majorly clients concern since ERA is a governmental organization one there are different economic, social and political factors which creates the urgency to start a specific project.

Cost certainty is sixteenth most ranked factor according to the clients response with relative importance index (RII) equals 75.76%, the consultants ranked this factor with relative importance index (RII) equals 77.14% and the contractor ranked as the twenty-five level of importance with importance index (RII) equals 65.45% (Love P. E., 1998) also acknowledged that certainty of final cost is one major important factor which should be considered prior of selecting project delivery methods because one of the client major concern is to finish the project with in the intended budget.

Yap Zhi Shan et al, 2019 findings shows that price or cost certaintiy is the first ranked factor among all the factors this result is quite contrary with our country respondents, this shows ERA's projects are always subjected to cost increase most of the time and decrease in some project cases therefore, achieving cost certainity is not the major concern. (Okunlola, 2012) also emphasise in his findings cost certainity is one of the top most important factor should be checked for selecting appropriate delivery methd. Scope definibility is seventeenth ranked selection criteria for client respondents with relative importance index (RII) equals 75.15%, the consultant's response is also the same with relative importance index (RII) equals 70.48% and ranked eighteenth one, but the contractor group of respondents resulted the better importance position for this particular factor which is relative importance index (RII) equals 75.45% in thirteenth level of importance. this factor also ranked in the same position with the client result by (El-Sayegh, Significant Factors Affecting the Selection of the Approporiate Project Delivery Method, 2007) since scope of the project is one apposite issue in project administration. any scope change will cause change in time and cost therefore it has a vast impact in project.

The client experience in particular delivery method is another important criterion which ranked as eighteenth level of importance by the client representatives with relative importance index(RII) of 73.94%. the contractor is also agreed with the client trough giving the same importance level with (RII) of 70.91%,

the consultant respondents ranked the criterion as twenty-three importance level with (RII) value of 65.91%. the result of this study for this factor is defers from the result obtained by Odhigu et al., (2011) and Husam & Sedki (2009) results as they ranked client's experience factor in the fifth and eighth position respectively. On the other hand, Shafik & Martin (2006) and Mahon (2011) investigates that client's experience factor is the second and third rank position respectively which they are a little differ than the result of this study. Early time estimation definition is another factor which gets nineteenth level of importance by the client respondents with (RII) value equals 73.33%, this criterion gets thirteenth level by the consultant respondent and fifteenth by the contractor with (RII) value of 75.24% and 73.64% respectively. This criterion is also considered significant for selection of DBB delivery method based on the findings of (Ghadamsi, 2016). Quality certainity is ranked as twenteeth important crterion with (RII) value of 72.73% with (RII) value by the client respondents and ranked as ninteenth importnt factor by consultant with (RII) value of 69.52% group and twenty-three level of importance by the contractor respondents withh (RII) value of 66.36%. (Peter Love *et al*, 2008) considered this criterion as one of te major criteria based o their findings. Price competition is ranked as twenty one level of importance by client respondents with (RII) value of 70.91%, consultats ranked the criterion as fourtheenth level of imporance with (RII) value of 74.29% and contractors also ranked the factora as the ninteenth important one with (RII) value of 70%. This factor is consieredn as the fifth impotant criterion under the category of projecct buiness case and financing by the research study of (Ademola Eyitope *et al*., 2012). Contractors capability and availability is another factor which is ranked as twenty two level of importance by client respondents with (RII) value of 70.3% and the consultant is also ranked the factor as twenty one level of importance with (RII) value of 67.62% but the contractors respodents gave a better importance position for the criterion as twelveth important value with (RII) value of 76.36%. this factor is important since the contractor capacity in involving different type of delivery method is critical because different DMs need different staff arangements, financial capacity, working schedule and methodology. (Ahmed Sari, 2007) also considered the criterion as one of the major selection criteria for construction management at risk project delivery method selection process. Technology availaility is another factor ranked as twenty three level of importance with (RII) value of 68.48% by the client, consultants and contractors ranked the factor as tewnty seventh and twenty eighth importance level with (RII) score of 60.95%, 63.64% respectively.

Market copetitiveness is the other criterion which gets (RII) value of 67.27% by the client respondents as twenty fourth level of importance, the consultant is also ranked the factor as twenty fieves level of importance. The result shows client and consultant respondents have similar perspectives in this factor, but the contractor respondents gave forteenth level of importance with (RII) value of 74.55%. Possibility for inovation is the twenty fiveth most important criterion among all the criteria by the client respondents with (RII)value of 66.67% consutants are agreed on this importance level of this criterion with (RII) value of 62.86% , contractor respondents also replied as the level of importance for this factor is twenty fourth level with (RII) value of 66%. Budget constraint is the twenty sixth important fator as of the client representative respondents with (RII) value of 65.45%, consultant respondents is also ranked the factor as twenty two level of importance but the result obtained from the contractors respondents is far from the two results by ranking the factor in the tenth level of importance with (RII) value of 77.27%.

Regulatory body interference is the twenty seventh important criterion for the client and contractor group of respondnts with (RII) value of 64.84%,62.73% respectively, respondents from the consultant group ranked the factor as twenty fourth level of importance with (RII) value of 64.76%.

4.3 Data Analysis from Document Review

This analysis part of the research paper discusses the main challenges of the selected projects gathered through reviewing each project progress reports, status reports, claim heads, extension of time approval (assessment) documents, variation approval documents and completion documents for those fully completed projects. The projects are Selected from RSDP VI and RSDP V which are above 70% completed and fully completed. For this analysis 22 project data were analyzed among this 18 were Design bid build projects and 4 were Design build projects.

4.3.1 Developing analysis themes

In order to analyze the qualitative data gathered from the projects document, document review themes are prepared. Prepared theme contains the following five major steps.

Theme 1 → brief description of project basic information like project location, contractor, consultant, commencement date, project duration and project contract cost

Theme 2 → Identify major causes of delay in project duration

Theme 3 → Identify major causes of cost increase or decrease

Theme 4 → Analyze similarity and difference between cause of delay and cost overrun

Theme 5 → draw a valid conclusion

The case study projects are collected from North, South, East, West and Express regions. The document availability determines the number of projects from region to region. The following table 4.7, shows the location and name of the projects gathered for analysis.

Table 4.7:The location and name of the projects selected for analysis

No	North	South	East	West	Express
1	Jaragedo-Zagora-Jibasra Mariam-Debretabor Road Project	Hadero-durgi	Dalol-Musli-Bada	MekenajoDembidolo Road Upgrading Project Contract 1: Mekenajo-Ayra	Mojo-Hawassa Highway Project, Phase I: Modjo-Zeway, Lot1: Mojo-Meki
2	Zema river bridge - Felegebirhan	Hawassa-Chuko	Fik-Hamero-Imi Road Project,	MekenajoDembidolo Road Upgrading Projec Contract 2: Ayra-Chanka	Dire Dawa–Dewelle
3	Dessie – Kutaber – Tenta Junction Road Upgrading Project	Salayish-Omo	Dichito-Galafi	Mizan – Dima – Boma Road project, Contract 1: Mizan - Dima	Lebu- Akaki
	Mekelle Industry park	Mender-Hana Lot 1	Arbereketi - Gelemso	Contract II: Dima-Raad Bridge.	
	Gashena - Bilbala Lalibela Bypss	Jinka - Mendir		Bedele- Metu	
		Konso Yabelo		MekenajoDembidolo Road Upgrading Project Contract 3: Chanka - Dembidolo	
		Adaba-Angetu			
		Kibre Mengist - Shakiso			
		Yirga Chefe - Hagere Maryam			

4.3.2 Problems and challenges associated with different delivery method in ERA

As it is stated in the chapter 3, the case study projects are gathered from all regions (East, West, South, North and express road) with above 70% completion and fully completed Ethiopian Road Authority projects undertaken in RSDP IV and RSDP V from both DBB and DB project delivery methods. The case study projects are totally 22. Data's are gathered through document analysis of each projects clam heads for extension of time raised by the contractors, employer assessment and approval documents and

variation order assessment and approval documents to collect the causes of time extension, variation orders and cost increase of the project. The cause for the extension of time and cost are the challenges faced by each project. The following table presents, the general short descriptions of, contract cost, project location, project start time, contract duration, actual cost, actual contract time and the cause for each approved extension of time and cost increase.

