APPROPRIATE PROJECT DELIVERY SYSTEM SELECTION MODEL USING ANP

IN CASE OF ETHIOPIAN ROAD AUTHORITY (ERA)

GENET FEKADU

A THESIS SUBMITTED TO DEPARTMENT OF CIVIL ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN CONSTRUCTION ENGINEERING AND MANAGEMENT.

SCHOOL OF ENGINEERING AND ARCHITECTURE

OFFICE OF GRADUATE STUDIES

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

JUNE, 2023

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DECLARATION

I hereby declare that this Master's Thesis entitled "Appropriate project delivery system selection model using ANP in case of Ethiopian road authority (ERA)" is my original work .That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All sources of material that are used for this thesis have been dully acknowledged through citation

Genet Fekadu _____ _____

Name Signature Date

RECOMMENDATION

I/we, the advisor(s) of this thesis, hereby certify that I/we have read the revised version of the thesis entitled “appropriate project delivery system selection model using ANP in case of Ethiopian road authority (ERA)” prepared under my/our guidance by Genet Fekadu submitted in partial fulfillment of the requirements for the degree of Mater’s of Science in Construction Engineering Management. Therefore, I/we recommend the submission of revised version of the thesis to the department following the applicable procedures.

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APPROVAL PAGE

I/we, the advisors of the thesis entitled “appropriate project delivery system selection model using ANP in case of Ethiopian road authority (ERA)”and developed by Genet Fekadu, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by Genet Fekadu have read and evaluated the thesis entitled “appropriate project delivery system selection model using ANP in case of Ethiopian road authority (ERA)”and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Construction Engineering and Management

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TABLE OF COTENTS……..……..…….…..……..……..PAGE.NO

LIST OF TABLES

TABLE……..……PAGE

LIST OF FIGURE

FIGURE……..……...PAGE

LIST OF ACRONYMS AND ABBREVIATIONS

AHP- Analytical hierarchy Process

ANP- Analytical Network Process

CII -Construction Industry Institute

DB -Design-Build

DBB- Design Bid Build

EEPCO -Ethiopian Electric Power Corporation

ERA -Ethiopian Road Authority

ETB -Ethiopian Birr

G1 -Grade one

GMP -Guaranteed Maximum Price

MCDM-Multi-Criteria Decision Making

PD -Project Delivery

PDM -Project Delivery Method

PDS -Project Delivery System

RII -Relative Importance Index

SPSS -Statistical Package for Social Science

PPP -public private partner

λ max = The largest Eigen-value

ABSTRACT

Construction industry plays a major role for economic development of this world. However, it is exposed to problems such as delay, cost overrun, quality (defects) and low satisfaction of clients as major problems. There are many reasons of these problems. Among those reasons implementation and interpretation of the Project delivery method has its own negative impact. Having this in background the study sets general objective as appropriate project delivery system selection model adapted for road projects in the country /Ethiopia/.The general objective addressed through three specific objectives aimed to determine performance relationship of DBB and DB project, to establish set of criteria to select appropriate PDM and to develop appropriate PDM selection model. To achieve the study, the paper used a quantitative and qualitative research approach. And due to the purpose, an exploratory and descriptive research design is used. Using those techniques the different findings from questionnaire and case study discussed accordingly. The target population for this study is total number of road construction projects commenced by ERA and whose progress is more than 50%. Non-probability, Purposive sampling used to Select samples from the population. Based on the research objectives; questionnaires were prepared and distributed to 95 professionals. From this, the researcher collects 79 (83.15%).The collected data were analyzed using a statistical package for social science software (SPSS). With regard to reliability, the results showed that all measures used in this study have an acceptable level of reliability. The 1st specific objective deal with Performance comparisons and case study which used empirical data on three DBB and three DB currently finished projects were analyzed and results as, DB project delivery system have minimum schedule growth, low cost deviation and moderate quality. Next, A relative importance index was used to rank the top selection criteria of project delivery system. From the result of RII value on selection criteria of PDM, Respondents ranked "client requirement for schedule, cost and quality" as the first, second and third respectively with RII value of 0.921, 0.876 And 0.875 "respectively from the total 19 factor. Finally, an analytical network process (ANP) was analyzed based on 19 selection criteria's to select appropriate project delivery methods and results DB delivery method as appropriate project delivery method with λmax results of 7.339 and Consistency ratio of 0.107 which was acceptable in case of ERA.

Key Words:-Project delivery method, Design bid build, Design build, Innovative and Alternative delivery methods, Analytical network process

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the research

Economy is the horse power of this world which is achieved through different ways; the major one is by construction industry (khan, 2008).This construction industry has its own measurement of success factors such us right time delivery, equivalent price, quality standard and client level of satisfaction (Skitmore Martin, 1995). However those success parameters faced to many challenges (Thehaye, 2016). One cause of this challenges created by improper selection of project delivery system which results contract disruption and claims. Abebe & Girmay, (2012) describes claim as "additional" which means it may be additional of time, additional of cost and also additional of time and cost. Dealing with Project delivery system such as design bid build (DBB) which mostly used in Ethiopia, time is not constraints and this lead to lag of schedule which results time or time and cost claims.

Project delivery method interpreted in different ways by different scholars such as assignment of responsibilities to the different parties involved in a project in order to establish a framework of the entire design, procurement and construction process (Oyetunji & Anderson, 2006). There are various delivery methods available in the construction industry, from the traditional design-bid-build (DBB) to Innovative project delivery systems (Nida, Irtishad, & Youngcheol, 2014). Innovative project delivery method contains:- design build, construction management at risk, construction management at fee, Public Private Partnership, Integrated project delivery system and Force account are the major one.

As discussed above, construction industry is a major role player for economic growth of one country. These construction industries have many subsets, and one of the subset is road projects. Roads are the back bone of a country's infrastructure and the frame of a country's economic development. They support growth in agriculture and industry, open corridors, port links and tourism areas, and connect each region to the rest of the country. Roads also furnish access to internal markets and social infrastructure such as schools and health centers

In Ethiopia road construction increased during Italian occupation from 1936 up to 1941, but after Italian released the country it become decreased because of lack of budget (funds).Recently around 1990, as one of development goal, Ethiopian government establish 10 year Road sector development program which latter expand up to June 2010.To help Ethiopian road sector developing program to be achieved, using appropriate construction delivery method is an important factor. Actually Ethiopia is practicing the traditional methods (Design Bid Build) while there are other innovative delivery methods. This delivery system is developed overtime, based on problem solving from the previous .This kind of delivery system divided the Project in to different package however, many constructions owners have experienced a verity of frustration using this delivery system due to: time consuming, its exposure to claims, it causes adversarial relationships among the parties and also the absence of contractors inputs in the design decision. To solve those kinds of problem, Ethiopian road construction, which Administered by Ethiopian Road Authority start to practice DB (design build) project delivery system since 2003. And also ERA is on the way to practice PPP (Public Private Partnership) type of delivery system. ERA have been making some feasibility study to adapt PPP type of project delivery system which the study come to end almost with positive results which means PPP will be suitable and applicable recently in some kinds of projects in ERA.

From innovative delivery method, DB (design build) is practiced since 2003 E.C in ERA and this leads to overcome some problems which created by traditional design bid build delivery system. It will reduce fragmentation and only one procurement process and a single contractor provides the entire process. For an owner the primary benefit is the simplicity of having one party responsible for the development of the project. In addition, design team and contractor are procured together, providing a complete team approach, opportunity to fast track and save time, construction expertise is available from the beginning of design, leads to value engineering and constructability improvements from the beginning of the design process, allows ability to fast track the project from conception to occupancy, diminishes risk of need for re-design due to enhanced collaboration between owner, contractor and design team, less adversarial relationship between design and construction teams due to the fact that architect works for the contractor not the owner (Wubishet, 2006).

Even though, Innovative delivery method such as DB, CM at risk and CM at fee can be effectively applied in oromia, Ethiopia (Lema, 2006).But Still now there is lack of adapting innovative project delivery system in the country which implies lack of guide lines or frame work In choosing which procurement system to apply for any specific project (Habtamu, 2019).

Having the above-mentioned facts in mind, this paper aims to determine the factors which influence adaption of Innovative project delivery systems and selection criteria's of project delivery system. Additionally to evaluate different project delivery systems in terms of different performance parameters and also to establish appropriate project delivery system selection model which support the client or his representative(consultant) in best decision making during selection of project delivery system which minimize the effect that caused by improper selection of PDM.

1.2 Statement of Problems

Achievement of Construction performance parameters such as time, price, quality and client satisfaction are the main goal of construction projects. But in developing countries, this construction industry lacks its achievement and faced challenges (Tsehaye, 2008). There are cases in which improper selection of project delivery method can be cited as one of the main causes of contract disruption and then claims. According to Abebe & Girmay,(2012) describes claim as "additional" which means it may be additional of time, additional of cost and also additional of time and cost. And Project delivery system such as design bid-build (DBB) which mostly used in Ethiopia, time is not constraints and this lead to lag of schedule which results time or time and cost claims. In addition to claim, technical demands of new and complex building systems, which required more coordination between the project stakeholders, have also created a need for innovative project delivery methods (Nida, Irtishad, & Youngcheol, 2014).

Ethiopian Road Project such as, ERA /Ethiopian Road Authority/ and AACRA/ Addis Abeba City Road Authority/ usually use the traditional DBB approach (Habtamu, 2019). And by default the standard bidding documents, the procurement method and overall process and its organization for the different services and works complement and match with the PDM. This traditional delivery system usually results in cost overruns, creates disputes between parties, risks are retained by clients and clients are responsible for errors and omissions in design and low bid will usually result in frequent change in orders (Pakkala, 2002).

In the case of ERA, while the traditional project delivery approach has served the country well, it has also received criticisms stemming from cost and time overruns and quality problems. Contract administration and entire relationship among parties has been ended up with litigious relationships (Habtamu, 2019) and (Rahel,2016). Additionally Ethiopian Roads Authority (ERA) has attempted the design-build method for some fourteen (14) rural roads projects some years

back. 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. None of the projects were completed at contract period. Maximum of 84% and minimum 27% of the work were completed at the end of contract period. The major challenges and drawbacks are lack of adapting alternative project delivery system, lack of guidelines for procurement of goods and services ; and also lack of selection guideline of project delivery system (Rahel,2016).Therefore it is the interest of the research work to assess the factors which influence adaption of innovative project delivery systems and also to determine selection criteria's of project delivery system, to compare performance of project delivery system and, finally to develop appropriate project delivery method selection model which use client or his representative in decision making of delivery method selection.

1.3 Research Questions

1. How performance relationship between DBB and DB is determined?

2. How a set of criteria is established to select appropriate project delivery system for contemplated road construction project?

3. How appropriate project delivery method selection model is developed through analytical network process for the contemplated road construction project?

1.4 Objective of the research

1.4.1 General Objective

To develop appropriate project delivery method selection model using analytical network process/ANP/ in case of Ethiopian Road Authority.

1.4.2 Specific objectives

1. To determine performance relationship between DBB and DB Road Construction Projects.

2. To establish set of criteria to select the appropriate project delivery system for contemplated road construction projects.

3. To develop appropriate project delivery method selection model using analytical network process (ANP) for the contemplated road construction project.

1.5 Scope of the study

First, the research is focusing on Road projects which was in the execution phase and also finished projects located in different parts of the country owned by Ethiopian Road Authority. The research focused on a client which is ERA (Ethiopian Road Authority), consultants which mean client representative who have agreement with the client and additionally to know their view of this project delivery system, contractors are also included.

1.6 Significance of the study

The finding in this research will help clients or his representative (consultants) in decision making of project delivery system selection. This was enable the client in developing the selection practice of innovative project delivery system which can help them in increasing communication between project team, process efficiency, productivity, quality and also controlled cost and schedule. It is also vital in reducing the likelihood of conflicts or claims that raised on time and cost because it recommend appropriate project delivery system selection model.

1.7 Limitation of the Study

The major limitations according to this study while conducting, processing and writing Includes lack of locally adapted literatures regarding the selection of appropriate project delivery system using analytical network method. The second limitation was related with the document review part of the study there was a problem of effective documentation and report preparation and also there is lack of clear and precise document. Due to this only clear and completed documents were consumed for this research work as discussed in the methodology part.

1.8 Organization of the study

This research is classified in to five chapters. The first chapter deals with introduction of the research that includes general background, background to the study area, statement of the problem, scope/delimitation of the study, significance of the study, limitation of the study, structure of the study and definition of key terms. The second chapter deals with related literature review. The third chapter deals with research methodology. The fourth chapter

deals with result discussion/interpretation. The fifth chapter deals with conclusion and recommendations.

1.9 Definition of Terms

- Delivery method- refers to the assignment of responsibilities to the different parties involved in a project in order to establish a framework of the entire design, procurement and construction process
- Consultants: - For this study, Consultants will refer to Architectural, Quantity surveying and Project management firms involved in the projects giving advice and developing deigns.
- Contractor: - in this study contractor is the party responsible for the completion as well as the construction of the works.
- Client: -For this study Client is a person for whom a project is carried out.

CHAPTER TWO

2. RELATED LITERATURE REVIEW

2.1 Introduction

This chapter provides a detailed review of different works of literature related to the objectives of the study. This chapter starts by giving highlight on the project delivery method definition, type, selection criteria, factors of influence to adapt innovative project delivery method, comparison of performance for DBB and DB project delivery method and then discuss about appropriate project delivery method selection model.

2.2 General

Achievement of Construction performance parameters such as time, price, quality and client satisfaction are the main goal of construction projects. But in developing countries, this construction industry lacks to fulfill its achievement and faced challenges (Thehaye, 2008). There are cases in which improper selection of project delivery method can be cited as one of the main causes of contract disruption and then claims. Claim defined, as additional which means it may be additional of time, additional of cost and also additional of time and cost. Project delivery system such as design –bid-build (DBB) which mostly used in Ethiopia, time is not constraints and this lead to lag of schedule which results time or time and cost claims (Abebe & Girmay, 2012). In addition to claim, technical demands of new and complex building systems, which required more coordination between the project stakeholders, have also created a need for innovative project delivery methods (Nida, Irtishad, & Youngcheol, 2014).

At present, there are no industry-wide accepted definitions of project delivery methods, and many groups, organizations, and individuals have developed their own. In so doing, they have often used different characteristics to define the delivery methods and this has resulted in a multiplicity of definitions. The term delivery method refers to the assignment of responsibilities to the different parties involved in a project in order to establish a framework of the entire design, procurement and construction process (Oyetunji & Anderson, 2006). After definition of project delivery method was reviewed, next classification of project delivery system was discussed.

2.3 Types of Delivery methods

There are various delivery methods available in the construction industry, from the traditional design-bid-build (DBB) to innovative project delivery system (Nida, Irtishad, & Youngcheol, 2014). No project delivery system is perfect, but based on the unique requirements of each project one particular project delivery system might be better than the others. It is obvious that the decisions made in the early stages of the project's life cycle could have more significant effects on outcome of the project than decisions made in later stages. Proper decisions made early on may help the owner avoid re-bidding and re-designing the construction and therefore may save a considerable amount of cost for the project. Thus, an owner must select an appropriate method for his/her required services after careful evaluation of the project's needs and characteristics (Nida, Irtishad, & Youngcheol, 2014).

The main differences among delivery methods lie in:

- Contract formation and, most crucially, the parties to whom the various responsibilities and risks are assigned;
- The incentives to meet the contract requirements;
- The assignments to carry out contract administration and other project management services (Manual, 2012).

2.3.1 Design-Bid-Build (DBB)

It is the traditional delivery method which exercised throughout the world in public and private projects. Client, Consultant and Contractor are the main role player of this delivery method. The client /owner make two separate contract one with consultant for design purpose which is selected based on their qualification such as experience, past performance, technical competence and other related factors and the second with contractors for construction purpose by making competitive bids based on drawings, specifications, and supporting information which prepared by consultant and the procedure goes to selection of lowest responsive bids (Fong, C; Avetisyan, H; Cui, Q, 2014). This selected price may not lowest cost for the project but it is the lowest cost associated with the design documents prepared for the project before actual construction begins.

In the DBB project delivery method, the responsibility of a designer is to prepare complete construction document for the owner. This document contains drawings, specifications, and supporting information which considered as a fulfillment of different construction constraints

and objectives. Based on completed document the client selects the contractor through bidding. The selected contractor construct according to the standard contract document under the supervision of the designer/supervisor which undertaken by administration relationship rather than contractual agreement and also the owner fulfills financial and other obligation to contractors (A society of American Inistitute of Architects, 2015).

In addition to competitive bidding, DBB project can be also awarded by negotiation bases and best value bases which are advantageous in reducing probability of project award to contract who has submitted a mistakenly low bid amount and it also increase the habit of contract for the next chance of negotiation contract.

Because of some gaps such as cost, time, quality and expert related drawback the owner /client need to make multi stage contracts which can be categorized into two bidding structure. The first one is design bid build single bidding structure and the second one is design bid build separate prime bidding. Under the first which means single prime bidding the owner make contract with consultant for design purpose and after the design is prepared the general contractor is selected .Additionally the owner make contract with general contractor who undertake the construction phase and this general contractor can make contract with subcontractors by taking accountability of the work done by them .when we come to the second one which is design bid build separate (multiple) prime bidding, the owner contract with consultant and multiple prime contractor for design and construction purpose respectively. The designer prepare bid package for multiple general contractors such as Sanitary, Electrical and Civil work contractors (Sameh, 2016)

This project delivery method is also known by initially low bid which DBB form of contracting is believed to offer for the client might not result in the ultimate lowest cost or final best value. This idea raises that; designers may have limited knowledge of the true cost and scheduling ramification of design decision in the DBB form of contracting (Leavy, 2006). When compared to other delivery system in DBB, there is less participation of client on design in other way the owner depends on the design team for constructability review. The Design Bid Build systems known by its check and balance mechanisms which may come at the expense of increased agency inspection efforts. This mechanism applied through the formation of linear and sequential relationship between design and construction service providers which make fragmentation, lengthy and miscommunication between stakeholders and neglect the input of contractor on design and projects sustainability issues regarding the performance matrix until the design is

complete and the construction contract is executed. The agency owns the detail of design during construction and the risk associated with any change conditions, unknown errors, omissions that are encountered during construction (Keith, 2009). Additionally DBB delivery method have many advantage for instance it applies to a wide range of project as it is well established and easily understood and also DBB provides clearly defined role for all parties (Leavy, 2006).

2.3.2. Design-Build (DB)

Design-Build is delivery method in which design and construction run by single contractor/entity. In this delivery method the owner make a contract with single contractor/entity which is design build entity for design and construction purpose. And the owner desire for a single source of responsibility. This characteristics leads to speedy completion of time because of construction begins before design is complete and project cost are defined early in the process. In addition to this it also plays significant role in cost constraints by minimizing the owner's exposure to design errors and omissions and there by promote schedule certainty which increase its popularity in both public and private (Smith, 2009).

The design-build entity can be existing as one entity with both contractor and designers or the contractor can hire the designer (who is not agent for owner) from outside as part of the contractor. The design team is responsible for providing the owner objective (what he/she want) starting from design service to construction at all. And also the owner prepare clear and defined design criteria which design builder will follow and the design build entity used as early constructability input. The scale of design work included depends on the extent to which the employer has already commissioned such work from others. The contractors design start from simple compressive design to full design which contain proposals, sketch schemes and production information's. The contractor will be totally responsible for undertaking the design work outlined in the contractor's proposals, for fabricating the building, and for coordinating and integrating the entire process. And the owner by his side is responsible for operation, maintenance and financial aspects. But the owner exposed to some tradeoffs like loss of design control and lack of architect who work in owners best interest which lead to the owner to require administrative architects to assist in defining building program, writing performance requirements, selecting the design build entity and administrating the design build for the owner (keith, 2009). Owners must consider some issues for suitability of Design Build such us he/she can outline clear and defined expectation, statement of requirement end users need and priorities for the project to all bidders. In addition the owner prepared and check its capacity to hire in

house (consultant) and project management experts; understand the risk apportionment between himself and design build entity; have the project financing in place and be prepared to award the contract within the tender/proposal validity period.

Listed below are some of the unique characteristics of DB:

- The owner typically completes only 5-30% of preliminary design before it is turned over to design-build team for completion (Paek and Lee, 1992).
- The owner develops a details Request for Qualifications (RFQ), Instructions to Proposes (ITP) and Request for Proposals (RFP). These documents are then used to identify and Short-list interested DB teams and provide instructions for the short-list DB teams to follow as they develop their proposals (School Facilities Planning Division, California Dept. of Education, 2002).
- The owner conducts a thorough up-front effort to identify project-specific goals and technical, public and political challenges that may hinder achievement of those goals.
- The owner conducts a risk assessment workshop with key team members from the owner's team and resource agencies to identify risks (technical, political, environmental, etc.) to project goals and determine if project scope should be adjusted to adequately address identified risks, (Peckka,. 2002).
- The owner conducts a follow-up risk assignment workshop with key team members from the owner's team and resource agencies to assign identified risks contractually to the party (owner or DB team) who is best able to manage that risk.
- DB provides an opportunity for design-builder to incorporate alternative technical concepts at the proposal and construction phases to more efficiency deliver projects.
- DB requires both the owner and the DB team members to assume new roles. Because the owner and the Design Builder assume new roles, the owner will conduct audit and oversight responsibilities while maintaining project control with fewer staff. Conversely, the design-build firms must increase the size of their staffs to fully perform their contract obligations, (Thomas, et al, 2002).
- Because the owner and the Design builder assume new roles, the owner, resource agencies and Design Builder will conduct education and training sessions on their respective roles and responsibilities with staff to ensure delivery success (Peckka,. 2002).

2.3.3 Construction Management at-Risk (CM at-Risk)

Construction management (CM) is one of project delivery method in which construction manager which is hired by qualification of the owner at early stage of the project life cycle to give services such as preconstruction service and to manage/direct those elements as schedule, cost, construction methodologies and procurement strategy. There are two forms of Construction Management:- Construction Management at Risk and Construction Management at Fee(Agent) (CMAA, 2007)

Under Construction Management at Risk system, is one of the system which follow philosophy of integrated processes, wherein the owner first selects a design firm to design the project and then separately hire a construction management (CM) firm who initially acts as the project manager at design stage and takes responsibility as general contractor at construction stage. Thus construction manager provides expert support to the owner before the construction, including constructability, budget and schedule advice, and acts similarly to a contractor during construction and also responsible for delivery of construction work including quality and performance of the project. In this method first the owner contract with Construction Manager and then the designer is selected through this construction manager, finally contract is formed between the owner and the designer. This at Risk in addition, the construction manager acts as a general contractor by signing a number of trade contracts with sub-contractors and suppliers. A CMAR becomes a construction manager/general contractor hybrid instead of the traditional general contractor (Construction Management Association of America, 2012).

CM firm usually takes the risk of the construction at a Guaranteed Maximum Price (GMP). AIA (2005) and AGC (2004) highlighted the typical characteristics of CMR as; separate contracts between owner-designer and owner-contractor, selection based on technical qualification, direct contracts with trade sub-contractors, and allowance for preconstruction services, GMP, commitment to a fixed delivery schedule, transparency, minimum adversarial relationship and elimination of bid shopping. CMR promotes greater control by the owner over the project design as compared to DB (Cunningham, 2005). Further, CMR in contrast to DB brings general contractor on board to the design process at early stage, where their inputs can benefit the project. CMR has added advantages over other PDS, in term of schedule compression, quality, innovation, cost certainty and elimination of adversarial relationship through excellent teaming.

Advantages of the CM at risk:

- The construction manager CMR is an agent of the owner in managing the design process, but takes the role of a vendor when a total cost guarantee is given. Many professional CMR are leery of this change of role and resist being placed "At risk".
- Earlier knowledge of costs
- More professional relationship with the constructor
- Owner has familiarity with the process
- CMR is faster than traditional design-bid-build
- The CMR option offers the opportunity to begin construction prior to completion of the design.
- The CMR can bid and subcontract portions of the work at any time, often while design of unrelated portions is still not complete.

Disadvantages of the CM at risk:

- The contractual relationship among designer, CMR and owner, once construction begins is underway; the CMR converts from professional advisory role of the Construction manager to the contractual role of the general contractor.
- At that time, tension over construction quality, completeness of the design and impacts to schedule and budget can arise:
- Since a commitment is made to a contractor earlier in the process, a premium is placed on the proper selection of the CMR to provide the best value to the owner.
- There are still two contracts for the owner to manage Contractually, the parties have different agenda and objectives
- The designer may not include constructor input.
- Firm costs for the project are seldom known until later
- CMR project delivery is slower than design-build.

2.3.4 CM at Fee

Construction management at Fee is delivery method similar to DBB the traditional method, in which the owner/client is responsible for design, bidding, and construction of the project, however the construction management organizations takes on responsibility for administration and management, construction issue, day to day activities and assume an advisory role or role of an agent to the client. In this method the construction manager is added to the team with powers of the owner. CM at agent provides early consulting and may assemble and coordinate the

consultant and the contractor. This method exempts the construction Manager from taking any risk for construction cost allows the owner to step back from the project. The agent assumes financial authority for the project. The consultant is selected through CMs to design the project and prepare construction document. The contractor selected through negotiation or bidding process and the cost of the work is established. In this delivery system the construction firm assumes the role of agent to owner in a contractual relationship very similar to that of architect and or Engineer. The construction Manager has limited risks because construction contract are between the owner and individual contractor. With this delivery system the owner assumes the risk for subcontractor performance, financial stability, fluctuation in material cost…etc.

In CM at Fee method, the construction manager is responsible for project and site management, but is not involved in actual construction work. The construction management monitor cost, time, quality and safety but does not take responsibility for them. The construction manager is paid a fixed or time based for service provided.

Advantages of the CMA:

- The work is divided into multiple packages and bid directly to the trades.
- The project's owner holds all trade contracts and the CM acts as the client's agent in the management and direction of the work.
- The CMA is normally selected at the same time as the Architect/Engineer or shortly thereafter and provides assistance in the design phase for costs, schedule and Constructability.
- The client has the possibility of speeding the construction by awarding elements of
- The work prior to the completion of design.

Disadvantages of the CMA:

- No single point of responsibility
- No guaranteed price
- Clients must manage more contracts
- Potential for additional design costs

2.3.5 Public-private partnership/PPP/

The governments have faced increase in public demands for infrastructure facilities (e.g. highways, railroads, schools) while the economic growth has slowed down and the taxes have

reached their highest affordable rates. The accumulated deficit has also put pressure on governments and has made them resistant to increase the ratio of debt to income in their countries. In this environment, cutting back on some public services and seeking new sources of finance have been the approaches many countries have followed. This kind of problem can be solved through exercising of PPP project delivery system (Quiggin 2004). There were so many definitions given to public private partnership PDM. Let us review some of them (Akintoye et al 2003). The term "Public-Private Partnership" (PPP) refers to several different types of public and private sector agreements. The National Council for Public Private Partnership gives the following definition for PPP: "A Public-Private Partnership is a contractual agreement between a public agency (federal, state or local) and a private sector entity. Through this agreement, the skills and assets of each sector (public and private) are shared in delivering a service or facility for the use of the general public. PPP can be defined as collaboration between a private party and a government entity through a long-term contract with the aim of providing an asset or service to the public, where the public party is responsible for a significant risk and management role, and profits is aligned to performance (WB, ADB, & IDB, 2014).This definition distinguishes PPP from other collaborative arrangements between public and private sector that are simply pumping private capital into the infrastructure projects, i.e. privatization. PPP is different from privatization because with privatization the government does not have a direct control over ongoing operation, whereas with a PPP the government retains the ultimate responsibility (Grimsey and Lewis 2005a).

Based on these reports some of the major types of PPP are

- Build-Own-Operate (BOO),
- Design Build-Finance-Operate-Maintain (DBFOM),
- Design-Build-Finance-Operate (DBFO),
- Build-Operate-Transfer (BOT), Design-Build-Operate-Maintain (DBOM), and
- Design Build (DB) (USDOT 2007) (Grimsey and Lewis 2005a).

2.3.5.1 Design-Build-Operate-Transfer (BOT) Method

In this project delivery method, a private company is responsible for design, construction, operation, and maintenance and financial of the project for a specified concession period (Pakkala, 2002). The contractor assumes the risks of financing until the end of the concession period. During this concession period, the company collects revenues from operating the project

to recover its investment and to earn a profit. At the end the concession period, ownership of the project is transferred to the client/owner.

2.3.5.2 Design Build Operate/Maintain

Design Build Operate Maintain (DBOM) is one type of PPP delivery system in which a contractor performs the role of operator for the facility in addition to the design and construction of the building. The contractor, usually a joint venture between a design-build firm and an operations firm, holds a single contract with the owner. The term for the O&M of the facility is typically 10-15 years. This contracting arrangement varies greatly from DB and DBB as one entity is contracted in place of three separate entities (the designers, the constructors, and the operators and maintainers).

Familiarity with building sector is so low for DBO/M that few found it superior to more familiar delivery system for producing benefit, and few expect to see it growth in the next few years (Nida, Irtishad, & Youngcheol, 2014).

2.3.6 IPD

IPD is innovative delivery method which can be led by philosophy of integration. This integration formed between different stakeholders involved, the overall process, interaction, project/programs organizational structure and practices into a process. From those different integrations formed, integration of stake holder holds collaboration among owner, contractor, consultant, subcontractor, financier, municipalities, suppliers, facilities managers and end users that uses the knowledge and wisdom of all participants to enhance project outcomes, increase value for money, reduce waste, and optimize efficiency through all phases of design and construction .All of them involved at start of planning up to end of the project which means up to end users (Sargiss, 2018). Recently IPD exists as a method that has the potential to reform project delivery. It differs from other project delivery methods by focusing on the general improvement and the integration of processes, tools, and people in a single system (Azhar,N; Kang,Y and Ahmad.I, 2014).This integration exploits the participants' abilities and insights to decrease waste and optimizes efficiency through the different stages of design, fabrication, and construction (Architects, 2007).

IPD have many advantages from those the main advantageous of IPD is the capability of all parties to take part in the project as early as the design stage (Kent, D; Becerik, G, 2010). As explained above the IPD construction method starts from the concept stage through to the

handover and operation stage with the aim of achieving a building under the integration of the design team, owner, and contractor. Furthermore, its target is to enhance project outcomes through a shared risk and reward system, early party involvement, and multi-party contracts (Fish & Keen, 2012) .The basic concept is based on a singular, multi-party agreement between the owner, designer and contractor, with shared project objectives, shared risks and shared rewards. In IPD, owners has the benefit of cost, schedule and program certainty at early stage, while designer and contractor mutually gain or lose profit based on achieving project outcomes rather than individual team.

2.3.7 Force Accounted Delivery system

In situations where the owner/or a single organization of certain facility financed design and construction on his own we call it that the project adapts the traditional PD approach which is called as force account or in-house development method. In different parts of the world in the past and also at this time it has been frequently used for housing and industrial development projects due to some advantages and owners capabilities and capacities to adopt it. In most cases firms adopting this system are either property developers which has design and construction facilities or contractors who diversified in to property development and merchant banking. Under this delivery method all their risk and uncertainties are born by the owner by himself and due to this it's advisable to use in project that have low risk and uncertainties are born by the owner himself and due to this it's advisable to projects that have low risks. In some countries construction industry and different sectors the execution of certain project using this PDM is regulated with maximum allowable project cost and best interest of the institutes. The different benefits may include from being an independent system securing work through the tender system generating projects that are conceived during the periods of slow economic activity for delivery some times in the future when the demand is expected to improve are the major one. In some countries construction industries and different sectors execution of certain project using this PDM is regulated with maximum allowable project cost and best interest of the institutes (Thomas and Philip, 2002). On the contrary with the outsourced one force account PDM characterized by its high internal dimension and self-dealing of possible project tasks including the design, building and supervision tasks by the project owner himself. In case of our countries practicable in different sectors that have their own complete and organized different department as that of facility and building department in their agency for small scale projects and in contrary for large scale projects where the local capacity is not satisfactory. Most municipalities specially

use this method in the past for delivery of different projects for the society which are under their capacity. But today due to different policy and strategic changes towards the general market system and also the municipality offices it is not practicable especially in cities that are relatively well structured and developed (Zewdu, 2012).

2.4 Project Delivery system and their relation with project performance (success factors)

Construction project success can be indicated by project performance. Salaheldin, (2009) has a define performance as the degree to which project fulfills primary objectives in order to meet the needs of customers. The project performance can be measured by key performance indicators (KPIs).The widely accepted performance measurements of a project identified by different scholars are time, cost, and quality. These three factors represent the Key Performance Indicators (KPIs).According to Omran, Abdurrahman & Pakir ,(2012) project performance success is dependent on its performance. This performance of projects is measured based on expected quality standard, timely completion, within cost estimates and client satisfaction. A construction project is considered successful if it is handed over to the client on time, within the budget and to the required quality standards (Takim and Akintoye, 2003). But from time to time this success factors modified by including additional performance parameters such as health and safety performance, environmental performance, customer satisfaction and innovation were included (Harty, 2008). Following are six areas in which construction projects are evaluated and consequently can be seen as success criteria.

Cost

This parameter traditionally has been seen as one of the most important success indicators. Completing project within intended budget is the major criteria project success by stakeholders. Overall project cost, i.e. the overall cost that a project incurs from inception to completion, is of major interest as it shows the resource usage in economic terms. Another important aspect regards cost predictability, that is, whether the final overall cost is line with the initial cost estimate (Swan and Khalfan, 2007).project cost related objectives are always at the center of decision making towards the delivery method.to be adapted and many other project constraints. These factors include insuring that the construction project is completed with the lowest possible time within the predefined scope and quality. When we compare those three PDMs (DBB,DB and CMR) towards fulfilling the cost constraints construction management methods is the most effective in ensuring staying within budget even if the question of relatively higher or lower

budget allocated there. Design-Bid-Build methods provide the greatest flexibility and power to interfere for the owner to incorporate changes during the design and construction of the project. However, this may come at a high cost even though the competitive procurement proven to award the least competitive bidder (Sameh, 2013).

Due to market fluctuations of different resource price managing the two constraints is very crucial task by all parties involved. Due to inflation in the economy time value of many decreased and loss its current power in the long run to accomplish the planned amount of work as budgeted. Due to this interactive effect between the two constraints emphasis must be given to work on delivery of the project as fast as possible throughout the entire project life cycle phase.