Table 4.8:The case study project challenges

Analyzed claim cases

<table>
<tr><td colspan="2">Case Study 1
Zema river bridge – Felegebirhan
General description: - the project is located in the northern part of Ethiopia; the project length is 82.8km. the type of delivery method is Design-Bid-Build. The project was started in June 10, 2015 and its contract completion time was June8, 2018 but not completed on its contract completion time. The revised completion time is Nov 4, 2019. Now the project is 92% completed. Original contract cost was 1,130,938,771.88Birr but the actual cost is 1,187,736,680.13</td></tr>
<tr><td colspan="2">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 451 Days due to two claim heads,
Variation orders: - 62,794,898.09 due to six approved variation orders</td></tr>
<tr><td>Cause of Extension of time</td><td>Cause of variation</td></tr>
<tr><td>1. Delay due to increase in Quantity of Works,
2. design modification
3. Delay in Removal of ROW Obstruction and Issuance of Design</td><td>1. Additional work on Minor Drainage
2. Additional work due to Extension of Towns
3. Change of design on Bridge at km 168+046
4. Additional quantity in Rural Ditch
5. Additional work on Motta Town Roundabout</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Case Study 2
Dessie – Kutaber – Tenta Junction Road Upgrading Project
General description: - the project is located in the northern part of Ethiopia; the project length is 67.5km. the type of delivery method is Design-Bid-Build. The project was started in May 20, 2014 and its contract completion time was March 4, 2017. The contract duration was 1020 calendar days but not completed on its contract completion time. The revised completion time is June 30, 2018. Now the project is fully completed. Original contract cost was ETB 1,545,557,747.00 Birr but the actual cost is 1,536,717,241</td></tr>
<tr><td colspan="2">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 440 Days due to Seven claim heads,
Variation orders: - 8,840,506.28 due to two approved variation orders</td></tr>
</table>

Cause of Extension of time	Cause of variation
1. Adverse weather condition 2. Additional work due to variation order1 and 2	1. Design change (improve the alignment of the road; provide additional gabion protection works; introduce additional minor drainage structures.; and introduce new bridge structures.) 2. Earthworks, Construction of side drainage and overlay works on the pavement, and cleaning of existing cross drains and minor maintenance

Case Study 3

Hadero-durgi

General description: - the project is located in the Southern part of Ethiopia; the project length is 34.75km. the type of delivery method is Design-Bid-Build. The project was started in October 5, 2011 and its contract completion time was October 5, 2014 but not completed on its contract completion time. The revised completion time is May 2, 2016. Now the project is fully completed. Original contract cost was 368,311,065.4 Birr but the actual cost is 290,820,011.89 Birr

Main reasons for the delay and cost decrease: - issues extension of time and variation orders
EOT: - 252 Days due to three claim heads,
Variation orders: - (48,723,614.18) due to thirteen approved variation orders

Cause of Extension of time	Cause of variation
1. Exceptionally adverse climatic condition 2. ROW Problems in drainage outlets 3. Additional workload of mudula roundabout	1. Design change (Change of Concrete "U" Gutter to Stone Masonry, Concrete Curbing for Median, Hadero Town, Re-alignment b/n 50+031.56 - 56+830.89, 57+000 - 71+172.686, 55+660 - 55+820, Vertical alignment change)

Case Study 4

Hawassa-Chuko

General description: - the project is located in the Southern part of Ethiopia; the project length is 66km. the type of delivery method is Design-Bid-Build. The project was started in January 27, 2017 and its contract completion time was January 26, 2019 but not completed on its contract completion time. The revised completion time is December 15, 2019. Now the project is fully completed. Original contract cost was 965,247,145.48 Birr but the actual cost is 1,138,684,219.75 Birr

Main reasons for the delay and cost increase: - issues extension of time and variation orders

<table>
<tr><td colspan="2">EOT: - 324 Days due to two claim heads,
Variation orders: - 89,569,674.58 due to two approved variation orders</td></tr>
<tr><td>Cause of Extension of time</td><td>Cause of variation</td></tr>
<tr><td>1. Design change for Chuko drainage structure
2. Adverse weather condition and security issue</td><td>1. Design change for Chuko drainage structure
2. rock fill at Aposto.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Case Study 5
Salayish-Omo
General description: - the project is located in the Southern part of Ethiopia; the project length is 78.5km. the type of delivery method is Design-Bid-Build. The project was started in January 13, 2012 and its contract completion time was May 2, 2015 but not completed on its contract completion time. The revised completion time is September 27, 2017. Now the project is fully completed. Original contract cost was 684,401,176.06 Birr but the actual cost is 954,476,287.95 Birr</td></tr>
<tr><td colspan="2">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 876 Days due to five claim heads,
Variation orders: - 270,075,111.89 Birr due to Four approved variation orders</td></tr>
<tr><td>Cause of Extension of time</td><td>Cause of variation</td></tr>
<tr><td>1. Due to Adverse weather condition and security issues
2. Due to Quantity change
3. Due to possession of site</td><td>1. Rock excavation, Roadbed preparation and under cut
2. due to design modification for Hanna Town section
3. addition of minor structure
4. due to addition of retaining wall</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Case Study 6
Mender-Hana Lot 1
General description: - the project is located in the Southern part of Ethiopia; the project length is 72.87km. the type of delivery method is Design-Bid-Build. The project was started in February 3, 2016 and its contract completion time was February 2, 2018 but not completed on its contract completion time. The revised completion time is April 15, 2019. Now the project is fully completed. Original contract cost was 1,214,208,380.51 Birr but the actual cost is 1,373,268,271.09 Birr</td></tr>
<tr><td colspan="2">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 437 Days due to two claim heads,
Variation orders: - 159,059,890.58 Birr due to one approved variation orders</td></tr>
</table>

Cause of Extension of time	Cause of variation
1. Due to Adverse Climatic Condition 2. Due to Additional works at Jinka-town	1. Due to Additional works at Jinka-town

Case Study 7

Jinka - Mender

General description: - the project is located in the Southern part of Ethiopia; the project length is 51km. the type of delivery method is Design-Bid-Build. The project was started in January 5, 2015 and its contract completion time was January 4, 2017 but not completed on its contract completion time. The revised completion time is December 12, 2018. Now the project is fully completed. Original contract cost was 1,664,681,178 Birr but the actual cost is 1,668,794,447.63 Birr

Main reasons for the delay and cost increase: - issues extension of time and raised claim
EOT: - 274 Days due to Three claim heads,
Additional cost due to raised claim: - 4,113,269.63

Cause of Extension of time	Cause of Additional cost
1. Security issue and delayed payment	1. Security issue damage

Case Study 8

Konso Yabelo

General description: - the project is located in the Southern part of Ethiopia; the project length is 105km. the type of delivery method is Design-Bid-Build. The project was started in January 15, 2015 and its contract completion time was June 27, 2018 but not completed on its contract completion time. The revised completion time is March 6, 2020. Now the project is fully completed. Original contract cost was 1,192,527,441.13 Birr but the actual cost is 1,289,748,162.79 Birr

Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 646 Days due to two claim heads,
Variation orders: - 97,220,721.66 Birr due to eight approved variation orders

Cause of Extension of time	Cause of Variation orders
1. Konso Town Road Extension (2km) 2. Provision of Median, Modification on Drainage and Reconstruction of the Overlay Section for Yabello Town Section Road	1. Change of 1 type "A" Engineer's Vehicle to type "B" 2. Change of type of Bitumen from 80/100 to 60/70 penetration grade 3. Shoulder Surfacing change 4. Additional Structures and vertical alignment modification

	5. Additional Structures and Centerline shifting from Km 0+000 to km 15+000 6. Konso Town Road Extension (2km) 7. Flood Protection Works for Mesgerdo River Bridge, Additional Drainage Structures and Other Ancillary Works 8. Provision of Median, Modification on Drainage and Reconstruction of the Overlay Section for Yabello Town Section Road
Case Study 9 **Adaba-Angetu** **General description: -** the project is located in the Southern part of Ethiopia; the project length is 105km. the type of delivery method is Design-Bid-Build. The project was started in November 17, 2014 and its contract completion time was November 17, 2017 but not completed on its contract completion time. The revised completion time is August 27, 2018. Now the project is fully completed. Original contract cost was 1,249,684,230.55 Birr but the actual cost is 1,261,847,591.92 Birr	
Main reasons for the delay and cost increase: - issues extension of time and variation orders EOT: - 283 Days due to two claim heads, Variation orders: - 12,690,318.33 Birr due to Four approved variation orders	
Cause of Extension of time	Cause of variation order
1. Due to delay in re-establishment of missed monuments and inaccurate survey control points 2. Due to delay in exceptionally adverse weather condition and approval of working drawing from Km 0+000 to Km 7+000 3. Due to delay from increased quantity of earth work volume following the modification made in vertical and horizontal alignment as part of design review	1. Due to Treatment for Expansive soil 2. Revised design of bridge 3. Land slide mitigation Measure and Alignment Shift from Km 6+000 - 10+300
Case Study 10	

Kibre Mengist -Shakiso

General description: - the project is located in the Southern part of Ethiopia; the project length is 19km. the type of delivery method is Design-Bid-Build. The project was started in July 18, 2016 and its contract completion time was March 17, 2017 but not completed on its contract completion time. The revised completion time is June 19, 2017. Now the project is fully completed. Original contract cost and actual cost is 149,525,402.94 Birr

Main reasons for the delay: - issues extension of time
EOT: - 94 Days due to One claim head,

Cause of Extension of time

1. Delay due to late site handover

Case Study 11

Yirga Chefe -Hagere Maryam

General description: - the project is located in the Southern part of Ethiopia; the project length is 72km. the type of delivery method is Design-Bid-Build. The project was started in April 1, 2013 and its contract completion time was March 31, 2016 but not completed on its contract completion time. The revised completion time is January 18, 2019. Now the project is fully completed. Original contract cost was 994,787,103.49 Birr and actual completion cost is 1,060,278,234.27Birr

Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 664 Days due to four claim heads,
Variation orders: - 85,843,520.80 Birr due to Four approved variation orders

Cause of Extension of time	Cause of variation order
1. Delay due to delay in possession of the quarry site 2. Delay due to Variation in Town Section 3. Delay due to delay in removal of obstruction 4. Delay due to forceful closure of the crusher by the local people	1. Due to Variation for the widening of the town cross-section 2. Variation for provision of engineer`s facility 3. Variation for provision of Gender sensitization 4. Variation for the provision of remedial measure on slope stability problem

Case Study 12

Dalol-Musli-Bada

General description: - the project is located in the Eastern part of Ethiopia; the project length is 41.2km. the type of delivery method is Design-Build. The project was started in January 25, 2016 and its contract completion time was January 24, 2019 but not completed on its contract completion time. The revised completion time is August 22, 2019. Now the project is 87.5% completed. Original contract cost was 1,249,624,731.89 Birr and actual completion cost is

<table>
<tr><td colspan="2">1,316,134,789.02 Birr</td></tr>
<tr><td colspan="2">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 212 Days due to one major claim head,
Variation orders: - 66,510,057.13 Birr due to Two approved variation orders</td></tr>
<tr><td>Cause of Extension of time</td><td>Cause of variation order</td></tr>
<tr><td>1. Delay due to removal of obstructions and due to social unrest in the area</td><td>1. due to vehicle type change for the engineers</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Case Study 13
Arbereketi - Gelemso
General description: - the project is located in the Eastern part of Ethiopia; the project length is 57.5km. the type of delivery method is Design-Bid-Build. The project was started in May 25, 2015 and its contract completion time was May 25, 2018 but not completed on its contract completion time. The revised completion time is May 1, 2020. Now the project is 87.5% completed. Original contract cost was 1,012,102,686.09 Birr and actual completion cost is 1,018,376,811.96 Birr</td></tr>
<tr><td colspan="2">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 707 Days due to two major claim head,
Variation orders: - 6274125.88 Birr due to Four approved variation orders</td></tr>
<tr><td>Cause of Extension of time</td><td>Cause of variation order</td></tr>
<tr><td>1. Due to time required to carry out the critical activities, rainy season, Row obstructions</td><td>1. Replacement of Radio communication by prepaid card for the engineers
2. Review of design quantities and alignment modification
3. Modification of drainage structure type and locations and provision of masonry retaining wall at deep section
4. Change of walkway and parking lane width and provision of roundabout at Bedessa Town</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Case Study 14
Mekenajo Dembidolo Road Upgrading Project Contract 1: Mekenajo-Ayra
General description: - the project is located in the Western part of Ethiopia; the project length is 52 km. the type of delivery method is Design-Bid-Build. The project was started in October 7, 2011 and its contract completion time was April 14, 2014 but not completed on its contract completion time. The revised completion time is May 1, 2016. Now the project is fully completed. Original contract cost was 633,534,840.48 Birr and actual completion cost is 650,710,812.33Birr</td></tr>
</table>

Main reasons for the delay and cost increase: - issues extension of time and variation orders EOT: - 429 Days due to Three major claim heads, Variation orders: - 24,464,634.96 Birr due to Seven approved variation orders	
Cause of Extension of time	Cause of variation order
1. Retaining Wall Variation Works in Inango and Guliso and delayed removal of obstructions in this section 2. due to Vo no 3, Provision of Retaining Wall in Inango and Guliso towns 3. Delay additional work	1. Design review (additional drainage work) 2. Additional structure work (provision of Retaining Wall in Inango and Guliso town) 3. Design review issue (change of Dimension of side drain and use of pre-cast panels for type 3 side drain) 4. Additional request from local government
Case Study 15 **Mekenajo Dembidolo Road Upgrading Project Contract 2: Ayra-Chanka** **General description: -** the project is located in the Western part of Ethiopia; the project length is 52 km. the type of delivery method is Design-Bid-Build. The project was started in October 7, 2011 and its contract completion time was April 14, 2014 but not completed on its contract completion time. The revised completion time is January 10, 2016. Now the project is fully completed. Original contract cost was 633,534,840.48 Birr and actual completion cost is 639,627,703.00 Birr	
Main reasons for the delay and cost increase: - issues extension of time and variation orders EOT: - 636 Days due to Three major claim heads, Variation orders: - 6,092,862.52 Birr due to Six approved variation orders	
Cause of Extension of time	Cause of variation orders
1. Delay or disruption caused by obstructions within the construction corridor (Delay in removal of ROW obstructions in town sections) 2. Delayed access to site ROW 3. Delay caused by varied (increased) quantities	4. Change in pavement type (Substitute of 150mm Sub-base layer with 150mm Capping Layer) 5. Design review issue (Omission and Substitution of physical works) 6. design review issue, Additional drainage work (Change of Urban drain type from Concrete to Masonry) 7. Provision of roundabout in ayira town 8. Additional request from local government (Extension of town section work in Alemteferi town) 9. unplanned additional work (Access for pedestrian and cattle's)

<table>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Case Study 16
Mekenajo Dembidolo Road Upgrading Project Contract 3: Chanka - Dembidolo
General description: - the project is located in the Western part of Ethiopia; the project length is 52 km. the type of delivery method is Design-Bid-Build. The project was started in October 7, 2011 and its contract completion time was April 14, 2014 but not completed on its contract completion time. The revised completion time is February 19, 2016. Now the project is fully completed. Original contract cost was 648,530,585.91 Birr and actual completion cost is 689,082,129.95 Birr</td></tr>
<tr><td colspan="2">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 676 Days due to Three major claim heads,
Variation orders: - 40,551,544.04 Birr due to Six approved variation orders</td></tr>
<tr><td>Cause of Extension of time</td><td>Cause of variation orders</td></tr>
<tr><td>1. Delay caused by varied (increased) quantities
2. Delay additional Work (EOT associated with VO-4 enhancement of Dembidolo Town Drainage system)
3. Delay caused by varied (increased) quantities (due to variation 1)</td><td>1. provision of Median in Dembidolo town and substitution of Type B urban cross section around Gebarobi roundabout that heads towards dembidolo with Type A and utilizing the cost saving for the construction of 700m spur road to a Hospital around Gebarobi town)
2. Design review, additional drainage work (Change in Urban Drain type from Concrete to Masonry)
3. Design Review Issue (Modification of Dembidolo Roundabout, Dembidolo Drainage modification, change of rural open drain type from type 3 to 2, Additional quantities due to access to Residents)</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Case Study 17
Mizan – Dima – Boma Road project, Contract 1: Mizan - Dima
General description: - the project is located in the Western part of Ethiopia; the project length is 91.6 km. the type of delivery method is Design-Bid-Build. The project was started in September 23, 2013 and its contract completion time was September 22, 2016 but not completed on its contract completion time. The revised completion time is December 19, 2019. Now the project is 94% completed. Original contract cost was 458,942,946.19 Birr and actual completion cost is 584,698,223.89 Birr</td></tr>
<tr><td colspan="2">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 967 Days due to Four major claim heads,</td></tr>
</table>

Variation orders: - 125,755,277.7 Birr due to Six approved variation orders	
Cause of Extension of time	Cause of variation orders
1. for Mizan-Aman town extension 2. for ROW Obstruction, Design changes in Mizan-Aman and belated issuance of Design Drawings 3. delayed Design drawings variation instructions and instruction of VO No3. 4. due to unaccounted time in previous EOTs, exceptional adverse weather, delayed payment & suspension of the project, disruption of work at quarry site at km 11+800rhs, and Force Majeure (riot, disorder…)	1. Mizan-Aman town extension 2. Mizan-Aman Median Extension 3. Provision of "U" Gutter ditch in Kuja and Kite kebeles.

Case Study 18

Mizan – Dima – Boma Road project, Contract 2: Dima-Raad Bridge.