The traditional DBB method may not always be able to meet such requirements because it is linear and confronting approach of projects design construction process. Alternative delivery options that permit fast tracking of the design and construction are preferred in economic exposed to a risk of inflation.(Thomas and Philip, 2002) .

Time

Knowing the fact that the delivery method implemented for certain construction project has a direct impact towards the major success factors of project .Time is the critical one among them which is considered while the selection procedure of PDM. From many different previous studies the traditional procurement system has been identified as the slowest project delivery approach and this is due to the fact that pre-contract stage of this system is longer, more time is available for the client and design team to scrutinize and review the design before construction. In addition to this its adversarial nature of contract management process due to communication problems throughout projects life cycle leads to a longer project delivery time. On the other hand DB and other innovative delivery approaches where the design and construction are integrated allowing for earlier construction date. It also allows the process of detail design and construction to run almost in parallel and concurrently to each other, thus reducing the overall project development period considerably. As a single entity responsible for both design and construction the contractor is able to control not only the construction time but also the time reserved for the design the project, thus reducing the overall contract duration. In this type of procurement system the contractor has always been selected based on its past experience, knowledge and competency in construction as such by giving it the design responsibility, the contractor very often able to reduce construction time. This is done by him rationalizing the design and construction process and site activities (Rosli et al.,2006).

Additionally, Project duration is simply the number of days/weeks/months from start to completion of the project Completing projects in a predictable manner on time (within schedule) is an important indicator of project success and the construction industry is frequently criticized for project delays (Faridi and El-Sayegh, 2006). Schedule overruns (sometimes results time growth) are often very negative since they hinder the client to start using the end product as planned.

Quality

Satisfactory time and cost performance is of little value if the project delivers inferior quality. The concept of quality is closely related to customer satisfaction, which has gradually been elevated in importance in the construction industry (Latham, 1994). Quality related factors that measure the project delivery methods ability to attain the highest overall quality. Although a high quality always desired by owners each method achieves this objective in different way other than the project delivery method adapted. The difference, however, is not as significant as that of the time, scope and the cost related factors. Delivery approach that probably form the platform of check and balance between the different participants and specially between the builder and supervisor may lead to best quality(Sameh, 2013).So that it is clear that delivery method that best leads interaction and communications between the different participant is considered the better delivery approach like that of innovative PDMs including integrated PDM (Jha & Iyer ,2006).

Customer satisfaction is commonly described as a comparison between the customer's pre-purchase expectations and their post-purchase perceptions. Hence, it involves the customer's final feelings about whether the outcome provided a satisfying or dissatisfying experience. Since construction industry products are highly customized and co-created during the construction process, the concept of quality regards both the final product and the process during which is created. Therefore, we see two main aspects of quality. First, quality of end product has to do with the users' satisfaction with the finished construction and it is a critical success factor. It is also related to how the final product and its function meet the specification (Chan and Chan,2004).The second aspect of quality is the service quality during the construction process, which reflects the client's perception of the process during which project participants interact to create the end product (Maloney, 2002).

Environmental performance

Environmental management in construction has become a critical issue in recent decades since the actors start to acknowledge that the construction industry is one of the major contributors to environmental problems (Tam et al., 2006a). Environmental impact is affected by both the activities performed during the construction process and the material and technical solutions incorporated in the end product (Crawley and Aho, 1999). Furthermore, the environmental performance depends not only of choices made but also how these choices are executed. Hence, two main aspects can be identified within this area. First, it is in what degree the construction actors make environmentally friendly choices of material and processes, i.e. in the planning and procurement choose those material and those methods that will leave the least environmental "footprint" over the construction's life span (not only the construction period). Second, it is about how the material and processes are used during construction, i.e. environmentally friendly use of material and processes. With little concern over environmental impacts, excess loss of material and improper waste treatment are always common in the construction industry (Tam et al., 2006b).

Relation of PDM on other performance parameters

Among the many other performance parameters scope related factors including the level of scope definition at the time of contract award is crucial to be considered. Each delivery method requires different level of scope definition to achieve the desired result. The level and number of changes and degree of flexibility allotted for the owner mostly make changes towards the predetermined project goal and size also related with the probable PDM. Many owners desire that the delivery method should be flexible enough to allow them to make changes as needed owners organizational structure related factor on the other hand is among the different factors affected by the project delivery implemented. It deals with the owner organizational structure and the level of professional expert and the level of professional expertise of its staff member throughout the chain of accountability. Owner's desire for single or separate project contracts is also among the different factors that probably affect the project performance. He can prefer arrangements like DB or BOT due to their nature off fast track delivery and predetermined amount of fixed budget or the possible set of financial support they allot (Sameh, 2013).

The construction industry in different sectors undergo through different technological and administrative changes across the entire spectrum. Perhaps the most notable change is the increased complexity and the cost of building services, particularly the climate control services.

The greater complexity of designs requires a highly disciplined approach to managing designs by all parties involved at the different life stages of the project, particularly coordination and integration between the designer and builder and the contract administrator/supervisor incase if its separate service arranged on the contract. This is in order to ensure that the designer come up with constructible and brief design and specification outputs feasible to be accomplish within the rest the estimated amount of money and schedule and without a serious risks of errors, omissions and ambiguities in the documentation. So the organizational arrangement structured through a certain kind of PDM should have to make sure that those problems can be overcome by its adaption (Thomas and Philip, 2002).

Table 2.1 The common used project performance indicators by previous research studies

It.No	Indicator	Definition	Reference
1	Field rework factor	The ratio of total direct cost of field rework to actual construction phase cost	CII (2000)
2	Schedule deviation (total duration, phase duration, etc.)	Percent difference between original and actual schedule	Sanvido et al. (1992); Weston and Gibson (1993); Alarcón and Ashley (1996); Pocock et al. (1996); Griffith et al. (1999); CII (2000); CDT (2002); KPI (2003)
3	Change cost factor	Total cost impact of changes which is a ratio of total cost of changes to actual total project cost	CII(2000)
4	Urgent orders	Number of urgent orders divided by total number of orders in procurement phase	CDT(2000)
5	Subcontracting	Subcontracted costs divided by total project cost	CDT (2002)
6	Quality (defects)	The ratio of cost of repairing defects to total project cost	KPI (2003)
7	Safety (incident rate)	The number of incidents that a company experiences per a defined	CDT (2002); KPI (2003)

		number of full-time employees in any given time frame.	
8	Safety (lost workday incident rate)	The number of lost work days per a defined number of full-time employees in any given time frame.	CII(2000)
9	Number of contract modifications	Number of contract modification	Pocock et al. (1996); CDT (2002)
10	Percent amount of contract modifications	The percent ratio of total cost of contract modification to the contract value	CII(2000)
11	Number of claims (Percent amount of claims)	Number of claims:- percent ratio of total cost of claims to the contract value	Weston and Gibson (1993)
12	Value engineering savings	The percent ratio of total savings obtained by using value engineering practices to the total project cost	Weston and Gibson (1993)
13	Client satisfaction	It is measured based on questionnaire survey and state of award	KPI(2003):Yu et al(2005)
14	Productivity	The ratio of the output of a system to the inputs which are utilized to produce that output.	KPI(2003):CDT(2002)
15	Cost deviation (total cost, phase cost, etc.)	Percent difference between original and actual cost	Sanvido et al. (1992); Weston and Gibson (1993); Alarcón and Ashley (1996); Pocock et al. (1996); Griffith et al. (1999); CII (2000); CDT (2002); KPI (2003)
16	Intensity	Intensity is a hybrid schedule and	Konchar and Sanvido (1998);

		cost performance metric that is measured by assessing a project's total cost in million USD over its total duration in months	Bogus et al. (2010); Shakya (2013),
17	Scope Changes and Warranty and Latent Defects	measured total changes for each project as a total percentage out of 100%.	Industry Expert Workshop
18	Unresolved Claims,	It is measured based on questionnaire survey	Industry Expert Workshop
19	Project Meeting Specifications,	It is measured based on questionnaire survey	Industry Expert Workshop
20	Maintenance Requirements	It is measured based on questionnaire survey	Industry Expert Workshop
21	Early Estimating	It is measured based on questionnaire survey	Industry Expert Workshop
22	Complex Projects	It is measured based on questionnaire survey	Industry Expert Workshop

Source various journals

2.5 Selection Criteria for Project delivery system

All client weather private or public sector agencies require their project to be completed on time, within budget and to the highest quality. Some public sector agencies, however, stress that certain criteria are more important than others (Rowlinson, 1999). While such criteria can be broadly used as a guide to assist decision-makers with an initial understanding of the basic attributes of a particular procurement system they should not be used as the sole basis for selection. This is because of the underlying complexity associated with matching client needs and priorities with a particular method (Kumaraswamy and Dissanayaka, 1998). The National Economic Development Organisation (NEDO, 1985) identified nine generic criteria that public sector agencies could use to select their priorities for projects.

In addition, several studies have used modified versions of the NEDO criteria in an attempt to develop a procurement selection framework (e.g., Skitmore and Marsden, 1988; Love et al.,

1998; Ambrose and Tucker, 2000). Luu et al., (2003) state that the use of a limited number of factors, such as those identified by NEDO (1985), may inadvertently give rise to the selection of a sub-optimal procurement system. Since the selection of a procurement system is influenced by client characteristics (Moshini and Botros, 1990), project characteristics (Ambrose and Tucker, 2000), and the external environment (Alhamzi and McCaffer, 2000), selection criteria representing the constraints imposed on the project should be considered before a decision is made

The PDM selection process requires consideration and analysis of different, complex and dynamic factors which can be categorized under three groups: client objectives, project characteristics and external environment (Alhazmi and McCaffer 2000; Luu et al. 2003a).

Influencing Factors in PDS Selection.

A. Client Characteristics and Requirements

Client's experience:-Client's experience with similar projects (Luu D. , Ng, S.T, & chen, 2003). This issue relates mainly to the level of experience of an owner's staff in application of various delivery methods. In other words, the staff's comfort and confidence using a specific delivery method. Owners who have used a project delivery method in the past would have a higher level of experience with that method.

Client's capability:-Client's ability, e.g., ability in controlling, organizing and managing a project (Mafakhari, Dai, & Slezak, 2007).This issue is mainly focused on the quality and competence of the owner's employees and their ability to complete the duties that must be undertaken in each delivery method. There is a concern about the retirement of experienced employees negatively affecting the capability of an owner's staff during the project. So the availability of the experienced staff until the end of the project should be considered while evaluating staff capability

Responsibility:-The expectation of the client in the smallest number of stakeholders who take responsibility (Chen, Liu, & LI, 2011). Research in the area of risk management has indicated that the most effective approach for risk management is risk allocation assigning project risks to the parties in the best position to manage them. This means that the party assuming a certain risk should be the party who has the most control over that risk and is also most likely to survive the negative impact of such risk. The main vehicle for risk allocation is the contract. The type of

project delivery method selected by an owner will have a profound impact on risk allocation. Some methods allow the owner greater flexibility in allocating risks to the parties involved.

Client's involvement:-Client's willingness to be involved in the project after award of contract (Oyetunji & Anderson, 2006)

Risk distribution:-The expectation of the client in undertaking risk and loss (equally divided between the client and contractor; the client or the contractor undertakes the most risk) (Oyetunji & Anderson, 2006)

Design control:-The intention and degree of the client's control of the design. Different delivery methods have different checkpoints and decision-making steps. This section is focused on an owner's control over the details of design and quality of construction.

Client's requirement for quality:-Client's requirements that the project be of the best quality (Luu & Ng, 2005).

Client's requirement for schedule:-Client's wishes for project to be completed on schedule (Luu & Ng, 2005). This issue involves two aspects of a project schedule: controlling the schedule (keeping the duration of the project within the expected timeframe) and shortening the schedule. In other words, in this section, each project delivery method is evaluated with regard to schedule control and schedule compression.

Client's requirement for cost:-Client's wishes for project to be completed within budget (Luu & Ng, 2005). This issue includes several aspects of project cost, such as ability to handle budget restrictions, early and precise cost estimation, and consistent control of project costs. Below, each project delivery method is evaluated with regard to cost control and cost estimation.

B.Project Characteristics

Project scale:-Compared with the average scale of projects in the same industry (Touran A. , Gransberg, Molenaar, & Ghayamifar, 2010). Project size is determined by transit project cost value and physical dimensions. It seems that project size would strongly influence the choice of delivery method. It seems clear that project size needs to be considered in combination with other issues, such as schedule, agency staffing, and risk management in order to determine an appropriate project delivery method.

Complexity :-Whether the project requires a breakthrough in the construction method and management; complexity of the technology (Touran A. , Gransberg, Molenaar, & Ghayamifar, 2010)

Project type:-To which type the project belongs (e.g., building construction project, infrastructure project, industrial project) (Azhar, N; Kang, Y; Ahmad, I,U, 2014)

Scope clarity:-Degree of clarity of the project scope defined by the client (Luu & Ng, 2005)

Flexibility:-Degree of potential design changes during both design and construction periods (Mahdi & Alreshaid, 2005)

Dispute Severity:-of the potential dispute during construction of the project (Mahdi & Alreshaid, 2005).

C.External environment

Competition in the market:-Degree of competition of the contractors and project management companies in the construction market (Touran A. , Gransberg, Molenaar, & Ghayamifar, 2010). The choice of delivery method may affect the level of competition. In many cases, agencies are operating under a legal requirement that requires "free and open" competition. The owner's benefit from competitive market mainly because of the reduction in bid prices; if the choice of a certain delivery method reduces the number of qualified proposers /bidders, it would be considered as disadvantage. Currently, the volatility of bid prices in transportation projects is a major concern for the owners of projects.. Additionally, some project delivery methods may in advertently lead the agency to package projects in sizes that can effectively reduce competition due to bonding limitations and contractors' capacities.

Availability of materials:-Level of difficulty in the acquisition of necessary materials for the project (Touran A. , Gransberg, Molenaar, & Ghayamifar, 2010)

Availability of technology:-Level of difficulty in the acquisition of necessary technology for the project (Touran A. , Gransberg, Molenaar, & Ghayamifar, 2010)

Most obvious technological issue that can influence the implementation of IPD on any project is related to the legal ownership, liability and interoperability concerns. These challenges are posed by the integrated use of technology to achieve collaboration on IPD projects. Organizations looking forward to IPD should look towards the following issues. .

Influence of laws and regulations:-

In the public sector, federal, state and local laws governing procurement, procurement inhibit integration of project stakeholders. For most countries, DBB is still the most used project delivery systems (Miller, Galvin, Ibbs, & Mahoney, 2000). Different Ethiopian construction law applicable to public work contract has been analyzed and the kinds of project delivery system incorporated in laws are explored. The legal document which are the subject doctrine analysis include Civil Code of Empire of Ethiopia Proc.No.165/1960, The Commercial Code of the empire of Ethiopia Proc.No. 166/1960,Ethiopian Building Proc.No.624/2009, Ethiopian Building Regulations No.243/2011, The Ethiopian Federal Government and Property Administration Proc.No.686/2010 ,Commercial Registration and Business licensing Proc.No.980/2016 and the 2011 PPA (Public procurement Agency) conditions of contract for works issued by Federal Government Property Administration Public Procurement Agency. Following discussion will highlight some of the conflicting legal issues

There are two different criteria which make conflicting idea in procurement of design and construction service. Architects and engineers (A/Es) services for public projects are procured through negotiated contracts based on the competence and qualification for the desired services at fair and reasonable price. Price quotations are not part of selection criteria under quality-based selection. While on the other hand, Procurement laws of construction services mandates the selection of contractors on public contracts through open completion and based on lowest responsible bid. For such procurement, design documents needs to be 100% complete before the selection of contractor. Therefore, it does not allow involvement of key participants at the design stage, which is one of the key characteristics of IPD projects. Simultaneously it inhibits the other key characteristics of IPD like multiparty contracts, shared risks and rewards.

2.6 Multi-criteria decision making methodology (MCDM).

Delivery system takes the lion role in success of construction project. Therefore deep analysis and attention must be given to the selection of project delivery. But the practice of delivery selection is somewhat unstructured and wrong selection of construction procurement approaches which usually leads to project dissatisfaction of the client (Masterman, 1992). To overcome this problem several procurement selection systems have been developed to help the clients to choose the most appropriate one. Making the proper decision has always been an essential part of humans live. In the science world, modeling decision-making problems has been getting plenty

of attention from researchers in the decision analysis area. In the 19th century, Pareto, Von Neumann, Morgenstern and many other researchers began modeling the decision-making problems mathematically. At first, single criterion decision-making problems were studied. It was in 1951 that two research teams introduced the multi criteria problem (Koopmans 1951, Kuhn & Tuker 1951). In this kind of decision-making problem, the purpose is to find the most appropriate alternative among several alternatives while multiple conflicting criteria are considered (Mateu, 2002). However, in all of the models there is always a need to input the specific characteristics of client, project and possibly procurement process features that are subjective based on the point of view of the user. Further, it is strategically important to make sure that the selection is done systematically and in a closely\controlled manner. Whether such an approach is used for the selection is still doubtful.

There are several techniques or methods of multi criteria decision making analysis; the following 12 MCDM methods were identified throughout the review. Those methods are (1) multi-attribute utility theory, (2) analytic hierarchy process, (3) fuzzy set theory, (4) case based reasoning, (5) data envelopment analysis, (6) simple multi attribute rating technique, (7) goal programming, (8) ELimination Et Choix TR aduisant la realitE (ELECTRE), (9) Preference Ranking Organization Method For Enrichment Evaluation (PROMETHEE), (10) simple additive weighting and (11) technique for order of preference by similarity to ideal solution (TOPSIS) ,(12) analytic network process (Hatush and Skitmore, 1997; Holt, 1998; Velasquez, 2013; Mahdi et al., 2002). From various MCDM methods, the paper discussed on three of them.

2.6.1 Analytical hierarch process

One of the techniques for solving a multi-criteria problem is the Analytic hierarchy Process (AHP). AHP is a Multi-Criteria Decision-Making (MCDM) technique that allows for the consideration of both objective and subjective factors in selecting the best alternative. Analytic hierarchy Process (AHP) is an effective decision making technique based on multi-criteria decision making methodology which utilizes pairwise comparisons to derive ratio scales indicating the preferences of the decision makers among different alternatives and associated criteria. These comparisons are recorded in a comparison matrix and processed to determine the corresponding weights of the given criterion as well as available alternatives. The normalized weighted sum provides a weight associated with each available alternative and thus help decision maker to choose the best decision. It consider the human judgment, experience, perception and

feelings in the decision making process and also It help decision maker to select the most appropriate delivery method against a number of PDM with various alternatives

The Analytic Hierarchy process (AHP) first introduced by (Saaty in 1980). The purpose of AHP is to develop a theory and provide a methodology for modeling unstructured problems in different areas. Below, the philosophy behind the components of AHP is described briefly (Bruce et al 1989).

Analytic- AHP is a method in which numbers are used to make decisions. By using mathematics, it is easier to understand or describe better choices to others. Therefore, all methods of describing a decision are analytic, since they must use mathematical/logical reasoning.

Hierarchy- The AHP structures the decision-making problem in levels based on the decision maker's understanding of the situation. By breaking down the problem into levels - goals, criteria, sub-criteria, and alternatives - the decision maker can focus on smaller sets of decisions.

Process- People need time to think about a decision, gather new information, and so on. Therefore, any real decision-making problem involves a process of learning, debating and revising priorities.

Usually, there are three principles in AHP. These principles can be summarized as follows: the first principle is decomposition; decomposition is about breaking down the decision problem into smaller parts in order to simplify the decision-making process. The second principle involves constructing the pair-wise comparison matrices of the elements within a given level of the hierarchical structure with respect to the elements in the next highest level. The third principle provides a global set of priorities for the elements at the lowest level of the hierarchy, usually alternatives, by synthesizing the local priorities at the various levels of the hierarchy.

2.6.2 Fuzzy set theory

Fuzzy set theory first introduced by (Zadeh, 1965) has been used frequently to represent vagueness of human thought which was drawback of analytic hierarchy process. It represents the belongingness of an object to a set by means of membership functions which ranges from zero to one and has found many applications over the past many years. Some of the fields which utilize fuzzy sets include;-healthcare (Kilicetal., 2004), system modeling (Uncu et al., 2004; Uncu et al., 2003), supplier selection (Kahraman et al., 2003), control theory (Takagi and Sugeno, 1985), capital investment (Tang et al., 2005) etc. Fuzzy numbers are introduced as part of fuzzy set

theory which takes the form of a set of real numbers with a convex and continuous membership function of bounded support. These numbers can be used to accurately represent linguistic scales incorporating vagueness and uncertainties of human mind. Fuzzy AHP is simply an extension of the original AHP with human preferences recorded in the form of fuzzy numbers and hence the resulting comparison matrix formed is also composed of fuzzy numbers. However, to extract weights from these fuzzy comparison matrices require additional treatment as the arithmetic operations of fuzzy numbers is different from crisp numbers. To address this issue, various algorithms have been proposed over the years with an aim to process this fuzzy comparison matrix and extract weights. Some of the most popular algorithms are given by (Van Laarhoven and Pedrycz, 1983; Boender et al., 1989; Buckley, 1985; Deng, 1999).Among these FAHP algorithms, Fuzzy Extent Analysis (FEA) method (Chang, 1996) is the most frequently used FAHP algorithm (Ding et al., 2008). It utilizes the concept of extent analysis combined with degree of possibility to calculate weights from fuzzy comparison matrices. However, this method has been criticized (Wang et al., 2006) mainly due to the way fuzzy numbers are compared using degree of possibility. Over the last five years around hundred research articles have been published on how to compare fuzzy numbers which shows that there is no general consensus on a single method to rank and order fuzzy numbers (Zhu, 2014). Therefore, new analysis method fuzzification (Ross, 1995) and defuzzification by simply using the mid number of the triangular fuzzy number was introduced.

2.6.3 Analytical network process

Theoretical foundation of ANP

The Analytic Network Process (ANP) is a multi-criteria decision making tool used to derive relative priority scales of absolute numbers from individual judgments. It is introduced by (Saaty, T.L., 2005).Many real world decision problems cannot be constructed hierarchically because of the interaction and dependence of higher-level elements in a hierarchy on lower-level elements (Saaty, T.L., 2009).

AHP only employ uni-directional relation between decision levels and not appropriate for multi-directional relationship (Saaty, 1988; Meade and Sarkis, 1998). To enhance AHP, analytic network process (ANP) is developed. ANP is a generic form of AHP and allows for more complex interdependent relationships among elements (Saaty, 1996). It is also known as the systems with feedback approach (Meade and Sarkis, 1998).Feasibility of these methods has been verified through empirical research. Saaty developed the analytic network process (ANP) to

solve the problem of MCDM; this tool has been widely applied to decision-making problems in various fields, particularly in the selection of industrial projects. It consider not only vertical relation of hierarchies, it also considers feedback of horizontal relations. It have its own steps, first, the unstructured problem is deconstructed through qualitative analysis. The problem is then structured in accordance with the relationships between clusters. Lastly, an expert survey is conducted and the results processed using quantitative analysis. The candidate projects are then ordered by priority on which basis a final decision is reached. Cheng and Li (2005) were the first to use ANP in the selection of construction projects.

Employing both qualitative and quantitative analysis, ANP provides a systemized process of analysis that determines the weight of each criterion, which in turn determines the relevance of each criterion and the potential for successfully reaching the objective. Using a network approach, ANP structures a problem into a hierarchical format. Apart from its hierarchical analysis function, ANP can also be used to analyze feedback relationships between different levels and interdependent relationships among elements on the same level.

The major difference of ANP and AHP

The analytic network process ANP is a decision finding method and generalization of the analytic hierarchy process AHP. ANP can model complex decision problems, where a hierarchical model–as used in AHP–is not sufficient.

In AHP It's a top-down structure from the overall objective to criteria, from criteria to sub criteria down to alternatives. In ANP criteria, sub-criteria and alternatives are treated equally as nodes in a network. Each of these nodes might be compared to any other node, as long as there is a relation between them not only from top-down as AHP.

2.7 Application of project delivery method in Ethiopia

As known the client main goal in selecting project delivery method is to enhance efficient construction which meet project objective and allow projects to become cost effective, time scheduled, standard quality, owner's involvement during both design and construction periods. Contractor's capacity to discharge the contract responsibility should also be one of the criteria in adopting methods for project delivery. But when we come to the applicability or practice in Ethiopian context these aspects are not considered. Almost all construction project in Ethiopia use traditional design-bid-build project delivery method. But, there are also experiences on the

innovative delivery methods that justify no prohibitions on delivery method applications in Ethiopia.

For example, the Ethiopian Roads Authority (ERA) has attempted the design-build method for some fourteen (14) rural roads projects some years back. The Ethiopian Electric Power Corporation (EEPCO) is also employing the design-build method. The Amhara National Regional State has also employed the DB method to deliver one road project successfully (Alemketema-Sekota road Project). The Oromia National Regional State is currently using Design Review and Construction Supervision Consultancy approach. This, itself, is a shift from the traditional DBB method (Rahel,2016).

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. None of the projects were completed at contract period. Maximum of 84% and minimum 27% of the work were completed at the end of contract period (Rahel,2016).

2.8 Research Gap or Synthesis

After reviewing various journals about selection of appropriate project delivery method, factors affecting adaption of innovative delivery method, the researcher realize that there were some researchers conducted on the model to select appropriate project delivery method globally and in Africa. But when we come to Ethiopian context there was lack of research regarding the issue of the factors affecting adaption of innovative delivery method, selection criteria and selection models .This idea is supported by Rahel, (2016) and Mikael, (2021) who proved that there was lack of researches conducted in Ethiopia about Project delivery system. This is the major research gap which led to conduct this research.

Additionally Ethiopian Roads Authority (ERA) has attempted the design-build method for some fourteen (14) rural roads projects some years back. 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. None of the projects were completed at contract period. Maximum of 84% and minimum 27% of the work were completed at the end of contract period. The major challenges and drawbacks are lack of adapting modern project delivery system, lack of guidelines for procurement of goods and services; and also lack of selection guideline of project delivery system (Rahel,2016).Therefore it is the interest of the research work to assess the factors which influence adaption of innovative project delivery systems and also to determine selection criteria's of project delivery system and, finally develop appropriate project delivery method selection model which use client or his representative in decision making of delivery method selection.

As a result, this study will go one step ahead towards developing appropriate project delivery method selection model which will help the client or his representative in decision making on selection of project delivery system. And this leads to minimize its adverse effect on project performance.

CHAPTER THREE

3. METHODOLOGY

3.1 Introduction

This chapter discussed the research methods used which includes the research approach, the population, sample size, sampling technique, data source, and finally, the data analysis technique was discussed.

3.2 Research Approach and Design

3.2.1 Research Approach

According to Crewsel.J.,(2014) when selecting a research approach it is very important to consider the research problem because certain types of research problems call for specific approaches. Quantitative research approach is best for such studies like the “identification of factors that influence an outcome’’ (Crewsel.J., 2014).So considering the above mentioned fact the research approach that used in this research was a quantitative and qualitative approach. It was qualitative because it asses a problem by taking professionals opinions, view and perceptions on factors influencing adaption of innovative project delivery system, it also assess selection criteria of project delivery system and used analytical network process based on decision of client/ his representative to develop appropriate project delivery method selection model. ANP was selected from MCDM because ANP can model a complex decision problem and also considers horizontal and vertical relations which lead to more precise results. It is also quantitative because it tries to take empirical data to compare project delivery method performance. And also measure the problem by investigating facts using statistical tools and calculating weight matrix and priorities using Analytical network process.

3.2.2 Research Design

Research design is a mapping strategy which is based on sampling technique. It essentially includes objectives, sampling, research strategy, tools and techniques for collecting the evidences, analyzing the data and reporting the findings. It is a planning Stage of research which is usually made logically visualizing its practicability. The selection of research components is done keeping in view of the objectives of the research. The strategy that has been followed for this research work follows first, to formulate a research problem and then the research design i.e. the data and information Sources determined to solve the problem based on the formulated research design. On The basis of the data and information sources the research instruments decided. Then the required data collected and analyzed. Finally, available documentary sources reviewed for cross-checking the validity and conformity of the information obtained through the overall research work which is all implies the application of mixed approach. A descriptive and exploratory survey design attempted to collect from the relevant population (client, consulting firms, contractors) to determine the effectiveness of the PDM adopted on the overall Performance and factors which influence adaption of innovative project delivery system and also selection factors of PDM as a major variable under consideration.

3.3 Population, Sample Size and Sampling Technique

3.3.1 Population

According to Mark, (2009) the full set of cases from which a sample is taken is called the population. The population for this study is total number of road construction projects commenced by ERA and whose progress is more than 50%.Clients, contracting, and consulting companies was important data sources for this study. Non-probability, Purposive sampling used to Select samples from the population under the owner and consultant side in order to Come up with genuine information from the limited number of primary data sources who Can contribute to the study and directly linked to the study title which was appropriate project delivery method selection model. Since project delivery system was prepared by client or his representative, both of them have direct involvement.

3.3.2 Sample Size

The sample for this study was:

- Client was ERA. Which have 307 currently active projects through different regions of the country (Ethiopia) (source, ERA). There are six categories of Regions according to ERA projects. Those are: - South, North, West, East, Central and Express way regions. Under this six region categories there were a number of projects which totally results 307 currently active projects. From those projects, to get genuine information, the paper focus on projects which run more than 50 % in progress, since performance comparisons and relationship among different kinds of project delivery systems was one of the aims of the paper; to get meaning full data it focuses on projects which run greater than 50 % in progress. Therefore there were 76 projects which there progress exist more than 50%.And those 76 projects have 42 different kinds of professionals/ those professionals include: - project manager/12/, contract administrator/19/, design engineers/11/ who was located in the main office in Addis Abeba.
- For this thesis, besides conducting questionnaire survey on the currently 307 active projects, case study on finished and fully documented six projects, 3 from DBB and 3 from DB was carried out to better examine the empirical performance comparisons of project delivery methods. The data was limited because of there was no more than 3 fully documented project which delivered through DB in recent time.
- From those six projects, 3 of them were designed and constructed by one entity which means it was DB delivery system and the 3 left DBB delivery project was designed and constructed by different part. Since there was lack of documented data on finished projects and only 3 recently finished and fully documents data was exist ,the paper take 3 out of 3 currently finished and fully documented project which delivered by DB /design-build/.
- Those 76 active projects were consulted by 23 different consulting companies. This means some of them consult more than one project and even some of consultants consult three projects from those 76 active projects.
- But here since the number of contractors involved in all 76 active sites is 39 in number. This means some contractors construct two and even some of them construct three sites from those 76 active Road projects which have more than 50% progress. Since contracting company was not direct involver on selection of project delivery system, to know their

perception and view on adaption of innovative project delivery system and to know their willingness whether they were ready to exercise innovative project delivery system the contracting party was included. Sample size determined using another category of probability sampling. According to mark, (2009) probability samples the chance, or probability, of each case will be selected from the population are known and are usually equal for all cases. Probability sampling is often associated with survey and exploratory research strategies. When conducting survey research, it is important that the researcher samples random people. This allows for more accurate findings across a greater number of respondents. This shows random sampling goes with the research design of contractor side selection. Among the probability sampling methods, a simple random sampling was used since the simple random sampling technique give each member of the study population an equal chance of being selected.

Based on the above explanation:- 42 client professional, 23 consulting firm was purposively selected. And 39 contracting company were selected. From this, for contracting company as explained above and since they are not direct involver, minimizing the sample data was good in saving time and money. Therefore, it's decided to use selecting a portion of the population from the total population this will work out by calculating the sample size using Yamane (1967) method. This method is applicable to a known population size.

For Contractor

Total Number of G-1= 39

$$n = \frac{N}{1 + N (e)\ 2}$$

= 39/ (1+39*0.0025) = 35.5=36`

So the targeted respondents of the questionnaire were construction professionals who were working on these construction companies and the client side (ERA). The inclusion criteria were the respondents should be construction professionals. This includes project managers, contract administrator, design engineer, resident engineers, supervisors, site engineers who are directly related to the title project delivery system in road construction projects. The exclusion criteria were an employee of the company whose job is not directly related to construction and nonprofessional employee of the company like daily labors is not included.

3.4 Data Sources and Data Collection Tools

3.4.1 Data Source

The study used both primary and secondary data. Primary data was collected first hand by the researcher using structured questionnaires to selected clients, contractors, and consultants. While secondary data was obtained from sources already existing such as journals, articles, researches, hand books and internet sources on related topics.

3.4.2 Data Collection Tools

The instrument for data collection used in the study is questionnaires. As stated by Mark, (2009) questionnaire is convenient while conducting survey research. A questionnaire is a written forms comprising of a set of questions that is used to gather the data required from a sample population. The questionnaire for the study was designed based on the information derived from reviewed literatures in correlation with objectives of the study.

3.4.2.1 Questionnaires

As stated by Mark et al., (2009) a questionnaire is the most widely used method in survey strategy. Survey provides an effective way to collect responses from a large sample before making analysis. To obtain the needed data, cloth ended questionnaire was used as a data collection tool, due to the sample size and the quantitative approach of the study

In this research, Questionnaires used to assess professional opinion, observation and attitude towards different project delivery methods. It is aimed to assess level of awareness of professionals on innovative project delivery method, how they perceive the effect of delivery method on project performance, how they relate project performance and delivery method and factors influencing adaption of innovative project delivery method and identifying their selection criteria of PDM.

3.4.2.2 Case study

The case study method is a very popular form and involves a careful and complete observation of a social unit, be that unit a person, a family, an institution, a cultural group or even the entire community (Kothari, 2004). Thus, case study is essentially an intensive investigation of the particular unit under consideration.

For this thesis, besides conducting questionnaire survey on the selected seventy six projects, case study on selected six projects was carried out to better examine and compare performance of DBB and DB project delivery system based on performance parameters.

From those six projects two of them designed and constructed by foreign consultant and contractor and the left four of them designed and constructed by local and consultants and contractors are from domestic and overseas background. Six of them was fully documented and recently finished projects in the last three years. Three of these projects were delivered through Designed Bid Build (DBB) and the left three projects delivered through Design-Build (DBB) so that important issues related to empirical performance comparison of DBB and DB were studied to seek appropriate alternative delivery methods.

For the case study data such as Actual project schedule, planned /estimated/ project schedule, actual total cost, contract/estimated/ total cost and cost of repairing defects were collected for analysis.