General description: - the project is located in the Western part of Ethiopia; the project length is 60.26 km. the type of delivery method is Design-Bid-Build. The project was started in September 14, 2017 and its contract completion time was March 16, 2015 but not completed on its contract completion time. The revised completion time is October 28, 2019. Now the project is 90.84% completed. Original contract cost was 926,796,267.06 Birr and actual completion cost is 938,178,330.23 Birr

Main reasons for the delay and cost increase: - issues extension of time and variation orders EOT: - 774 Days due to Four major claim heads, Variation orders: - 11,382,063.17 Birr due to Three approved variation orders	
Cause of Extension of time	Cause of variation orders
1. Due to delay in removal of obstruction of Dimma Town, exceptional adverse weather condition, hostilities at sides and nearby 2. Due to late variation instruction	1. Due to modification and addition of minor drainages 2. Due to extension of Dima Town from 92+000 back to 91+600 3. Due to replacement of Box Culvert at 102+420

Case Study 19

Bedele- Metu

General description: - the project is located in the Western part of Ethiopia; the project length is 50.65 km. the type of delivery method is Design-Bid-Build. The project was started

<table>
<tr><td colspan="2">in February 15, 2013 and its contract completion time was February 14, 2016 but not completed on its contract completion time. The revised completion time is March 21, 2017. Now the project is fully completed. Original contract cost was 610,019,298.35 Birr and actual completion cost is 706,892,325.10 Birr</td></tr>
<tr><td colspan="2">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 401 Days due to Four major claim heads,
Variation orders: - 96,873,026.75 Birr due to Seven approved variation orders</td></tr>
<tr><td>Cause of Extension of time</td><td>Cause of variation orders</td></tr>
<tr><td>1. Due to variation of quantities issued by the engineer
2. Due to Failure to give possession of site- obstructions, Issue of VO no 01, Regarding unforeseeable rainfall
3. Due to Exceptional Adverse climate condition, Delay in removal of Right of Way obstructions, Due to VO-1, 2 &3, Rework in failed sections, Extension& revision of side drains</td><td>1. Due to During the revision of drawing due to ambiguities/discrepancies encountered specifications and schedule, Remedial measures for land sliding between km.61+120 to km. 64+320 to km. 65+300
2. Remedial measures for the embankment failure between km. 65+148 to km. 65+203 RHS
3. Access to public facilities & houses on high fill & cut sections of road with Handrails
4. Culvert outlet channelization & extension of side drains with turnouts
5. Change of side drain from Type-2 to Type-3 between km. 77+800 to km. 78+132</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Case Study 20
Mojo-Hawassa Highway Project, Phase I: Modjo-Zeway, Lot1: Mojo-Meki
General description: - the project is located around central part of Ethiopia; the project length is 50.65 km. the type of delivery method is Design-Build. The project was started in November 28, 2015 the project original duration was 1279 calendar days and its contract completion time was February 14, 2016 but not completed on its contract completion time. The revised completion time is May 27, 2019. Now the project is 80% completed. Original contract cost was 3,669,604,000 Birr and actual completion cost is 3,675,286,150 Birr</td></tr>
<tr><td colspan="2">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 246 Days due to Two major claim heads,
Variation orders: - 5,682,150 Birr due to one approved variation order</td></tr>
<tr><td>Cause of Extension of time</td><td>Cause of variation order</td></tr>
<tr><td>1. Delay due to variation order given</td><td>1. Urgent requirement of un-compacted crushed aggregate base course materials by</td></tr>
</table>

<table>
<tr><td colspan="2"></td><td>the Employer for the construction of access road to Hawassa Industrial Park, Ethiopia</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Case Study 21
Mojo-Hawassa Highway Project, Phase I: Modjo-Zeway, Lot1: Mojo-Meki
General description: - the project is located in the central part of Ethiopia; the project length is 220 km. the type of delivery method is Design-Build. The project was started in October 1, 2014 the project original duration was 1095 calendar days and its contract completion time was September 30, 2017 but not completed on its contract completion time. The revised completion time is June 17, 2019. Now the project is fully completed. Original contract cost was 5,959,546,167.00 Birr and actual completion cost is 7,602,084,729.00 Birr</td></tr>
<tr><td colspan="3">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 614 Days due to Three major claim heads,
Variation orders: - 1,642,538,562 Birr due to one approved variation order</td></tr>
<tr><td colspan="2">Cause of Extension of time</td><td>Cause of variation order</td></tr>
<tr><td colspan="2">1. Due to Variation order for the 2nd AC layer
2. Due to Security Problem
3. Delay due to Instruction for Improvement of Shoulder Edge Drop-off, Delay in confirmation and delivery of Toll Bill Printer, Disruption of work at Km85 Crusher Plant by local people, Security Event</td><td>1. Additional 50mm Asphalt concrete layer in order for the road served extended period under the expected traffic load</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Case Study 22
Pawi Junction-Fendika-Ayma Road Project,
General description: - the project is located in the central part of Ethiopia; the project length is 82.87 km. the type of delivery method is Design-Build. The project was started in December 27, 2012 the project original duration was 913 calendar days and its contract completion time was June 27, 2015 but not completed on its contract completion time. The revised completion time is June 18, 2017. Now the project is fully completed. Original contract cost was 1,337,718,925.93 Birr and actual completion cost is 1,549,906,444.13 Birr</td></tr>
<tr><td colspan="3">Main reasons for the delay and cost increase: - issues extension of time and variation orders
EOT: - 721 Days due to seven major claim heads,
Variation orders: - 212,187,518.20 Birr due to Two approved variation order</td></tr>
<tr><td colspan="2">Cause of Extension of time</td><td>Cause of variation order</td></tr>
</table>

1. purported scope and alignment change from the original alignment 2. Variation Order No: 1 3. Due to scope and alignment change from the original alignment and due to adverse weather condition 4. Claim for extension of time due to delay of design approval of Crossing structures construction	1. Design and Construction of culverts and bridge for road crossing irrigation canals 2. scope and alignment change from the original route alignment
Case Study 22 **Pawi Junction-Fendika-Ayma Road Project,** **General description: -** the project is located in the central part of Ethiopia; the project length is 82.87 km. the type of delivery method is Design-Build. The project was started in December 27, 2012 the project original duration was 913 calendar days and its contract completion time was June 27, 2015 its actual completion time is its contract completion time. Now the project is fully completed. Original contract cost was 287,857,251.51 USD and actual completion cost is 295,658,863.61 USD	
Main reasons for the cost increase: - issues variation orders Variation orders: - USD 7,801,612.10 due to Two approved variation order	
Cause of variation	
Due to provision of temporary traffic sign and road marking Due to fencing and land preparation for bus parking lot Due to construction of PVC pipe crossings with manholes, 20 culverts for crossing water supply and sewerage lines	

The above table 4.8 shows the challenges identified from the data gathered from 19 case study projects which have above 70% completion and fully completed Ethiopian Road Authority projects undertaken in RSDP IV and RSDP V, as it is stated in the chapter 3, the case study projects are gathered from all regions, foreign and locally funded type of projects, local and foreign contractors and consultants participated and from both DB and DBB type of delivery methods to see if the challenges of the projects can vary in different scenario with in the same deliver method.

As a result, the challenges of different projects are more or less similar in different cases, the major challenges are from the following major causes which cause delay in project completion time, extra cost and scope change of the projects.

Design change: - Improve the alignment of the road; provide additional gabion protection works; introduce additional minor drainage structures.; and introduce new bridge structure, Design review, additional drainage work (Change in Urban Drain type from Concrete to Masonry), Design change for Chuko drainage structure, Change of Concrete "U" Gutter to Stone Masonry, Concrete Curbing, Modification of drainage structure type and locations and provision of masonry retaining wall at deep section,

Right of way issue or late removal of obstructions: - Delay due to removal of obstructions,

Change due to local government request: - Additional work on Motta Town roundabout, due to Variation for the widening of the town cross-section, Change of walkway and parking lane width, Provision of roundabout in Ayira town, extension of town section work in Alemteferi town, unplanned additional work (Access for pedestrian and cattle's).

1) **Late or inappropriate engineers' action:** - Delay due to Instruction for Improvement of Shoulder Edge Drop-off, claim for extension of time due to delay of design approval of Crossing structures construction, delay in confirmation and delivery of Toll Bill Printer, Due to late variation instruction and delayed payment approval.
2) **Adverse climatic condition**: - Additional time extension due to adverse climatic condition.
3) **Security issue related to social unrest:** - Delay due to forceful closure of the crusher by the local people, disruption of work at quarry site, and Force Majeure (riot, disorder…).
4) **Variation orders and or Additional work**: - Retaining Wall Variation Works in Inango and Guliso, Additional 50mm Asphalt concrete layer in order for the road served extended period under the expected traffic load.
5) **Unforeseen physical and subsurface conditions**: - Rework in failed sections, Extension& revision of side drains, Remedial measures for the embankment failure, Land slide mitigation Measure.
6) **employer requirement changes**: - Scope and alignment change from the original route alignment, Urgent requirement of un-compacted crushed aggregate base course materials by the Employer for the construction of access road to Hawassa Industrial Park, purported scope and alignment change from the original alignment.

The above case study projects challenges are occurred in both types of delivery methods, but DB projects shows a smaller number of extensions of time request and variation orders. the challenges of projects will be analyzed in line with the advantages and disadvantages of both DB and DBB delivery methods. Therefore, the following table summarizes the advantages and disadvantages of delivery methods from the literature and the challenges faced by case study projects for further discussions.