3.5 Data Analysis Technique

In order to answer research questions and objectives, descriptive statistics such as frequencies and percentages was used to present the demographic and educational characteristics of respondents and to rank the top most selecting criteria of project delivery which is aim of objective number one and two RII was used. For objective number three analytic network process systems was used. ANP was selected from MCDM because ANP can model a complex decision problem and also considers horizontal and vertical relations which lead to more precise results.

In this context, data was collected, summarized and, analyzed using statically Package for Social Scientist (SPSS) version 20.

3.6 Reliability

The Reliability of the collected data was assessed using a statistical package for social sciences (SPSS). A reliability test is conducted to check whether each item in the scale is free from error of measurement (Kumar, 2011).If a questionnaire is examined at different times and across different populations, and it produces the same results, the questionnaire is "reliable" (Field, 2009).In this test, Cronbach's alpha values range from 0 (un-reliable) to

(reliable) with 0.7 being considered a relatively strong value of reliability. Widely used methods when using SPSS for assessing reliability are Cohen's Kappa Coefficient for categorical data and Cronbach's alpha for continuous data (Likert-type scales). Since the data collection was based on a Likert-scale, Cronbach's alpha method was used to check reliability.

Table 3.1 Reliability statics Cronbach's alpha result

Variables	Cronbach's Alpha	N of item
Selection Criteria's of PDM	0.719	19
Performance Parameters	0.798	15
Over all reliability	0.813	34

Therefore, the internal consistency of, 19 selection criteria's of project delivery system, 15 performance comparison parameters which constitute a total of 34 variables of Likert Scale questions were verified by calculating "Cronbach's alpha" from the valid responses. The higher the alpha coefficient score, the more reliable the generated scale is a value of 0.7 is an acceptable coefficient. The result showed an alpha coefficient value of .813 is greater than 0.7 that confirmed the questionnaire reliability by all respondents which measure the same construct.

3.7 Validity

The validity, in essence, refers to the appropriateness of the measures used, the accuracy of the analysis of the results and generalizability of the findings (Mark et al., 2009: p.202). In order to provide supporting evidence that the researcher measure what it intends to measure, a test for content validity will be conducted by a pilot study. To check the content validity 15 questionnaires will be distributed to experienced professionals in construction projects. After that, the questionnaires will be modified based on the received comments and distributed to the targeted populations.

3.8 Ethical consideration

Ethical considerations taken into account throughout the process of conducting this study. The researcher informed all prospective participants about nature and the objective of the study and their participation was optional. It is clarified that their response to the offered questions

is only for the purpose of academic research and would never be disclosed to anyone at all times. When reviewing secondary data from journals, articles, proceedings, and related sources, every source is acknowledged both in-text citation and referencing

CHAPTER FOUR

4. DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter discussed the data analysis and findings from 95 questionnaires completed by client (ERA), consulting company and contractors. The purpose of this study was to develop appropriate project delivery method selection model in case of ERA. And also the questionnaire focuses on opinion of professionals on application of different delivery methods and their experience on performance of delivery methods with regard to different performance parameters and finally the questionnaire tries to assess professionals' judgment in using appropriate project delivery method selection model.

4.2 Questionnaire Survey Response Rates

Table 4.1 Respondents response rate

Organization	Sample size	No.of respondent Collected	No.of respondent rejected	No.of respondent used	Percentage of respondents used
Client	42	35	2	33	41.77%
Contractor	36	29	3	26	32.91%
Consultant	23	20	0	20	25.32%
Total	101	84	5	79	100%

Source own survey (2022)

Respondents were divided in to three groups, i.e. client, consultants and contractors. Table 4.1 shows a total of 95 questionnaires were distributed to respondents. Out of which 38 were client, 21 were consultant and 36 were contractor. A valid response of 33, 20, and 26 were returned respectively and used in the analysis which constituted 79 respondents and this represented an 83.15% response rate which is considered as a good response. According to Saunders et.al.,(2016) over 80 percent of all questions answered other than by a refusal or no answer, it is considered as a complete response (Saunders et.al, 2016).

4.3 Demographic Characteristics of Respondents

The purpose of this section was to know the demographic background of respondents. The demographic information used in these researches was educational background, profession, type of organization the respondents represent.

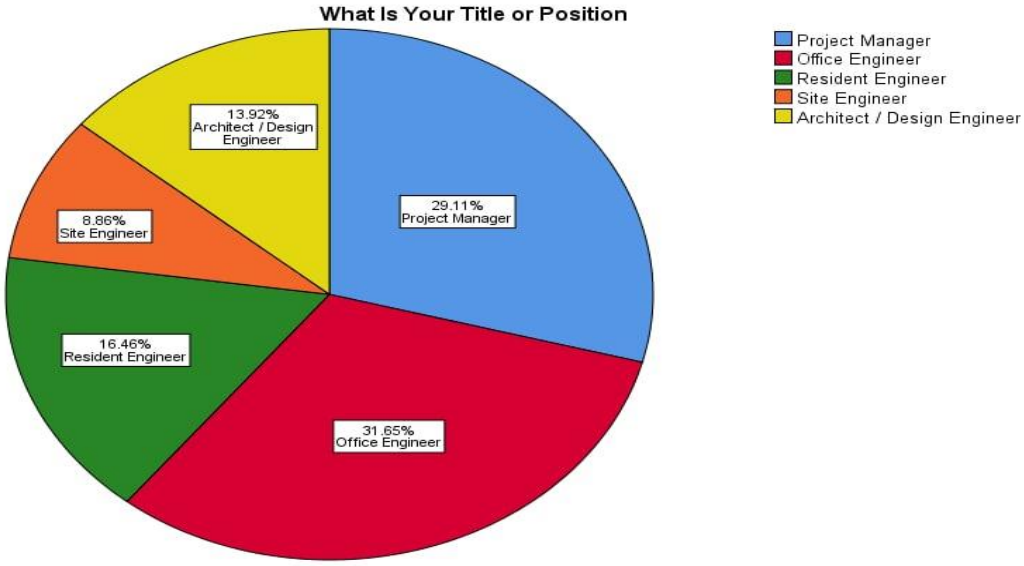

FIGURE 1 RESPONDENT PROFESSIONAL POSITION

Source: Own Survey (2022)

Of all 79 questionnaires collected the professional position of respondents indicates that 31.6% office engineers, 29.11 % of the respondents were project managers, 13.92% Architect, 8.87% site engineers and 16.45% resident engineers . This implies that all the questioners were filled and responded by professionals who are directly related to the thesis topic.

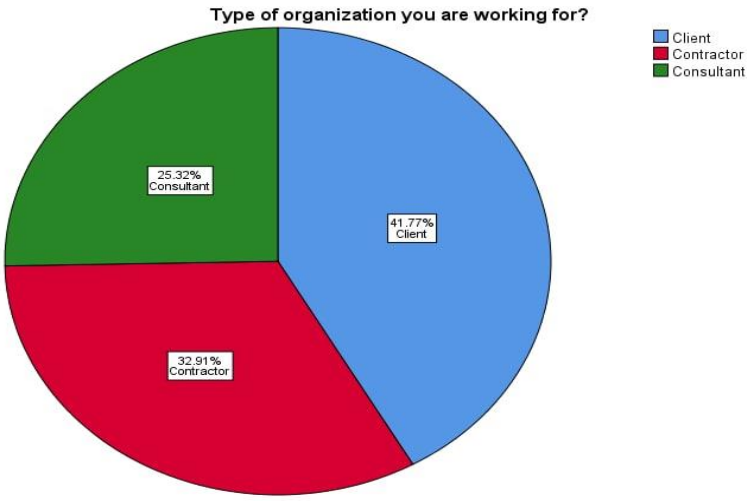

FIGURE 2 RESPONDENTS ORGANIZATION TYPE

Source: Own Survey (2022)

The second question asked in the demographic section was the type of organization the respondents represent. Of all 79 questionnaires collected 33 % were professionals from the client side, 20% from consultant side, and 26% from the contractor side. This implies that all the contracting parties were well represented by the respondents and majority of respondents were clients which the title more depend on clients/ his representative opinion or judgment.

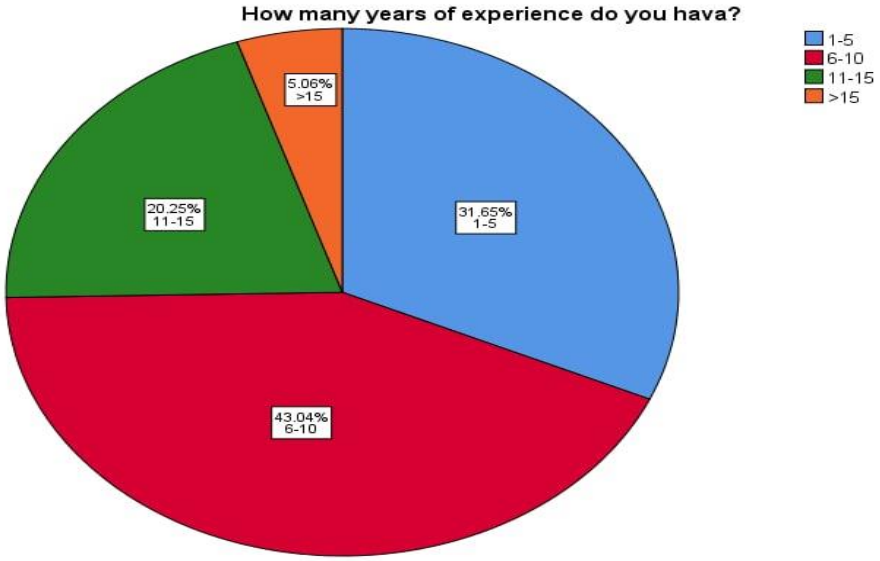

FIGURE 3 RESPONDENT YEAR OF EXPERIENCE

Source: Own Survey (2022)

The above diagram indicates the experience of the respondent, 25 (31.65%) were less than five years, 34 (43.04%) were five up to ten years, 16 (20.25%) of the respondent employees are in the range of eleven up to fifteen years, four (5.06%) of the respondent was above fifteen years' experience in the industry. Overall 54% of respondent's experience was above 10 years which also supports the idea that they were participated in implementing projects both at operational and procurement or at bid levels. Consequently, it was believed that respondents had some knowledge and understanding of the topic related to delivery system in general and awareness of the procedure to select appropriate project delivery system in particular. This makes them dependable and credible sources of information which is vital to realize the research objective.

4.4 Currently practicable PDM and factors affecting adaption of innovative PDM in ERA

Table 4.2 PDM applied in ERA

		Delivery method applied in your project			
		Frequency	Percent	Valid percent	Cumulative percent
Valid	DBB & DB	67	84.8	84.8	84.8
	PPP	5	6.3	6.3	91.1
	Force Accounted DM	7	8.9	8.9	100%
	Total	79	100%	100%	

Source: Own Survey (2022)

Most of respondent 67 out of 79 which results 84.81 %, said that DBB and DB is applicable in ERA and also among other choices some of respondents 5 (6.33%), 7(8.86%) said PPP and Forced Account delivery method respectively are applied. This indicates there is some ambiguity among respondents on the detail understanding of the delivery system applied currently. A different kinds of cross check held by question of respondents and directorate of ERA, Force Accounted PDM are applied on few projects because recently the country faced some peaceful challenges and the work stopped. To overcome this problem, the company constructs few road projects by himself. Additionally PPP is at Feasibility study whether it is suitable or not to apply and almost the analysis show positive results which lead to usage of this delivery system especially on Express way category of Roads.

Table 4.3 PDM selection criteria used in ERA

PDM selection criteria used in ERA ?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Due to legal and regulatory restriction	13	16.5	16.5	16.5
	as a default System	19	24.1	24.1	40.5
	Through different analysis and selection procedure	30	38.0	38.0	78.5
	Due to its advantages	7	8.9	8.9	87.3
	Administrative codes or policy with negativity	10	12.7	12.7	100.0
	Total	79	100.0	100.0	

Source: Own Survey (2022)

Table 4.3 above demonstrates that major reason for the adaption of the PDM was through different analysis and selection procedure as 30 respondents or 38% of the participant agreed. It is adaption as a default system for the public project, the other selection criteria was through legal and regulatory restriction and due to its advantage also pointed as a reasons by participants covering in percentage 24.1%,16,5% and 8.9% respectively.

4.5. Analysis of performance comparison results of DBB and DB project delivery system.

The firs specific objective of the study is to assess the existed performance relationship of DBB and DB project delivery systems. This objective analyzed through case study and questionnaires.

4.5.1 Case study Analysis

Case study on selected six projects was carried out to better examine and compare performance of DBB and DB project delivery system based on performance parameters by using empirical data on six projects.

Six of them was fully documented and recently finished projects. Three of these projects were delivered through Designed Bid Build (DBB) and the left three projects delivered through Design-Build (DBB) so that important issues related to empirical performance comparison of DBB and DB were studied to seek appropriate alternative delivery methods.

For the case study, data such as Actual project schedule, planned /estimated/ project schedule, actual total cost, contract/estimated/ total cost and cost of repairing defects were collected for analysis.

A, Total Schedule Growth

To obtain the total schedule growth of a project, the actual total schedule and planned total Schedule is required (Sanvido et al. (1992); CII (2000); CDT (2002); KPI (2003).

Total Schedule Growth (%)

$$= \frac{\text{Actual Project Schedule } (Days) - \text{Planned Project Schedule } (Days)}{\text{Planned Project Schedule } (Days)} \times 100$$

B, Cost Performance Metrics

To obtain the total cost growth of a project, the actual total cost and the contracted total costs are required (Sanvido et al. (1992); CII (2000); CDT (2002); KPI (2003).

Total Cost Growth (%) =

$$= \frac{\text{Actual total cost (USD)} - \text{contract total cost (USD)}}{\text{Contract total cost (USD)}} \times 100$$

C, Quality (defects). (Sanvido et al. (1992); CII (2000); CDT (2002); KPI (2003).

$$= \frac{\text{cost of repairing defects (USD)}}{\text{Total project cost (USD)}}$$

D, Intensity

Intensity is a hybrid schedule and cost performance metric that is measured by assessing a project's total cost in million USD over its total duration in months. This metric measures how fast construction is put in place and the budget is expended until the project is completed.

It is another way of measuring project speed (Sanvido et al. (1992); CII (2000); CDT (2002); KPI (2003).

$$\text{Intensity (million USD)/months} = \frac{\text{Total project cost (million USD)}}{\textit{Total Project Duration (Months)}} \times 100$$

Table 4.4 Empirical data of performance parameters for DBB and DB projects

	DBB			DB		
Performance Parameters	Completed projects	Actual Project Schedule in calendar days	Planned(Estimated) project schedule in calendar days	Completed projects	Actual Project Schedule in calendar days	Planned(Estimated) project schedule in calendar days
Total schedule growth	Bonga to Felege Selam Road project	697	548	Alem ketema to sekota RP	752	685
	Ameya to Cheda	594	365	Illu to Gobba RP	393	365
	Teeppi to Cheda	2446	1844	Modjo to Batu ERP	1578	1495
Cost performance metric		Actual total cost in million ETB	Contract(Estimated) total cost In million ETB		Actual total cost In million ETB	Contract(Estimated) total cost In million ETB
	Bonga to Felege Selam Road project	347.56M	338.13M	Alem ketema to sekota RP	572.34M	570.98M
	Ameya to Cheda RP	314.789M	294.77M	Illu to Gobba RP	630.65M	630.65M
	Teeppi to Cheda RP	1.123B	912.986M	Modjo to Batu ERP	1.07B	1.002B
Quality (defects)		Cost of repairing defects In million ETB			Cost of repairing defects In million ETB	
	Bonga to Felege Selam Road project	670,000		Alem ketema to sekota RP	297,763.86	
	Ameya to Cheda	312,056		Illu to Gobba RP	314,873.73	
	Teeppi to Cheda RP	498,345		Modjo to Batu ERP	898,985.09	

Intensity		Total project cost (million)/Total project duration in month		Total project cost (million)/Total project duration in month
	Bonga to Felege Selam Road project	12.95	Alem ketema to sekota RP	19.79
	Ameya to Cheda.RP	13.77	Illu to Gobba RP	41.72
	Teeppi to Cheda RP	11.94	Modjo to Batu ERP	19.28

Source: Own Survey (2022)

Table 4.5 Empirical performance comparison analysis of project delivery system

	DBB		DB	
Performance Parameters	schedule growth=Actual project schedule-Planned project schedule/Planned project schedule			schedule growth=Actual project schedule-Planned project schedule/Planned project schedule
Total schedule growth	Bonga to Felege Selam Road project	27.19	Alem ketema to sekota RP	9.78
	Ameya to Cheda	62.74	Illu to Gobba RP	7.67
	Teeppi to Cheda	32.65	Modjo to Batu ERP	5.55
Cost performance metrics	Total Cost growth (100%)=Actual total cost -Contract total cost /Contract total cost *100			Total Cost growth (100%)=Actual total cost -Contract total cost /Contract total cost *100
	Bonga to Felege Selam Road project	2.79	Alem ketema to sekota RP	0.24
	Ameya to Cheda	6.79	Illu to Gobba RP	0
	Teeppi to Cheda	23.00	Modjo to Batu ERP	6.79
Quality (defects)	Cost of repairing defects In ETB			Cost of repairing defects In ETB
	Bonga to Felege Selam Road project	0.67	Alem ketema to sekota RP	0.520
	Ameya to Cheda	0.31	Illu to Gobba RP	0.31
	Teeppi to Cheda	0.498	Modjo to Batu ERP	0.84

Intensity		Total project cost (million)/Total project duration in month		Total project cost (million)/Total project duration in month
	Bonga to Felege Selam Road project	12.95	Alem ketema to sekota RP	19.79
	Ameya to Cheda	13.77	Illu to Gobba RP	41.72
	Teeppi to Cheda	11.94	Modjo to Batu ERP	19.28

Source: Own Survey (2022)

Table 4.5 above demonstrates as a case a study results on six projects, three from DBB and three from DB projects and discussed on four performance parameters which was discussed in below. For this research work, empirical data was taken from ERAs recently finished projects to compare performance of DBB and DB project delivery system and to choose appropriate delivery approach.