Table 4.9:Advantages, disadvantage and challenges of delivery methods

Design-Bid-Build Advantages	**Design-Bid-Build Disadvantages**	**Design-Build Advantages**	**Design-Build Disadvantages**	**Major Challenges of projects**
❖ Widely applicable	❖ Tends to yield base level quality	❖ Client not familiar with the construction process	❖ Reduced opportunities for smaller local contractors	❖ Right of way issue or late removal of obstructions
❖ Well established and easily understood	❖ Least-cost approach requires higher level of inspection by the agency	❖ Project is technically complex	❖ Increased risk of contractor results in higher cost	❖ Design change
❖ Clearly define the scope	❖ The client bears design risk	❖ Client desires a single point of responsibility	❖ Less client control over final design	❖ Change due to Local Government Request
❖ Provides the lowest initial price that responsible, competitive bidders can offer	❖ No built-in incentives for providing enhanced output	❖ Low likelihood of variations to the project	❖ Accelerated construction can potentially overextend the workforce	❖ Late or inappropriate engineers' action
❖ Design is completed before construction	❖ Lack of input from the construction industry during the design stage exposes the agency to claims related to design and constructability issues	❖ Innovation and quality improvements through: Alternative designs and construction methods	❖ Elimination of traditional well-known check and balance	❖ Adverse climatic condition
❖ Clearly define the role for each party	❖ Tends to create an adversarial relationship among the contracting parties, rather than foster a cooperative atmosphere in	❖ A quick start works on site		❖ Security issue related to social unrest

	which issues can be resolved efficiently and effectively			
❖ Well established and easily understood	❖ Fragmented contract may lead to claim & dispute	❖ Except for Owner changes, no change orders		❖ Variation orders and or excess in quantity
❖ Bill of quantities can be used for valuing variations	❖ Initial low bid might not result in ultimate lowest cost	❖ Opportunity for cost sharing		❖ Unforeseen physical and subsurface conditions
❖ The designer is experienced enough to oversee both the design and construction		❖ Owner involvement in the process is limited		❖ Employer requirement changes
❖ Extensive litigation has resulted in well-established legal precedents		❖ Construction budget control		
❖ As construction features are typically fully specified, client with significant control over the end product (however, this may come at the expense of increased agency inspection efforts)				

Advantages and disadvantages of delivery methods helps to identify which project delivery method is better in which scenario and indeed faced challenges of projects also used to see what projects real challenges are. The following discussion is presented relating the advantages and disadvantages of projects with their actual project challenges to illustrate which project delivery method is better in which type of scenario for mainly identified problems from the case study projects.

i. Right of way issue or late removal of obstructions

Right of way obstruction is the major challenge of ERA's project, from 22 case study projects 19 projects have faced challenges caused by late removal of obstructions from the project site area, this result shows

right of way issues cause extension of time claim and project time delay as a result. As it is discussed in the literature review right of way should be considered in early design stage of the project. ROW obstruction shall in the first place be identified as much as possible during design services and be ready for removal before the construction program for works. Changes in Design causing alignment changes shall be minimized during construction works not to cause other ROW obstructions. ROW obstruction removal is a joint risk event that requires both client and contractors' responsibility. In the DBB type of project delivery method the design of the project is prepared prior to the contractor start the project work, in this regard the designer is responsible in identifying the obstructions and let the client to remove the obstructions at early stages but in our case study projects late removal is alters the project work. When we come to the DB project delivery method, the contractor has a better chance in identifying obstructions and can notify for the client and the other major advantage for the DB contractor is, the contractor can prepare a schedule which consider the removal time of obstructions from the project site to avoid extension of time claims raised due to late removal.

According to claim and dispute administration manual prepared by SMEC, in 2018, the contractor shall first identify right off ways required to be removed in accordance with the consented or approved construction program before 1 or 3 or 6 months according to the different Contracts because they are obstructions that prohibits him to execute the works. The manual also stated that, the Engineer shall develop a proposal whether such a Right Off Ways Obstructions shall be removed based on the design consultant ROW related reports, or advice other remedial measures such as realignments in consultation with the Employer and the Contractor in order to recommend for the Employer Viable Options with a priority for alternative solution than Removal of Right Off Ways Obstructions to minimize effects on the Affected Community.

ii.Variation and excess in quantity

Variations often cause disputes and dissatisfactions among the parties involved in construction projects. (Aftab Hameed Memon, Significant Causes and Effects of Variation Orders in Construction Projects, 2014) Thus, it is very important to control VOs in a construction project. From project challenges the major causes of variation orders occurs due to defect in design, requirement change or scope change due to alignment change, extension of the work due to local government request, unforeseen physical condition. as we can see from the advantages of design-bid delivery method variation order can be substantially decreased since the design builder is responsible for the detail design preparation (Yang, 2010) in the detail design preparation the contractor is expected to have well experienced design team to undertake the design preparation and reduce the risk of variation order related to design defects. Requirement change or scope change requests especially from the local society can also be incorporated in the design stage if the design builder will provide a space for discussion before going through the detail design about the scope of the project, the points it touches and the positive and negative impact of the project for their local area to reduce the upcoming requests after the construction work has started. Variation orders caused by unforeseen physical condition is common problem for both DBB and DB type

of delivery methods since it is unforeseen condition it can cause variation order in order to mitigate the incident. Therefore, from the advantages of DB delivery method and the data gathered from case study projects, using DB delivery method is better in reducing the challenge.

iii. Design change

From the result of data gathered on both design-bid-build and design-build type of ERA's projects one of the major challenges encountered is design change. As it can be seen from the case studies the major challenges of design- bid- build projects related to design change are due to two major causes, the first reason of design change is due to requirement changes like expansion of previous works, addition or change of previously designed town sections, bridges and alignment change. The second one is from incompleteness of the project design and lack of considering every aspect on the design before entering to construction stage. The above Design- build case study projects also faced a challenge of design change due to requirement and scope change of the employer due to different reasons. (Titouan Plusquellec *et al*, 2017) in their comparative study of delivery methods stated that Design-Build delivery method should avoild the design related problems since the contractor is responsible for the design issues. They also stated that the single entity responsibility for the design and construction in Design-Build delivery method is the major advantage it has over Design-Bid-Buil delivery method.

(Ehsan Alvani *et al*, 2014) stated that the Design-build contractor is responsible for the design, preparation of detail technical specifications and drawings, construction, testing and commissioning of the project in doing so the major advantage of choosing the design-build delivery method is to eliminate the design change problems. Therefore, project design change problem will substantially decrease if design-build delivery method will be used for such projects where the design change cause lots of extension time and cost overrun.

iv.Employer requirement change (Scope change)

Project scope is defined as reviewing the project charter, requirements documents, and organizational process assets to create a scope statement, adding more information as requirements are developed and change requests are approved. The main outputs of scope definition are the project scope statement and updates to project documents (Nibyiza, 2015). As discussed in the literature review, the project scope can be critical rout cause for the project delay and cost overrun (Sharareh Kermanshachi, 2020). From the data gathered from ERA's projects the main cause of employer requirement change is initiated from local government request which comes after the construction process has started and urgent economic issues which leads to design change like Hawassa Industrial park. When the employer obliged to change the project scope the process of change is easier in DB project delivery method than DBB projects, since the contractor is expected to prepare detail design and it reduces fragmentation of design and construction process (Ehsan Alvani *et al*, 2014). In DBB projects its fragmentation nature increase the project time and cost significantly than DB projects but it is easier to quantify and control the change.

v.Adverse climatic conditions

Adverse climatic or weather condition is one of the force majeure events in the construction projects. ERA's current contract documents for both DB and DBB entitled an extension of time in the Standard Contract Conditions of contract. It does not allow Adverse Climatic Conditions to be an Employer Risk Events using the Particular Conditions of Contract. This implies the Contractor shall assess the potential Adverse Climatic Conditions and make considerations in the Construction Program, as only related to EOT entitlements. Claim and Dispute manual prepared by SMEC,2018 states that, if force majeure or beyond foreseen situations happens, such a provision will not be applicable because the Contractor could only assess the past ten years trends to determine the maximum and minimum numbers of Adverse weather that had been encountered to consider the average number of adverse days per month and / or year in the Construction Program. Since the issue of adverse climatic condition is more of contractual issue that cannot be solved through delivery methods the risk will be reduced trough the Employer obliged the Design Services Consultant to determine such days of Adverse Climatic Conditions per month and / or per year to include as a limit to be considered as foreseen Adverse Climatic Conditions in the Construction Program. The Employer / Employer's Representatives shall check the Contractors unforeseen average days of adverse climatic conditions per month / year, if differs from the Consultant estimates to decide his position. If disagreements occur, it will be a subject of disputes and the dispute resolution system allowed in the Contract. when the contractor submits the Construction Program, the Contractor shall include such detail particulars that shows how many days are considered as adverse climatic conditions and where they are used in the Construction Program.

vi. Security issue related to social unrest

Social unrest is a security problem or phenomenon that alters the construction process by affecting the movement of workers in the construction site Social unrest as cause and consequence Real or perceived risk (threat, potential harm) can cause tensions and move people to act (Ortwin Renn, 2011). Social unrest is a broad term that is typically used by law enforcement to describe one or more forms of disturbance caused by a group of people. it is typically a symptom of, and a form of protest against, major socio-political problems. Typically, the severity of the action coincides with the level of public outrage. In addition to a form of protest major socio-political problems, civil disturbances can also arise out of union protest, institutional population uprising, or from large celebrations that become disorderly. Lack of security obliged the construction to shut down until the problem is solved. In most cases when social unrest occurred it would cause the damage on completed and undergoing works through destruction as a way of showing opposition. In both DB and DBB project delivery methods the damage will be measured according to the contract.