Schedule Deviation

As the result on Table 4.5 shows average schedule deviation of three projects of DBB and DB project results 40.86% and 7.67% respectively. Knowing the fact that the delivery method implemented for certain construction project has a direct impact towards the major success factors of project .Time is the critical one among them which is considered while the selection procedure of PDM. From many different previous studies the traditional procurement system has been identified as the slowest project delivery approach and this is due to the fact that pre-contract stage of this system is longer, more time is available for the client and design team to scrutinize and review the design before construction. In addition to this its adversarial nature of contract management process due to communication problems throughout projects life cycle leads to a longer project delivery time. On the other hand DB and other innovative delivery approaches where the design and construction are integrated allowing for earlier construction date. It also allows the process of detail design and construction to run almost in parallel and concurrently to each other, thus reducing the overall project development period considerably. As a single entity responsible for both design and construction the contractor is able to control not only the construction time but also the time reserved for the design the project, thus reducing the overall contract duration. In this type of procurement system the contractor has always been selected based on its past experience, knowledge and competency in construction as such by giving it the design responsibility, the contractor very often able to

reduce construction time. This is done by him rationalizing the design and construction process and site activities (Rosli et al.,2006).

Cost Growth

As the Table 4.5 demonstrates average cost growth of three projects of DBB and DB project results 10.86% and 2.34% respectively. This shows DBB project has high cost growth than DB project throughout project life cycle. This parameter traditionally has been seen as one of the most important success indicators. Completing project within intended budget is the major criteria project success by stakeholders. Overall project cost, i.e. the overall cost that a project incurs from inception to completion, is of major interest as it shows the resource usage in economic terms. Another important aspect regards cost predictability, that is, whether the final overall cost is line with the initial cost estimate (Swan and Khalfan, 2007).project cost related objectives are always at the center of decision making towards the delivery method.to be adapted and many other project constraints. These factors include insuring that the construction project is completed with the lowest possible time within the predefined scope and quality. When we compare those three PDMs (DBB,DB and CMR) towards fulfilling the cost constraints construction management methods is the most effective in ensuring staying within budget even if the question of relatively higher or lower budget allocated there. A design-Bid-Build method provides the greatest flexibility and power to interfere for the owner to incorporate changes during the design and construction of the project. However, this may come at a high cost even though the competitive procurement proven to award the least competitive bidder (Sameh, 2013).

Due to market fluctuations of different resource price managing the two constraints is very crucial task by all parties involved. Due to inflation in the economy time value of many decreased and loss its current power in the long run to accomplish the planned amount of work as budgeted. Due to this interactive effect between the two constraints emphasis must be given to work on delivery of the project as fast as possible throughout the entire project life cycle phase.

The traditional DBB method may not always be able to meet such requirements because it is linear and confronting approach of projects design construction process. Alternative delivery options that permit fast tracking of the design and construction are preferred in economic exposed to a risk of inflation.(Thomas and Philip, 2002) .

Quality/ defect occurrence/

According to Table 4.5 results average quality/defect occurrences/ of three projects of DBB and DB project results 0.49% and 0.56% respectively. Satisfactory time and cost performance is of little value if the project delivers inferior quality. The concept of quality is closely related to customer satisfaction, which has gradually been elevated in importance in the construction industry (Latham, 1994). Quality related factors that measure the project delivery methods ability to attain the highest overall quality. Although a high quality always desired by owners each method achieves this objective in different way other than the project delivery method adapted. The difference, however, is not as significant as that of the time, scope and the cost related factors. Delivery approach that probably form the platform of check and balance between the different participants and specially between the builder and supervisor may lead to best quality (Sameh, 2013).So that it is clear that delivery method that best leads interaction and communications between the different participant is considered the better delivery approach like that of innovative PDMs including integrated PDM (Jha & Iyer ,2006).

Generally DB project delivery systems have good performance on schedule, cost, intensity than DBB project delivery system. This idea was supported by Molenaar et al., (1999) studied single-step, two-step, and qualification based design-build (DB) projects from an owner's perspective. Data from 104 DB projects, mostly U.S. Federal building projects, were collected from a national survey. Cost growth, schedule growth, expectations, administrative burden, and owner satisfaction data were obtained. Results showed that two-step DB outperformed single-step and qualifications based DB by a margin of 2.6% for cost growth and 1.5% for schedule growth. This study focused on the DB method for building projects.

Bingham et al., (2018) performed a quantitative study that measured cost and schedule performance for 40 DBB, 21 DB, and 18 CMAR transportation projects. DB had the least average cost change at negative 5.37%, meaning that the average DB project was completed under the original budgeted cost. While for average schedule change, DBB (4.65%) outperformed both CMAR (13.27%) and DB (20.24%). In this study, DBB was observed to be superior to APDM; however, statistical analysis showed no statistically significant differences between the three delivery methods. This study focused on transportation projects.

4.5.2 Questionnaire result of performance relationship of DBB and DB projects.

This part deal with performance relationship of PDM by result of questionnaires on 15 selected performance parameters.

Based on the Table 2.1 which implies the common used 22 project performance indicators by previous research studies; and also this paper used nineteen/19/ performance parameters. From 22 parameters, three of them have no full empirical data. But the left four parameters analyzed based on case study which used empirical data and the left fifteen/15/ of them analyzed based on questionnaires. Those four of performance parameters were; Schedule, cost, quality and intensity. Therefore 6 recently finished and well documented projects were used for analysis as discussed in above table 4.5.

Table 4.6 Performance comparison analysis of project delivery system

Performance parameters	Different kinds of PDM	Frequency						
		5th(Strongly Agree)	4th(Agree)	3rd(Neutral)	2nd(Disagree)	1st(Strongly Disagree)	Mean Score	RII
Number of contract modification	DBB	0	34	17	19	9	2.96	0.59
	DB	0	13	49	9	8	2.85	0.57
Client satisfaction	DBB	27	25	18	9		3.89	0.78
	DB	41	29	9	0	0	4.41	0.88
Number of claim occurred	DBB	0	27	48	4	0	3.29	0.66
	DB	0	11	52	16	0	2.94	0.59
Administrative Burden(good in minimizing burden)	DBB	20	24	27	8	0	3.71	0.74
	DB	30	29	16	14	0	4.33	0.87
Suitable for Administration and team work	DBB	40	23	11	5	0	4.24	0.85
	DB	21	25	33	0	0	3.85	0.77
Scope change	DBB	38	29	22	0	0	4.71	0.94
	DB	0	21	54	0	4	3.16	0.63
Maintenance Requirements	DBB	26	18	20	15	0	3.7	0.74
	DB	0	20	10	24	3	2.04	0.41
Early	DBB	17	20	12`	24	6	3.23	0.65

Estimating	DB	33	24	22	0	0	4.14	0.83
Suitable for Complex Projects	DBB	19	22	11	24	3	3.38	0.68
	DB	42	21	11	5	0	4.27	0.85
Minimize Adversial relationship	DBB	0	11	52	16	0	2.94	0.59
	DB	50	20	9	0	0	4.52	0.90
Warranty and defect	DBB	18	34	27	0	0	3.89	0.78
	DB	10	22	14	18	15	2.92	0.58
Project meeting specification	DBB	19	22	11	24	3	3.38	0.68
	DB	39	20	11	9	0	4.13	0.83
Unresolved claim	DBB	18	19	37	5	0	3.63	0.73
	DB	16	21	32	10	0	3.54	0.71
Meeting project expectation	DBB	17	20	12`	24	6	3.23	0.65
	DB	38	29	22	0	0	4.71	0.94
Appropriatenes s	DBB	17	20	12`	24	6	3.23	0.65
	DB	38	24	17	0	0	4.27	0.85

Source: Own Survey (2022)

As Table 4.6 demonstrates DB projects are high in scope definition, which means low in scope change, suitable for complex projects, low adversial relationship and also it is good in minimizing administrative burden of contractor. In case of DBB projects it is suitable for team work which results good quality. Among the many other performance parameters scope related factors including the level of scope definition at the time of contract award is crucial to be considered. Each delivery method requires different level of scope definition to achieve the desired result. The level and number of changes and degree of flexibility allotted for the owner mostly make changes towards the predetermined project goal and size also related with the probable PDM.

Many owners desire that the delivery method should be flexible enough to allow them to make changes as needed owners organizational structure related factor on the other hand is among the different factors affected by the project delivery implemented. It deals with the owner organizational structure and the level of professional expert and the level of professional expertise of its staff member throughout the chain of accountability. Owner's desire for single or separate project contracts is also among the different factors that probably affect the project performance. He can prefer arrangements like DB or BOT due to their

nature off fast track delivery and predetermined amount of fixed budget or the possible set of financial support they allot (Sameh, 2013).

The construction industry in different sectors undergo through different technological and administrative changes across the entire spectrum. Perhaps the most notable change is the increased complexity and the cost of building services, particularly the climate control services. The greater complexity of designs requires a highly disciplined approach to managing designs by all parties involved at the different life stages of the project, particularly coordination and integration between the designer and builder and the contract administrator/supervisor incase if its separate service arranged on the contract. This is in order to ensure that the designer come up with constructible and brief design and specification outputs feasible to be accomplish within the rest the estimated amount of money and schedule and without a serious risks of errors, omissions and ambiguities in the documentation. So the organizational arrangement structured through a certain kind of PDM should have to make sure that those problems can be overcome by its adaption (Thomas and Philip, 2002).

4.6 Descriptive Analysis on selection criteria's of PDM Result

After identifying from the literature review the different selection criteria for project delivery system, the questionnaire was prepared, incorporating 19 factors categorized into 3 groups. And the responses were ranked according to their RII scored.

Relative importance index was calculated using the formula (Sambasivan and Soon, 2007).

RII =∑w/A*N

RII=1*n1+2*n2+3*n3+4*n4+5*n5/ 5*N, Where

- w is weighting given to each factor by respondents ranging from 1 to 5.
- (n1 = number of respondents for strongly dis agree,
- n2 = number of respondents for disagree,
- n3 = number of respondents for neutral,
- n4 = number of respondents for agree,
- n5 = number of respondents for strongly agree).
- "A"' is the highest weight (that is 5 in this case), and
- N is the total number of respondents.

The RII value had a range between 0<RII ≤ 1. The highest value of RII, the more important selection criteria.

Table 4.7 Selection criteria of project delivery system result and discussion

Item	Total	Weight	RII	Mean	Rank
Client experience with similar project	79	302	0.765	3.82278	10
Client capability in controlling, organizing and managing project	79	327	0.828	4.13924	5
Client involvement	79	260	0.658	3.29114	16
Risk Distribution:- expectation of owner in number of stakeholder participated	79	303	0.767	3.83544	9
Client requirement for quality	79	345	0.873	4.36709	3
Client requirement for cost	79	346	0.876	4.37975	2
Client requirement for schedule	79	364	0.922	4.60759	1
Intention and degree of clients design control	79	242	0.613	3.06329	19
Responsibility(The expectation of the client in undertaking risk and loss)	79	312	0.79	3.94937	8
Project scale	79	281	0.711	3.55696	14
Project complexity	79	302	0.765	3.82278	10
Project type	79	342	0.866	4.32911	4
Scope clarity(Degree of clarity of project scope defined by client)	79	315	0.797	3.98734	7
Flexibility (Degree of design change during design or construction)	79	283	0.716	3.58228	13
Dispute severity	79	255	0.646	3.22785	17
Competition in market(Degree of competent contractors in market)	78	321	0.823	4.11538	6
Availability of material	79	300	0.759	3.79747	12
Availability of technology	79	243	0.615	3.07595	18
Influence of law and regulation	81	267	0.659	3.2963	15

Source: Own Survey (2022)

Table 4.7, presents descriptive statistics mean and relative importance index for the selection criteria of project delivery method and their respective rank according to their mean and RII value.

The above table illustrates the respondent's insight towards client characteristics and requirement factors take the lion role in selection criteria of project delivery system. Respondents ranked "client requirement for schedule" as the first selection criteria of project delivery method with RII value of 0.921. This client request for schedule selection criteria is further ranked 1st from the total 19 selection criteria's. Time is one of the most important project success criteria for any project. Time has been addressed as one of the main criterion by which to evaluate a project's degree of success. This issue involves two aspects of a project schedule: controlling the schedule (keeping the duration of the project within the expected timeframe) and shortening the schedule. In other words, in this section, each project delivery method is evaluated with regard to schedule control and schedule compression. It has also been mentioned as major factor, which can help the other factors/criteria to be met (Faridi and El-Sayegh, 2006, Swan and Khalfan, 2007).

"Client request for cost" was ranked as the second selection criteria of project delivery method with RII value of 0.876. Completing project within intended budget is also the major criteria of project success by stakeholders. This issue includes several aspects of project cost, such as ability to handle budget restrictions, early and precise cost estimation, and consistent control of project costs. Below, each project delivery method is evaluated with regard to cost control and cost estimation. Overall project cost, that is the overall cost that a project incurs from inception to completion, is of major interest as it shows the resource usage in economic terms (Chan and Chan, 2004).

The 3rd ranked selection criteria According to the responses collected was "Client request for quality". Satisfactory time and cost performance is of little value if the project delivers inferior quality. The concept of quality is closely related to customer satisfaction, which has gradually been elevated in importance in the construction industry (Latham, 1994, Egan, 1998, Forsythe, 2007). Customer satisfaction is commonly described as a comparison between the customer's pre-purchase expectations and their post-purchase perceptions. Hence, it involves the customer's final feelings about whether the outcome provided a satisfying or dissatisfying experience. Since construction industry products are highly customized and co-created during the construction process, the concept of quality regards both the final product and the process

during which is created. Therefore, we see two main aspects of quality. First, quality of end product has to do with the users' satisfaction with the finished construction and it is a critical success factor. It is also related to how the final product and its function meet the specification (Chan and Chan,2004).The second aspect of quality is the service quality during the construction process, which reflects the client's perception of the process during which project participants interact to create the end product (Maloney, 2002).

It was identified as the 4th factor 'project type' which is with a RII value of 0.865 from the total 19 factor. This project types stands to which type the project belongs (e.g., building construction project, infrastructure project, industrial project) and it must get consideration during delivery system selection (Azhar, N; Kang, Y; Ahmad, I,U, 2014).

4.7 Analysis to select appropriate PDM based on ANP result

The Analytic Network Process (ANP) is a multi -criteria decision making tool used to derive relative priority scales of absolute numbers from individual judgments. It is introduced by (Saaty, T.L., 2005).Many real world decision problems cannot be constructed hierarchically because of the interaction and dependence of higher-level elements in a hierarchy on lower-level elements (Saaty, T.L., 2009).

The Analytic Network Process (ANP) is a generalization of the Analytic Hierarchy Process (AHP) by considering the dependence between the elements of the hierarchy (Saaty, T.L., 2009).Feasibility of these methods has been verified through empirical research. To solve the problem of MCDM; this tool has been widely applied to decision-making problems in various fields, particularly in the selection of industrial projects. It has its own steps as,

First, the unstructured problem is deconstructed through qualitative analysis. The problem is then structured in accordance with the relationships between clusters. Lastly, an expert survey is conducted and the results processed using quantitative analysis. The candidate projects are then ordered by priority on which basis a final decision is reached

Step 1: Model construction and problem structuring: The problem should be stated clearly and decomposed into a rational system like a network. The structure can be obtained by the opinion of decision makers through brainstorming or other appropriate methods.

Step 2: Pair-wise comparisons matrices and priority vectors: In ANP, like AHP, decision elements at each component are compared pair-wise with respect to their importance towards their control criterion, and the components themselves are also compared pairwise with respect to their contribution to the goal. Decision makers are asked to respond to a series of pair-wise comparisons where two elements or two components at a time will be compared in terms of how they contribute to their particular upper level criterion (Saaty, T.L., 2009). In addition, if there are interdependencies among elements of a component, pair-wise comparisons also need to be created, and an eigenvector can be obtained for each element to show the influence of other elements on it. The relative importance values are determined with Saaty's 1-9 scale (Table 4.9), where a score of 1 represents equal importance between the two elements and a score of 9 indicates the extreme importance of one element (row component in the matrix) compared to the other one (column component in the matrix) (Saaty, T.L., 2009).

A reciprocal value is assigned to the inverse comparison; that is, aij=1/aji, where aij (aji) denotes the importance of the ith (jth) element. Like AHP, pairwise comparison in ANP is made in the framework of a matrix, and a local priority vector can be derived as an estimate of relative importance associated with the elements (or components) being compared by solving the following equation:

$$A \times w = \lambda max \times w \qquad (1)$$

where A is the matrix of pair-wise comparison, w is the eigenvector, and λmax is the largest eigenvalue of A. Saaty ,(1980) proposes several algorithms for approximating w. In this paper, the following three step procedure is used to synthesize priorities (Saaty, T.L., 2009).