4.4. Modeling and Validation

4.4.1 Modeling

This part of chapter four covers the development and validation of a model demonstrating the influence that the delivery method selection criteria will have on the project delivery method. The previous chapters take a detailed look at the selection criteria that are significant for both DBB and DB methods. This section covers the testing of the proposed hypotheses formulated on the influence of the selection of project delivery method. This section will also discuss the validation of the model, development of conceptual framework and a summary of this chapter. The framework will guide decision making process to select the appropriate delivery method. Though it does not necessary lead to a successful project but with other factors taken into consideration can influence the success of the project. One of the objectives of this research was aimed to develop a framework based on the result of the thesis findings. The framework will be used as a general guideline to help ERA for easer and clear decision making process.

Multi Attribute Utility Theory is considered as the technique appropriate for investigating the criteria of clients, contractors and consultant's perspectives for each method. By indicating the relative utility of each client requirement and the delivery method against a numerical scale, it is possible to obtain a set of utility factors. (Agha N. I., 2017). As stated in the literature review MAUT involves four steps which are

1. Client weights the relative importance of each significant factor that affecting the selection of procurement method.

2. Rationalized priority ratings are calculated (by dividing each of the priority ratings by the sum of all the ratings) and then entered the decision chart. The sum of the rationalized priority ratings should always be equal to 1.

3. Each rationalized priority rating is taken in turn and multiplied by each of the utility factors; the results will then be entered into the appropriate columns.

4. The totals of each of the results columns, under each delivery method, are calculated and ranked in descending order. The most appropriate delivery method will have the highest total result.

i. Data collection procedure

ERA's staffs, contractors and consultants who are involved in ERA's projects were asked to prioritize the factors influencing the selection of delivery method based on Likert scale and tested using Cronbach α of the SPSS package at 5% significant level. All the factors get Relative Importance Index exceeding 60% therefore, all of them were recognized as important significant factors based on the consensus of the respondents to be used in factor analysis. From the questionnaire result analysis as mentioned in part one of this chapter, all factors were identified as significant important factors affecting the selection of delivery method in construction projects in ERA as follows,

ii. Data analysis

The formula for data analysis is adapted from (Agha N. I., 2017). The decision making of selecting appropriate delivery method is analyzed using the following formula. M alternatives delivery methods and N significant criteria whereby the alternatives delivery methods are denoted as: ai (for i = 1, 2, 3, M) significant factors as Cj (for j = 1, 2, 3 …N). (Agha N. I., 2017) assumed that the performance values aij (for i = 1, 2, 3, M and j = 1, 2, 3, N) of each of delivery method in terms of each of the selection criteria. Also, that for each significant decision factor, the decision maker has determined its relative importance denoted as Cj (for j = 1, 2, 3, N). Lastly that the relative importance of the N factors satisfies the following normalization constraint.

$$\sum_{j=i}^{n} Cj = 1$$

This is termed the rationalized priority rating and is calculated as

$$Cj = \frac{RIp}{\sum_{p=1}^{K} (RIp)}$$

Where *RIp* - is the relative importance index (RII)

It is used to calculate the performance of the alternative's delivery methods by an additive utility (the weighted sum model) of the following form.

$$Pi = \sum_{j=i}^{n} aijCj$$

For i = 1, 2, 3, ……. M where Pi is the preference value of delivery method aij (i = 1, 2, 3, M) when all the significant important factors are considered simultaneously. For maximization case in this research, the best alternative is the one which has the largest preference value.

Table 4.10 below, published the rationalized priority rating (Cj) by the respondent's in this research.

Table 4.10:Rationalized priority rating (Cj) by the respondent's

NO	Selection Factors	RII (%)	Rationalize priority rating
1	Complexity of the project	90.91	0.044
2	Likelihood of construction risk or uncertainty	87.88	0.042
3	Political reasons and interference	87.27	0.042
4	The degree of desired client involvement	85.45	0.041
5	Flexibility for changes and variations	84.85	0.041
6	The importance of the project	82.42	0.040
7	Risk transfer or sharing	81.82	0.039
8	Claim and dispute administration	81.21	0.039
9	Transparency of work process	80.61	0.039
10	Staff experience	80.00	0.039
11	Early cost estimation definition	78.79	0.038
12	Early scope determination	78.18	0.038
13	design change	77.58	0.037
14	Avoid or minimize time & cost overrun	76.97	0.037
15	Urgency of time	76.36	0.037
16	Cost certainty	75.76	0.037
17	Scope definability	75.15	0.036
18	Client experience in procurement method	73.94	0.036
19	Early time estimation definition	73.33	0.035
20	Quality certainty	72.73	0.035
21	Price competition	70.91	0.034
22	Contractor's capability and availability	70.30	0.034
23	Technology availability	68.48	0.033
24	Market competitiveness	67.27	0.032
25	Possibility for innovation	66.67	0.032
26	Budget constraint	65.45	0.032
27	Regulatory body interference	64.85	0.031
	Total	**2075.15**	**1.00**

Respondents were asked to rate the suitability of delivery methods in examining the selection criteria or based on main factor groups using a Likert scale of 1 to 10. A rating of 1 means, low suitability in achieving a selection factor and 10 means, very high suitability in achieving a selection factor. The delivery methods considered were those in use in ERA which is design bid build method and design and build delivery method. The benchmark performance values (aij) of these delivery methods will be calculated and after that, the totals of each of the results columns, under each delivery method, are calculated and ranked in descending order. The most appropriate delivery method will have the highest total result.

4.4.2 Validation

The MAUT is selected because it is easier to use, widely applicable in different countries and do not need detail and complicated steps. Its validation ensures that, the approach meets its intended requirements in terms of the methods employed and the results obtained. By using MAUT the formulated hypothesis is tested. the case study for validating the model is randomly selected from the above projects.

A. Mekenajo Dembidolo Road Upgrading Project Contract 3: Chanka - Dembidolo

General description: - The project is located in the Western part of Ethiopia; the project length is 52 km. the type of delivery method is Design-Bid-Build. The project was started in October 7, 2011 and its contract completion time was April 14, 2014 but not completed on its contract completion time. The revised completion time is February 19, 2016. Now the project is fully completed. Original contract cost was 648,530,585.91 Birr and actual completion cost is 689,082,129.95 Birr. Based on the data gathered, this project had extension of time 429 Days beyond the contract time due to Three major claim heads. The project also had additional 24,464,634.96 Birr cost increase due to Seven approved variation orders.

Table 4.11:The average performance vales (aij) of delivery method

No	Selection Criteria	DBB				DB			
		Client Mean Score (aij1)	Consultant Mean Score (aij2)	Contractor Mean Score (aij3)	Average (aij)	Client Mean Score (aij1)	Consultant Mean Score (aij2)	Contractor Mean Score (aij3)	Average (aij)
1	Complexity of the project	7.2	7.3	7.4	7.30	6.8	7	8.31	7.4
2	Likelihood of construction risk or uncertainty	6	6.41	7	6.47	8.4	8.5	8.51	8.5
3	Political reasons and interference	6.5	6.9	6.91	6.77	8.2	7.2	9.11	8.2
4	The degree of desired client involvement	7.1	6.8	9.5	7.80	7.6	7.1	4.8	6.5
5	Flexibility for changes and variations	7.9	8.9	4.89	7.23	6.5	8	9	7.8
6	The importance of the project	7.6	8.3	7.29	7.73	7.5	7.1	5.12	6.6
7	Risk transfer or sharing	8	7.5	7.09	7.53	7	7	5	6.3
8	Claim and dispute administration	7.9	7.4	7.5	7.60	7	8.2	9	8.1
9	Transparency of work process	5.9	6	9.91	7.27	7.6	6	9.5	7.7
10	Staff experience	7.2	7.7	9.01	7.97	7.3	5.9	8	7.1
11	Early cost estimation definition	7.7	7	9.3	8.00	6.8	6.9	7.9	7.2
12	Early scope determination	7	6.1	7.81	6.97	7.4	7.3	6.21	7.0
13	design change	6.7	7.3	6.7	6.90	7.5	7.2	6	6.9
14	Avoid or minimize time & cost overrun	8	8.2	5.19	7.13	9.5	8.5	7.23	8.4
15	Urgency of time	7.8	7.8	7.71	7.77	6.6	6.8	5.5	6.3
16	Cost certainty	7.5	7.5	8.19	7.73	7	8.3	6	7.1
17	Scope definability	8	8	6.11	7.37	6.1	6.5	6.8	6.5
18	Client experience in procurement method	8.2	8.1	4.1	6.80	7	7.5	8.5	7.7
19	Early time estimation definition	6.8	7.2	4	6.00	7.5	8.2	8.6	8.1

20	Quality certainty	7.8	7.2	5.19	6.73	7	9	6.5	7.5
21	Price competition	7.3	8.2	6.4	7.30	6.5	7.4	7.79	7.2
22	Contractor's capability and availability	6	5	2.11	4.37	7.9	7	7.39	7.4
23	Technology availability	6.6	7	6.41	6.67	6.9	6.8	8.41	7.4
24	Market competitiveness	7.4	7.1	5.39	6.63	6.6	7.8	7.5	7.3
25	Possibility for innovation	6.5	7.1	7.4	7.00	7	6.7	6.9	6.9
26	Budget constraint	6.6	7.9	9.2	7.90	7.3	7.7	4.5	6.5
27	Regulatory body interference	7.3	6.9	6.71	6.97	7.2	6.6	6.81	6.9

The average performance vale for both (DBB & DB) is calculated from the respondents rank of suitability for each selection criteria. The performance vale given to each criteria depends on the perspective of the respondents from their experience. After identifying the performance value or suitability score of delivery methods the next step is multiplying the performance value with normalized relative importance index value of each selection criteria to get the weighted sum of each criteria.

Table 4.12:The weighted sum model results for the selection appropriate delivery method selection

NO	Selection Factors	Rationalize priority rating	DBB Average Mean Score	DBB result	DB Average Mean Score	DB result
1	Complexity of the project	0.032	7.300	0.24	7.4	0.24
2	Likelihood of construction risk or uncertainty	0.044	6.470	0.28	8.5	0.37
3	Political reasons and interference	0.042	6.770	0.29	8.2	0.34
4	The degree of desired client involvement	0.042	7.800	0.33	6.5	0.27
5	Flexibility or changes and variations	0.041	7.230	0.30	7.8	0.32
6	The importance of the project	0.036	7.730	0.28	6.6	0.24
7	Risk transfer or sharing	0.036	7.530	0.27	6.3	0.23
8	Claim and dispute administration	0.038	7.600	0.29	8.1	0.30
9	Transparency of work process	0.039	7.270	0.28	7.7	0.30
10	Staff experience	0.039	7.970	0.31	7.1	0.27
11	Early cost estimation definition	0.038	8.000	0.30	7.2	0.27
12	Early scope determination	0.039	6.970	0.27	7.0	0.27
13	design change	0.032	6.900	0.22	6.9	0.22
14	Avoid or minimize time & cost overrun	0.037	7.130	0.27	8.4	0.31
15	Urgency of time	0.041	7.770	0.32	6.3	0.26
16	Cost certainty	0.037	7.730	0.29	7.1	0.26
17	Scope definability	0.038	7.370	0.28	6.5	0.25
18	Client experience in procurement method	0.036	6.800	0.24	7.7	0.27
19	Early time estimation definition	0.037	6.000	0.22	8.1	0.30
20	Quality certainty	0.035	6.730	0.24	7.5	0.27
21	Price competition	0.035	7.300	0.26	7.2	0.25
22	Contractor's capability and availability	0.035	4.370	0.15	7.4	0.26
23	Technology availability	0.034	6.670	0.22	7.4	0.25
24	Market competitiveness	0.034	6.630	0.23	7.3	0.25
25	Possibility for innovation	0.033	7.000	0.23	6.9	0.23
26	Budget constraint	0.040	7.900	0.31	6.5	0.26
27	Regulatory body interference	0.031	6.970	0.22	6.9	0.22
	Total	1.000		**7.12**		**7.28**

From the results obtained in Table 4.11 and Table 4.12, the weighted sum model results by experts revealed that, design and build delivery method was the most appropriate delivery method option with preference value Pi equal 7.28. design-bid-build method was ranked second most appropriate delivery method with preference value Pi equal 7.12. It means that if a client used DB instead of DBB, variation orders due to design change will be substantially decreased. From the data gathered, the above tested

project has 7 variation orders due to design related problems increased the project cost. Variation order given were also delayed the project completion time.

4.5 Framework Development

The third objective of this research is to develop a framework to help ERA in order to systematically compare and select appropriate delivery method for its projects and to assist the decision making process. As discussed in the literature review there is no absolute delivery method which suites every project. Primarily, this framework guides how to select the most appropriate delivery methods for a particular type of road construction project and guide the decision making process. It also ensures systematic and consistent approach for PDM selection through the application of relevant selection models. The framework will Provides better understanding on various types of alternative construction delivery methods in practice. In this way, it will be possible to ensure that the project is procured in an efficient and effective way. The proposed framework consists of three main stages which are assessment of criteria to be used as an input, process and modeling the factors stage and data base output stage. The following Figure 13 shows the developed framework for the selection of an appropriate delivery method.

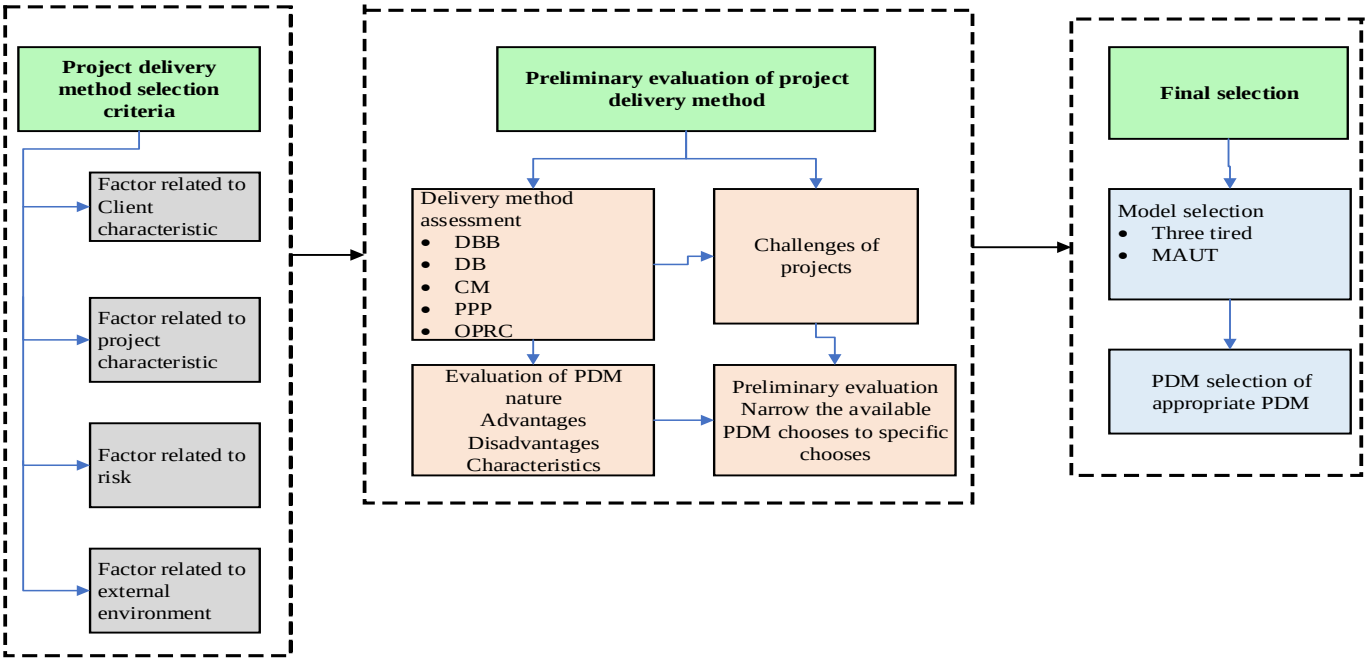

Figure 4.1:Developed framework for PDM selection

4.6 Discussion and chapter summary

This chapter presents a summary of the study. It embraces the findings from the literature review, survey data and case study document review results. This chapter discussion links and integrates the research findings. Leads to get conclusions and recommendations. provide suggestions for future research which

have emerged as a result of the findings of this study. This thesis critically examines the delivery method selection criteria, and investigates actual project implementation challenges. It also investigates different PDM selection models that are widely applicable and to use as a tool to evaluate some selection criteria.

Review of aim and objectives

This thesis has satisfied the aims and objectives specified in the introduction. It has identified 27 delivery method criteria and developed a model for appropriate delivery method selection. This research also tries to propose conceptual framework as a guideline for systematically guide the decision making process of ERA.

The first research objective was to investigate the delivery method selection criteria. The literature reviews in Chapters Two discovered that there are different researches in searching for the selection criteria. The number of criteria and the type are different based on every country experience and nature of construction. But most selection criteria are common for all infrastructure and building construction industries. The use of systematical delivery method selection method supports better performance and successful completion of projects. The result from survey instrument reveals that the selected 27 criteria are also important for ERA. The literature also reveals that there are different models widely used in Project delivery method selection.

The second research objective was to assess the challenges of ERA's projects. Based on the data analyzed from document review, right of way is one major challenge which cause extension of time. Variation orders, design change, adverse weather condition and social unrest are also another challenges which affect the project performance and timely completion. Advantages and disadvantages of DBB and DB are cross-checked with the project challenges. Most commonly occurred challenges can be reduced by choosing appropriate delivery method. DB projects showed less variation order and design change issues than DBB.

The third research objective was to develop a framework for selecting ERA's projects. From the literature review there are four major decision models widely used in the world. Three tiered selection model has three different approaches. Tier 1 used to select the probable delivery method selection for quick selection result. Tier 2 approach used delivery method selection criteria and score delivery methods to get the weighted result. The delivery method which gets the highest weighted score will be selected. Tired 3 approach is risk identification and analysis for delivery methods if Tier 2 don't result satisfied choice. Multi attribute utility theory and AHP models also used weighted criteria. MAUT is used for hypothesis testing. The model was verified by selected case study project. The conceptual framework developed as a result of the analysis.