The comparison value was taken from questionnaires result of respondents. From result of respondents average similar comparison result was used for analysis. After determining pair-wise comparisons for one particular criterion, the values are organized in the form of a matrix. The pair-wise comparison matrix for paper presented on Table 4.11 up to 4.35.

- Now that all of the matrices are developed and all the pair-wise comparisons are obtained, Eigen-vectors, i.e. the relative weights of criteria are calculated. This Eigen vector (priority) implies relative judgment of every criterion. There are several ways to find these weights; some of them are summarized as follows (Saaty ,1990):

a) Sum the elements in each row and normalize by dividing each sum by the total of all the sums; the results add up to unity. The first entry of the resulting vector is the priority of the first activity; the second is the priority of the second, and so on. In the example of electronic products mentioned before, the sum of the rows is a column vector;

b) Take the sum of the elements in each column and form the reciprocals of these sums. Then, normalize the reciprocals so that these numbers add to unity.

c) Divide the elements of each column by the sum of that column and then add the elements in each resulting row. Divide this sum by the number of elements in the row. By applying this method to the above example, the following matrix can be obtained

d) Multiply the n elements in each row and then take the nth root. Normalize the resulting numbers

- From those 4 alternatives the paper selects alternative "a" for analysis of weight (priorities). These final numbers provide an estimate of the relative priorities for the elements being compared with respect to its upper level criterion. Priority vectors must be derived for all comparison matrices.

  Example of Table 4.11 the total sum of first row was 9 and the total sum of each row was 15.78. Therefore according to priority analysis of alternative a ,the sum of first row (9) was divided to the sum of total row(15.78). These results 0.57

- To measure the reliability of judgments through the pair-wise comparisons, a consistency index (C .I) should be taken into consideration, as follows (`n' is the size of matrix):

  C.I=λ max-n/(n-1)

- λ max or Eigen value calculated as follows).Sum the column and multiply by priorities(Eigen vector).

- In order to compare the C.I Value of a particular matrix with a similar-sized matrix, a Consistency Ratio must be developed, as follows:

  C.R. = C.L/R.I.

Where R.I. is a known Random Consistency Index obtained from a large number of simulation runs, and is different for different size of matrices. Table 4.8 shows the value of the Random Consistency Index (RI.) for matrices of order 1 to 10 obtained by approximating Random Indices using a sample size of 500 different problems (Saaty, 2001).

Table 4.8 Average random index/ R.I/ based on no. of matrix

Size of matrix	6	7	3	4	5			8	9	10
random consistency index	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49

(Source: Adapted from, Saaty, 2001)

As mentioned, the acceptable C.R. range varies according to the size of matrix; for example, it is 0.05 for a 3 by 3 matrix, 0.08 for a 4 by 4 matrix, and 0.1 for all larger matrices, where n >=5. If the value of C.R. is equal to or less than that value, it indicates a good level of consistency in the comparative judgments represented in that matrix.

Step 3: Super matrix formation: The super matrix concept is similar to the Markov chain process (Saaty,T.L 1996).To obtain global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix. As a result, a super matrix is actually a partitioned matrix, where each matrix segment represents a relationship between two nodes (components or clusters) in a system (Saaty,T.L 1996).The local priority vectors obtained in Step 2 are grouped and located in appropriate positions in a super matrix based on the flow of influence from a component to another component, or from a component to itself as in the loop.

Note that any zero in the super matrix can be replaced by a matrix if there is an interrelationship of the elements in a component or between two components. Since there usually is interdependence among clusters in a network, the columns of a super matrix usually sum to more than one. The super matrix must be transformed first to make it stochastic, that is, each column of the matrix sums to unity. A recommended approach by (Saaty,T.L 1996) is to determine the relative importance of the clusters in the super matrix with the column cluster (block) as the controlling component (Saaty,T.L 1996). That is, the row components with nonzero entries for their blocks in that column block are compared according to their impact on the component of that column block (Saaty,T.L 1996). With pair-wise comparison matrix of the row components with respect to the column component, an eigenvector can be obtained. This process gives rise to an eigenvector for each column block. For each column block, the first entry of the respective eigenvector is multiplied by all the elements in the first block of

that column, the second by all the elements in the second block of that column and so on. In this way, the blocks in each column of the super matrix are weighted, and the result is known as the weighted super matrix, which is stochastic. Raising a matrix to powers gives the long-term relative influences of the elements on each other. To achieve a convergence on the importance weights, the weighted super matrix is raised to the power of 2k+1, where k is an arbitrarily large number, and this new matrix is called the limit super matrix (Saaty,T.L 1996).By normalizing each block of this super matrix, the final priorities of all the elements in the matrix can be obtained.

Step 4: Selection of best alternatives: If the super matrix formed in Step 3 covers the whole network, the priority weights of alternatives can be found in the column of alternatives in the normalized super matrix. The alternative with the largest overall priority should be the one selected.

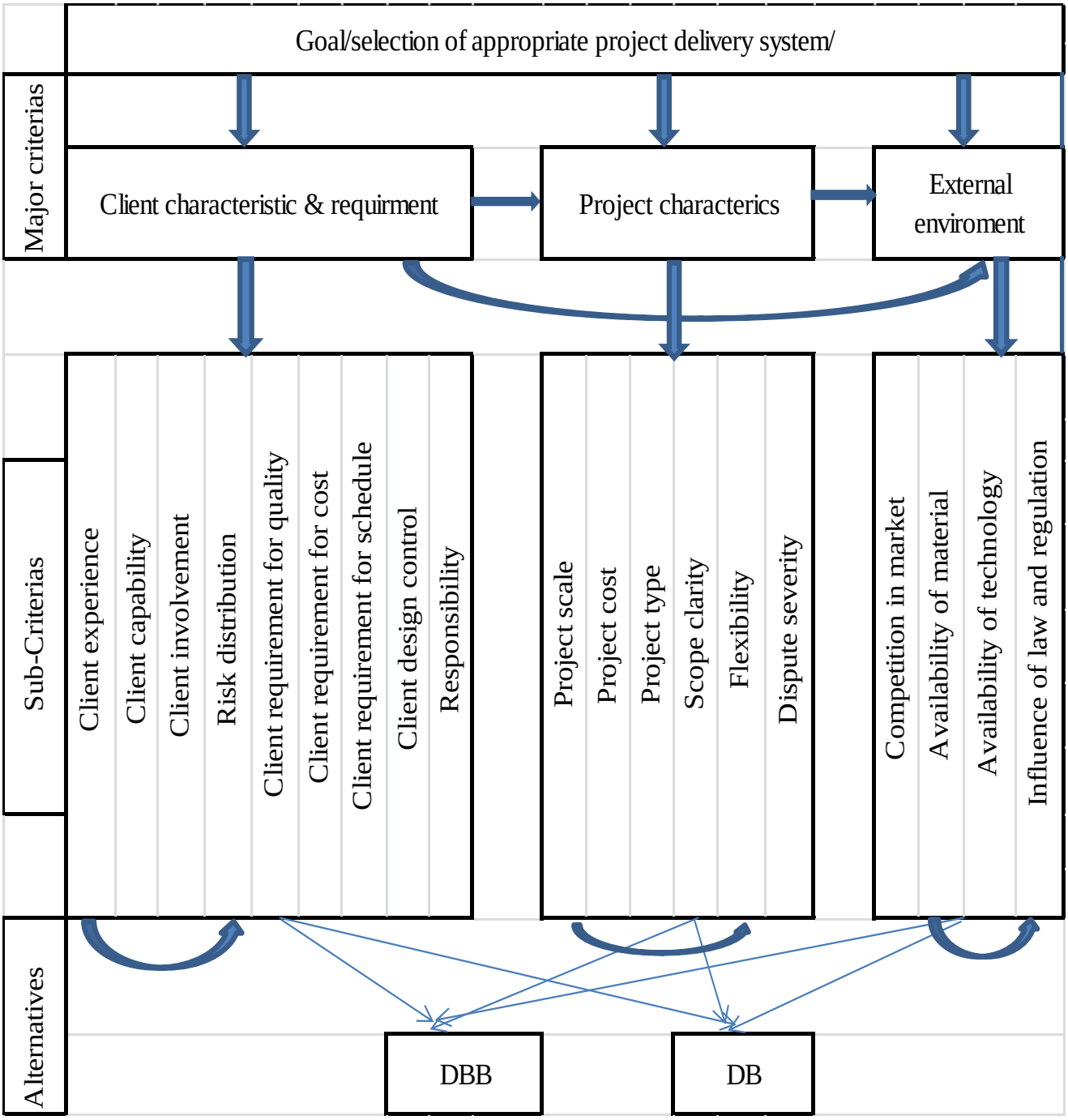

FIGURE 4 NETWORK MODEL TO SELECT PDM

Table 4.9 Rating Scale of pairwise comparisons

Intensity of importance	Definition	Explanation
1	Equal Importance	Two activities contribute to the objective
2	Weak or slight	
3	Moderate importance	Experience & Judgment moderately favor one activity over another
4	Moderate plus	
5	Strongly Importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another its dominance is demonstrated in practice
8	Very, Very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6&8	Intermediate values between adjacent scales values	When compromise is needed
	Reciprocal of previous values	If factor "i" has one of the previous mentioned numbers assigned to it when compared to factors "j" then j has the reciprocal value when compared with i

(Source: Adapted from, Saaty, 2001)

Table 4.11 Pairwise comparison matrix result of the main criteria with respect to the goal

Goal	Client characteristic and requirement	Project characteristic	External environment	Priorities	λ max	C.R
Client characteristic and requirement	1	3	5	0.57	2.14	0.024
Project characteristic	1/3	1	4	0.3379		
External environment	1/5	¼	1	0.0918		

Source: Own Survey (2022)

As the result of judgment on above table 4.11 shows client characteristic and requirement is moderate important than project characteristics in achieving the goal/appropriate project delivery system selection/. As a result of the box on second row and forth column indicates 5 in number which interpreted as client characteristic and requirement is strongly important than project characteristics in selection of appropriate project delivery system.

The value of the C.R. is close to the required value of 0.05, thus we are satisfied with the judgments and there is no need for reassessing them.

Table 4.12 Pairwise comparison matrix for sub criteria with respect to client characteristic and requirement.

Client characteristic and Requirements /160.645/											λ max	C.R
Goal	C.Experiance	C.Capablity	C.Involvement	Risk distribution	C.requirment for quality	C.requirment for cost	C.requirment for schedule	C.Design control	Responsibility	Priorities	1.13	0.09
C.Experiance	1	3	3	1/3	1/3	1/5	1/5	2	1/2	0.0657		
C.Capablity	1/3	1	4	4	1/3	1/3	1/5	4	2	0.1		
C.Involvement	1/3	1/4	1	1/3	1/3	1/5	1/5	2	1/3	0.031		
Risk distribution	3	1/4	3	1	¼	1/3	1/3	3	4	0.0944		

C.requirement for quality	3	3	3	4	1	½	1/3	5	3	0.142		
C.requirement for cost	5	3	5	3	2	1	¼	5	3	0.1696		
C.requirement for schedule	5	5	5	3	3	4	1	5	3	0.212		
C.Design control	½	1/4	½	1/3	1/5	1/5	1/5	1	1/2	0.023		
Responsibility	2	1/2	3	¼	1/3	1/3	1/3	2	1	0.162		

Source: Own Survey (2022)

The value of the C.R. is close to the required value of 0.1, thus we are satisfied with the judgments and there is no need for reassessing them

Table 4.13 Pairwise comparison matrix for sub criteria with respect to project characteristics

Project characteristic /61.4164/								λ max	C.R
	P.Scale	P.Cost	P.Type	Scope clarity	Flexibility	Dispute severity	Priorities		
P.Scale	1	1/3	1/3	¼	¼	2	0.07		
P.Cost	3	1	4	2	4	3	0.28		
P.Type	3	¼	1	3	2	3	0.2	2.07	0.12
Scope clarity	4	½	1/3	1	4	4	0.23		
Flexibility	4	¼	2	¼	1	4	0.19		
Dispute severity	½	1/3	1/3	¼	¼	1	0.04		

Source: Own Survey (2022)

The value of the C.R. is close to the required value of 0.1, thus we are satisfied with the judgments and there is no need for reassessing them

Table 4.14 Pairwise comparison matrix for sub criteria with respect to external environment

External Environment /25.947/						λ max	C.R
	Competion in market	Availability of material	Availability of technology	Influence of law & regulation	Priorities		
Competion in market	1	3	5	3	0.462	3.002	0.07
Availability of material	1/3	1	4	3	0.321		
Availability of technology	1/5	¼	1	2	0.133		
Influence of law & regulation	1/3	1/3	½	1	0.084		

Source: Own Survey (2022)

The value of the C.R. is close to the required value of 0.08, thus we are satisfied with the judgments and there is no need for reassessing them

Table 4. 15 Pairwise comparison matrixes for the alternative with respect to schedule

Schedule	DBB	DB	Priorities
DBB	1	1/7	0.125
DB	7	1	0.875

Source: Own Survey (2022)

The value of the C.R. is equal to the required value of 0.thus we are satisfied with the judgments and there is no need for reassessing them. All C.R values from Table 4.15 to Table 4.34 was the same.

Table 4. 16 Pairwise comparison matrixes for the alternatives with respect to cost

Cost	DBB	DB	Priorities
DBB	1	1/3	0.25
DB	3	1	0.75

Source: Own Survey (2022)

Table 4. 17 Pairwise comparison matrixes for the alternative with respect to quality

Quality	DBB	DB	Priorities
DBB	1	7	0.875
DB	1/7	1	0.125

Source: Own Survey (2022)

As the result of table 4.17 shows projects which delivered by DBB have very strong quality than projects delivered within DB. This means in DBB, design part and construction part done by different parties which lead to check and balance between them. And also the consultant which was client representative supervise every activities whether it was done according to the design and specification. But in DB projects, there is no client representative/consultant/ and also design and construction part done by one entity. This method has no check and balance and results low quality when compared to DBB projects.

Table 4.18 Pairwise comparison matrix for the alternatives with respect to client capability

Client capability	DBB	DB	Priorities
DBB	1	5	0.833
DB	1/5	1	0.167

Source: Own Survey (2022)

Table 4.19 Pairwise comparison matrix for the alternative with respect to project scale

Project scale	DBB	DB	Priorities
DBB	1	¼	0.2
DB	4	1	0.8

Source: Own Survey (2022)

Table 4. 20 Pairwise comparison matrix for the alternative with respect to potential increase in salary

Client experience	DBB	DB	Priorities
DBB	1	3	0.75
DB	1/3	1	0.25

Source: Own Survey (2022)

Table 4.21 Pairwise comparison matrix for the alternative with respect to client experience

Client involvement	DBB	DB	Priorities
DBB	1	5	0.833
DB	1/5	1	0.167

Source: Own Survey (2022)

Table 4.22 Pairwise comparison matrix for the alternatives with respect to risk distribution

Risk distribution	DBB	DB	Priorities
DBB	1	1/5	0.167
DB	5	1	0.833

Source: Own Survey (2022)

Table 4.23Pairwise comparison matrix for the alternatives with respect to client design control

Client design control	DBB	DB	Priorities
DBB	1	3	0.75
DB	1/3	1	0.25

Source: Own Survey (2022)

Table 4.24 Pairwise comparison matrix for the alternatives with respect to responsibility

Responsibility	DBB	DB	Priorities
DBB	1	1/7	0.125
DB	7	1	0.875

Source: Own Survey (2022)

Table 4.25 Pairwise comparison matrix for the alternatives with respect to project scale

Project scale	DBB	DB	Priorities
DBB	1	¼	0.2
DB	4	1	0.8

Source: Own Survey (2022)

Table 4.26 Pairwise comparison matrix for the alternatives with respect to project complexity

Project complexity	DBB	DB	Priorities
DBB	1	1/5	0.167
DB	5	1	0.833

Source: Own Survey (2022)

Table 4.27 Pairwise comparison matrix for the alternatives with respect to project type

Project type	DBB	DB	Priorities
DBB	1	1/6	0.143
DB	6	1	0.857

Source: Own Survey (2022)

Table 4.28 Pairwise comparison matrix for the alternatives with respect to scope clarity

Scope clarity	DBB	DB	Priorities
DBB	1	5	0.833
DB	1/5	1	0.167

Source: Own Survey (2022)

Table 4. 29 Pairwise comparison matrix for the alternatives with respect to flexibility

Flexibility	DBB	DB	Priorities
DBB	1	1/7	0.125
DB	7	1	0.875

Source: Own Survey (2022)

Table 4. 30 Pairwise comparison matrix for the alternatives with respect to dispute severity

Dispute severity	DBB	DB	Priorities
DBB	1	1/3	0.75
DB	3	1	0.25

Source: Own Survey (2022)

Table 4.31 Pairwise comparison matrix for the alternatives with respect to competition in market

Competition in market	DBB	DB	Priorities
DBB	1	7	0.875
DB	1/7	1	0.125

Source: Own Survey (2022)

Table 4.32 Pairwise comparison matrix for the alternatives with respect to Availability of materials

Availability of material	DBB	DB	Priorities
DBB	1	¼	0.2
DB	4	1	0.8

Source: Own Survey (2022)

Table 4.33 Pairwise comparison matrix for the alternatives with respect to availability of technology

Availability of technology	DBB	DB	Priorities
DBB	1	¼	0.2
DB	4	1	0.8

Source: Own Survey (2022)

Table 4.34 Pairwise comparison matrix for the alternatives with respect to Influence of law and regulation

Influence of law & regulation	DBB	DB	Priorities
DBB	1	6	0.857
DB	1/6	1	0.143

Source: Own Survey (2022)

In Table 4.11 the criteria listed on the left are one by one compared with each criterion listed on top as to which one is more important with respect to the goal of selecting a best project delivery system. In Table 4.12, the sub criteria clusters on the left are compared with the sub criteria clusters on top as to their importance with respect to client characteristics & requirement. In Table 4.16, the alternatives on the left are compared with those on top with respect to relative preference for best delivery method which meet schedule the sub criteria priorities in Table 4.11 are weighed by the priority of their parent criterion client characteristic & requirement to obtain their global priority. The priorities for each matrix are obtained as they were from the matrix of comparisons for the delivery system used in ERA. In Table 4.35, the rankings of the alternatives are given against the 19 covering criteria .We need to multiply each ranking by the priority of its criterion or sub criterion and add the resulting weighs for each alternative to get its final priority. We call this part of the process, synthesis.