CHAPTER 5

5. CONCLUSION AND RECOMMENDATION

5.1Conclusion

Project delivery method is the framework of all the project stakeholders' relations and responsibilities, so a substantial mistake in the delivery method selection may cost the owner through delayed performance. The analysis of PDM selection demands an understanding of the advantages and disadvantages of each PDM in achieving the project success. This research sheds light on the frequently subjective decision of PDM selection and makes it more systematic and defensible. This thesis, therefore, has Successfully explored delivery method selection criteria. A total of 27 factors affecting the selection of delivery method were synthesized in the main four groups in the survey, which were shown to be reliable. Investigated actual project challenges and the relationship of challenges with the type of delivery method used**.** Developed a model to select appropriated delivery method**.** Validated the model through an application to selected case study project. The finding suggest the model is valuable and suitable for use in practice.

This thesis provides a conceptual framework to guide the process of selecting delivery method. The frame work is designed to finalized the research process. Based on the results obtained from this research, the following research conclusion are drawn:

The selection criteria for project DM will influence which procurement system should be used in a project. Knowing delivery method selection criteria is the base for selecting the appropriate delivery method. Four group of PDM selection criteria are identified. Client related characteristics, project related characteristics, risk related factors and external environment are the four identified group of factors. There are 27 PDM selection criteria under the four groups of criteria. Survey instrument is used for evaluating the proposed criteria to be used for ERA projects. RII is used for assessing criteria relative importance to check whether the criteria are valid for our country road construction or not. Based on the result of the analysis, all criteria are found to be important. Considering all criteria will help in reducing the upcoming challenges of projects.

The road construction projects are facing different challenges. From the data gathered through case study projects, both DBB and DB projects have faced similar challenges but the intensity differs from project to project. Right of Way, design change, variation order, scope change and adverse weather condition are critical challenges which affect most projects. As a result of document analysis, DB projects showed up better in reducing design related problems and variation order challenges.

Generally, this research provides a comprehensive solution for a common challenge faced by ERA projects when they select a project delivery method (PDM) for their projects. The delivery method selected should help the owner to achieve their project goals and objectives in an efficient and cost-effective way.

A comprehensive study should include all the available PDMs and all the qualitative and quantitative characteristics of the project that may be influenced by the delivery method option. The proposed framework covered all aspects of a road project and developed a list of selection criteria that affect the choice of project delivery. A requisite well-structured decision making process was the foundation of the proposed framework for this decision aid tool.

5.2 Recommendation

Based on the findings of the analysis, recommendations are the most important ones that can be deduced by this research. The following major points are recommended.

- It is recommended that, early involvement of the contractors in the design stage can reduce project challenges related to design problems for design-bid-build delivery methods
- It is recommended that; ERA should have a systematic approach in resolving Right of Way issues. ROW issues are major challenges of projects.
- It is recommended to use the proposed framework as a guideline (Figure 13) which detailed in previous chapter to assist in the selection of an appropriate delivery method in ERA's road projects. ERA can use this framework to assess the quality level of a planning of construction project in terms of delivery method selection.
- It is also recommended that training courses, seminars, and workshops on the significance of using systematic way of delivery method selection should be conducted. These activities would improve the local practice in the selection process and increase the capabilities of procurement staff in using mathematical models for the selection of an appropriate delivery method.
- The client's actual needs, requirements, objectives and project goals must be interested and accurately transferred to the project team in order to enable the project team to develop a sound procurement strategy.
- ERA should use formal documentation of project files to reduce the hassle in finding different project information especially for researchers.

Recommendations for future research

The research results have identified areas that require further research efforts. The following points discuss suggestions.

- Future research should identify selection criteria used for CM, PPP and OPRC
- Future research should focus on developing models for the selection of different delivery methods like PPP.
- It is necessary to repeat this research paper in certain time interval to incorporate newly emerged analysis techniques, different ways of selecting delivery methods.

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Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university and that all sources of materials used for the thesis have been duly acknowledged.

Name: Edlawit Teka

Place: Addis Ababa, Ethiopia

Date of submission: September, 2020

Signature: _____

Title of the thesis:

"A Study on Improving Project Delivery Method Selection Criteria practice on Ethiopian Road Authority"

This thesis has been submitted for examination with my approval as University advisor

Name: Dr.-Eng. Wubishet Jekale

Signature: _____

Date: _____

Appendix I

Pilot Questionnaires

ADDIS ABABA UNIVERSITY

Dear Sir,

The purpose of this questionnaire designed is, to assess the practice of delivery system selection in ERA as a pilot study to get the research gap in for the research topic **A study on improving Project Delivery system selection criteria practice on federal road projects** This particular research is undertaken in Addis Ababa University, Institute of Architecture Building Construction and City Development, at the post Graduate Program of construction Management. Thus, your responses to the questions would be the basis for the research and kept confidential.

Therefore, please be helpful and give correct answers to each question.

For validation of the response, you are kindly requested to put your position in the department

_____

I thank you in advance for giving some of your precious time!

Justification for Questionnaire designed

The reason why I prepare and ask this questionnaire to the procurement and planning directorates is to

- ❖ To assess if they use delivery method selection criteria for their projects before choosing a specific delivery method
- ❖ To assess how they are selecting their project delivery methods
- ❖ To check if they have a governing framework on how to select their project delivery methods
- ❖ To assess if they already observe the impacts of their way of project selection to project performance and successful accomplishment.

Please give your response for the following questions by putting "√" marks at the space provided

1. Do you use project delivery method selection criteria for all projects?

   We use for all projects ☐ we don't use the criteria's ☐

   We use for some projects ☐

2. How does ERA select project delivery method?

From best practice	☐
Donner driven	☐
By using selection criteria guideline and framework	☐
Staff experience and availability	☐

3. If you don't have the selection criteria or framework what will be the reason?

Lack of knowing all the criteria's for selecting an appropriate delivery system	☐
Lack of delivery system selection framework	☐
Lack of knowledge about the impacts of improper selection of delivery systems on project performance	☐

4. Do you think lack of project delivery method selection criteria has an impact on successful completion of projects? ☐ Yes ☐ No

Appendix II

Research Questionnaires

ADDIS ABABA UNIVERSITY

Dear Sir,

The purpose of this questionnaire designed is, to get the appropriate weight of each delivery method selection criteria to select the appropriate project delivery method for each ERA's projects. Through a research topic **A study on improving Project Delivery system selection criteria practice on federal road projects** This research is undertaken in Addis Ababa University, Institute of Architecture Building Construction and City Development, at the post Graduate Program of construction Management. Thus, your responses to the questions would be the basis for the research and kept confidential.

Therefore, please be helpful and give correct answers to each question.

For validation of the response, you are kindly requested to put your position in your organization

_____

I thank you in advance for giving some of your precious time!

Researcher
Edlawit Teka

Part One: - Please identify (carefully) and express your opinion on the degree (level) of importance of the following factors affecting the selection of delivery method in construction projects in Ethiopian Road Authority. (Please tick the appropriate box). Very High Important = 5 High Important = 4 Medium important = 3 Low important = 2 Very low important = 1

For project delivery methods DBB and DB, the score should be given for each selection criteria based on the selection factors level of influence on the delivery method. The following table shows score points and their definitions. Bothe DBB and DB should be scored for each factors.

Score	Definition
10	Very high suitability for the selection factor
8	High suitability for the selection factor
6	Medium suitability for the selection factor
4	Low suitability for the selection factor
2	Very low suitability for the selection factor
9,7,5,3,1	Intermediate values between two adjacent judgments.

No	Factors	Level of Importance					Score of Delivery method based on the factors	
		Very High = 5	High=4	Medium=3	Low=2	Very Low=1	DBB (10-1)	DB (10 - 1)
Factors related to client characteristics								
1	The degree of desired client involvement							
2	Client's experience in procurement methods							
3	Flexibility for changes and variations							
4	Avoid or minimize time & cost overrun							
5	Transparency of work process							

6	Staff experience							
7	Possibility for innovation							
8	The importance of the project							
Please specify if any other factors								
No	**Factors**	**Level of Importance**					**Score of Delivery method based on the factors**	
		Very High = 5	**High=4**	**Medium=3**	**Low=2**	**Very Low=1**	**DBB(10-1)**	**DB (10 - 1)**
Project characteristics								
1	Scope definability							
2	Early time estimation definition							
3	Quality certainty							
4	Cost certainty							
5	Complexity of the project							
6	Price competition							
7	Design change							
8	Early scope determination							
9	Early cost estimation definition							
10	Urgency of time							
Please specify if any other factors								

Risk factors								
1	Likelihood of construction Risk or uncertainty							
2	Budget constraint							
3	Risk transfer or sharing							
4	Claim and dispute administration							
Please specify if any other factors								
No	**Factors**	**Level of Importance**					**Score of Delivery method based on the factors**	
		Very High = 5	**High=4**	**Medium=3**	**Low=2**	**Very Low=1**	**DBB(10- 1)**	**DB (10 - 1)**
External environment characteristics								
1	Political reasons and interference							
2	Market competitiveness							
3	Contractor's capability and availability							
4	Regulatory body interference							
5	Technology availability							
Please specify if any other factors								

Thanks for your cooperation!