Table 4.35 Synthesizing to obtain the final result

Criteria	Client characteristic & requirement (0.57)									Project characteristics 0.34						External Environment 0.09				Over all priorities
Subcriterias. Global .W= crite*subcri	C.E	C.C	C.I	RI.D	Qu	Co	Sch	C.D.C	Re	P.S	P.C	P.T	S.C	F	D.S	C.M	A.M	A.T	I.L & R	
	0.07	0.1	0.03	0.1	0.14	0.17	0.212	0.023	0.2	0.07	0.28	0.2	0.225	0.2	0.04	0.5	0.32	0.13	0.084	
DBB	0.75	0.8	0.83	0.2	0.88	0.25	0.125	0.75	0.1	0.2	0.17	0.1	0.833	0.1	0.75	0.9	0.2	0.2	0.857	0.3945
DB	0.25	0.2	0.17	0.8	0.13	0.75	0.875	0.25	0.9	0.8	0.83	0.9	0.167	0.9	0.25	0.1	0.8	0.8	0.143	0.6051

Over all λ max=7.339

C.R-0.107

The value of the C.R. is close to the required value of 0.1, thus we are satisfied with the judgments and there is no need for reassessing them.

According to Ali Touran and others (2009) no single project delivery method is appropriate for every project. Each project must be examined individually to determine how it aligns with the attributes of each available delivery method.

Therefore as a result of Table 4.35 the appropriate delivery system in case of those76 projects from ERA project is design build delivery system, which results over all priorities 0.6051/60.5%/ and the second one is DBB (design bid build) delivery system with over all

priority value of 0.3945/39.5%/.This result was supported by Freshteh .Mafakheri,(2006) who compares DBB, DB and CM@M for selection of Project Delivery System under Multi-Criteria, Multi-Level Decision Aid Model and results CM@M as the first, DB as the next and DBB as the third project delivery system with respect to minimum delay, minimum cost overrun and good quality assurance.

Migliaccio et al. (2010) evaluated 146 DB transportation projects across the United States that have project costs ranging from $150,000 to $1.84 billion. This study evaluated several performance metrics, which included: cost change; schedule change; and procurement duration. Findings in this study revealed that cost growth for DB projects was at 0.4%, while schedule growth was at 13%. This study focused on DB transportation projects.

Shakya (2013) studied the performance of 55 DB and 34 CMAR highway projects .Performance metrics used by the author to conduct this study included cost change, change order, cost-factors, and construction intensity. The results revealed that the average cost change of DB projects was negative 3.65%. Statistical analysis was completed using a one-way analysis of the variance (ANOVA), and the differences in cost change were found to be significant, as contract award cost growth was significantly lower in DB projects than in CMAR projects.

Bingham et al. (2018) performed a quantitative study that measured cost and schedule performance for 40 DBB, 21 DB, and 18 CMAR transportation projects. DB had the least average cost change at negative 5.37%, meaning that the average DB project was completed under the original budgeted cost. While for average schedule change, DB (4.65%) outperformed both CMAR (13.27%) and DBB (20.24%). In this study, DB was observed to be superior to APDM; however, statistical analysis showed no statistically significant differences between the three delivery methods. This study focused on transportation projects.

CHAPTER FIVE

5. CONCLUSION AND RECCOMENDATION

5.1 Introduction

Project delivery method is one of the foundation of Contracting strategy (Keith Molenaar et al, 2014).Therefore, this paper focus on this basic contracting strategy which is project delivery system. And also this chapter has three sub divisions. The first subdivision presents summary of the main findings: the second subdivision presents conclusion of the study resulting from findings. The third subdivision deals with the recommendation that is made on the basis of findings.

This research paper is therefore focused and guided by the following questions

- How performance relationship between DBB and DB is determined?
- How a set of criteria is established to select appropriate project delivery system for contemplated road construction project
- How Analytical Network Process of PDM selection model is developed to select the appropriate project delivery system for the contemplated road construction project?

The main objective of this study was to develop appropriate project delivery system selection model in case of Ethiopian Road Authority (ERA).This study used a quantitative and qualitative research approach for objective number one which was performance comparisons of project delivery system and due to the purpose, an exploratory and descriptive research design was used. The target population for this study is total number of road construction projects commenced by ERA and whose progress is more than 50%.Non-probability, Purposive sampling used to Select samples from the population. Based on the research objective, questionnaires were prepared and distributed to 95 professionals. From this, the researcher collects 79 (83.15%).The collected data were analyzed using a statistical package for social science software (SPSS). With regard to reliability, the results showed that all measures used in this study had an acceptable level of reliability. Descriptive statistics like frequency, percentage, mean were employed to analyze the background information of respondents. A relative importance index was used to rank the top selection criteria of project delivery system.

The result illustrates the respondent's insight towards client characteristics and requirement factors take the lion role in selection criteria of project delivery system. Respondents ranked "client requirement for schedule" as the first selection criteria of project delivery method with RII value of 0.921. This client request for schedule selection criteria is further ranked 1st from the total 19 selection criteria's. It has also been mentioned as major factor, which can help the other factors/criteria to be met (Faridi and El-Sayegh, 2006, Swan and Khalfan, 2007).

"Client request for cost" was ranked as the second selection criteria of project delivery method with RII value of 0.876. Completing project within intended budget is also the major criteria of project success by stakeholders (Chan and Chan, 2004).

The 3rd ranked selection criteria According to the responses collected was "Client request for quality". Satisfactory time and cost performance is of few values if the project delivers inferior quality (Latham, 1994, Egan, 1998, Forsythe, 2007). It was identified as the 4th factor 'project type' which is with a RII value of 0.865 from the total 19 factor. This project types stands to which type the project belongs (e.g., building construction project, infrastructure project, industrial project) and it must get consideration during delivery system selection (Azhar, N; Kang, Y; Ahmad, I,U, 2014)

Next, the result of performance comparisons analysis was made. In this regard Table 4.5 and 4.6 shows that all the quantitative and qualitative performance comparisons of DBB and DB project delivery method .And almost majority of performance parameter analysis shows priorities of DB project delivery method over DBB.

Finally, an Analytical Network process (ANP) was analyzed based on selection criteria to select appropriate project delivery methods and results DB delivery method as suitable project delivery method than DBB in case of those seventy six active projects of ERA .

5.2 Conclusions

The following are key findings of the research.

1. ERA has widely implement projects through DBB and the experience to use alternatives and innovative project delivery methods is low.

2. It is found that schedule is the major criterion that is affected more by delivery method used. Average influence is observed on cost growth for different delivery method. And time overruns in both methods have opportunities to be improved if appropriate PDM is applied. Delays hinder provision of service at right time and also contribute for increase in project cost and incur additional cost for consultancy service for extended time. In addition to its effect on cost growth delays also cause late response of capital invested on construction which is also loss for the owner.

3. There was a greater chance of finishing a project: with budget, improved construction speed and moderate quality if DB is used. It is generally concluded that it would be better to entertain DB for complex, defined budget, defined scope and shorter time projects with a need of minimized risk.

4. The result of the research also shows that innovation project delivery method application in ERA is moderate as compared to other company in the country. Since ERA was at plan to start PPTP and Force Accounted PDM it took one step ahead.

5. The most widely recommended alternative delivery system from the result of analysis was DB. However, there should be practice of other best alternative innovative project delivery.

5.3 Recommendations

The following recommendations were given from this study.

1. ERA has faced problems related to selection of appropriate project delivery system which results cost and schedule overrun and quality issues. Therefore, ERA needs to establish clear guideline for decision matrix to choose appropriate project delivery methods

2. DBB is widely implemented delivery method across the nation and one of the reason is that the existing legal framework; civil code and procurement system favors to use the system,

lack of agents which give the service of innovative project delivery system and hence shall be updated and apply alternative delivery method.

3.And also the paper recommended to adapt the different construction contract clauses and conditions, rules and regulations in a way that allows the use of different kinds of innovative and modern PDMs' other than the traditional DBB approach.

4. For future researches the paper recommends to develop a model to select appropriate project delivery system by using analytical hierarchy process (ANP) by including different kinds of Project delivery system. Since ERA plan to exercise PPP and Force Account project delivery system in future, it was good to include those alternative delivery system in selection process of project delivery systems.

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APPENDISES

QUESTIONNAIRES

Dear Respondent,

I am kindly requesting your willingness to participate in this research "Appropriate project delivery system selection model in case of Ethiopian Road Authority (ERA)". The questionnaires are designed for partial fulfillment of Ms. in Construction Engineering Management. The research result could be used as an input for clients, contractor and consultants, academician or other interested groups.

It is believed that your participation in this research will contribute in achieving objective of the research. Thus the quality of your response towards the question item determines the quality of the research result. Therefore please answer the question as objectively and honestly as possible and according to the instruction contained in body of the questionnaire. Finally, I want to assure you that all information provided in this survey will be treated with strict confidentiality and allowed to serve for the purpose of the research under consideration. If you have any question please feel free to contact me through the provided addresses.

Thank you in advance for your cooperation!!

Contact Address

E-mail: genetfekadu888@gmail.com

Part 1: Demographic profile of respondents

1.Type of organization you are working for?

[1] Client ☐ [2] contractor ☐ [3] consultant ☐

2. What is your title/position?

[1] Project Manager ☐ [2] Office Engineer ☐ [3] Resident Engineer ☐

[4] Site Engineer ☐ [5] Architect /design engineer ☐

3. How many years of experience do you have in construction industry

[1] 1-5 years ☐ [3] 11-15 years ☐

[2] 6-10 years ☐ [4] >15 years ☐

Part 2: General Question about PDM

4. Which delivery method do you apply in your project?

[1] Design -bid-build (DBB) ☐ [2] Design Build(DB) ☐

[3] Construction Management at Risk(CMR) ☐ [4] Construction Management at Fee ☐

[5] Public private partner (BOT) ☐ [6] Integrated Project Delivery

[7] Force Account Delivery Method ☐

5. Is there any selection procedure for delivery system you used in your building project?

[1] Yes ☐ [2] ☐ No [3] ☐ I don't now

6. If your answer is yes what are your selection criteria?

[1]Due to legal and regulatory restriction [2] as a default System

[3] Through different analysis and selection procedure [4] Due to its advantages

[5]Administrative codes or policy with negativity

Part 3. Evaluation of PDM by different kinds of performance parameters

Below are list of delivery system and performance parameters. From your experience, please express your opinion on which delivery system mostly meet every performance parameters ?Please put a tick mark "√"in the appropriate column according to the degree of rank.

Performance parameter	Different kinds of PDM							
		5th(Strongly Agree)	4th(Agree)	3rd(Neutral)	2nd(Disagree)	1st(Strongly Disagree)	Mean Score	RII
Number of contract modification	DBB							
	DB							
Client satisfaction	DBB							
	DB							
Number of claim occurred	DBB							
	DB							
Administrative Burden(good in minimizing burden)	DBB							
	DB							
Suitable for Administration and team work	DBB							
	DB							
Scope change	DBB							
	DB							
Warranty and defect	DBB							
	DB							
Project meeting specification	DBB							
	DB							
Unresolved claim	DBB							
	DB							
Meeting project expectation	DBB							
	DB							

Appropriateness	DBB							
	DB							

Part 4 selection criteria/factors for project delivery system.

Below are list of factors/criteria to selection project delivery system. From your experience, please express your opinion on which criteria used in ERA for project delivery system selection? Please put a tick mark "√"in the appropriate column according to the degree of rank

Major Factors	Sub factors	Rating Scale				
		5th(Strongly Agree)	4th(Agree)	3rd(Neutral)	2nd(Disagree)	1st(Strongly Disagree)
Client Characteristic and requirement	Client experience with similar project					
	Client capability in controlling, organizing and managing project					
	Client involvement					
	Risk Distribution:- expectation of owner in number of stakeholder participated					
	Client requirement for quality					
	Client requirement for cost					
	Client requirement for schedule					
	Intention and degree of clients design control					
	Responsibility(The expectation of the client in undertaking risk and loss)					
Project Characteristic	Project scale					
	Project complexity					
	Project type					
	Scope clarity(Degree of clarity of project scope defined by client)					
	Flexibility (Degree of design change during design or construction)					
	Dispute severity					

External Environment	Competition in market(Degree of competent contractors in market)					
	Availability of material					
	Availability of technology					
	Influence of law and regulation					

Part 5 develop a model to select appropriate project delivery system.

Based on below Table to make comparisons, by scale of numbers that indicates how many times more important or dominant one element is over another element with respect to the criterion or property with respect to which they are compared.

Intensity of importance	Definition	Explanation
1	Equal Importance	Two activities contribute to the objective
2	Weak or slight	
3	Moderate importance	Experience & Judgment moderately favor one activity over another
4	Moderate plus	
5	Strongly Importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another its dominance is demonstrated in practice
8	Very, Very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6&8	Intermediate values between adjacent scales values	When compromise is needed
	Reciprocal of previous values	If factor "i" has one of the previous mentioned numbers assigned to it when compared to factors "j" then j has the reciprocal value when compared with i

Table 4.12 Pairwise comparison matrix of the main criteria with respect to the Goal

Goal	Client characteristic and requirement	Project characteristic	External environment	Priorities
Client characteristic and requirement				
Project characteristic				
External environment				

Table 4.13 Pairwise comparison matrix for the sub criteria with respect to client characteristic & requirement

client characteristic and Requirements									
	C.E	C.C	C.I	RI.D	Qu	Co	Sch	C.D.C	Re
C.E									
C.C									
C.I									
RI.D									
Qu									
Co									
Sch									
C.D.C									
Re									

Table 4.14 Pairwise comparison matrix for the sub criteria with respect to project characteristic

Project characteristic						
	P.S	P.C	P.T	S.C	F	D.S
P.S						
P.C						
P.T						
S.C						
F						
D.S						

Table 4.15 Pairwise comparison matrix for the sub criteria with respect to External Environment

External Environment

	C.M	A.M	A.T	I.L & R
C.M				
A.M				
A.T				
I.L & R				

Table 4.16 Pairwise comparison matrix for the alternatives with respect to schedule

Schedule	DBB	DB
DBB		
DB		

Table 4.17 Pairwise comparison matrix for the alternatives with respect to cost

Cost	DBB	DB
DBB		
DB		

Table 4.18 Pairwise comparison matrix for the alternatives with respect to quality

Quality	DBB	DB
DBB		
DB		

Table 4.19 Pairwise comparison matrix for the alternatives with respect to client capability

Client capability	DBB	DB
DBB		
DB		

Table 4.20 Pairwise comparison matrix for the alternatives with respect to project scale

Project scale	DBB	DB
DBB		
DB		

Table 4.21 Pairwise comparison matrix for the alternatives with respect to potential increase in salary

Client experience	DBB	DB
DBB		
DB		

Table 4.22 Pairwise comparison matrix for the alternatives with respect to client experience

Client involvement	DBB	DB
DBB		
DB		

Table 4.23 Pairwise comparison matrix for the alternatives with respect to risk distribution

Risk distribution	DBB	DB
DBB		
DB		

Table 4.24 Pairwise comparison matrix for the alternatives with respect to client design control

Client design control	DBB	DB
DBB		
DB		

Table 4.25 Pairwise comparison matrix for the alternatives with respect to responsibility

Responsibility	DBB	DB
DBB		
DB		

Table 4.26 Pairwise comparison matrix for the alternatives with respect to project scale

Project scale	DBB	DB
DBB		
DB		

Table 4.27 Pairwise comparison matrix for the alternatives with respect to project complexity

Project complexity	DBB	DB
DBB		
DB		

Table 4.28 Pairwise comparison matrix for the alternatives with respect to project type

Project type	DBB	DB
DBB		
DB		

Table 4.29 Pairwise comparison matrix for the alternatives with respect to scope clarity

Scope clarity	DBB	DB
DBB		
DB		

Table 4.30 Pairwise comparison matrix for the alternatives with respect to flexibility

Flexibility	DBB	DB
DBB		
DB		

Table 4.31 Pairwise comparison matrix for the alternatives with respect to dispute severity

Dispute severity	DBB	DB
DBB		
DB		

Table 4.32 Pairwise comparison matrix for the alternatives with respect to competition in market

Competition in market	DBB	DB
DBB		
DB		

Table 4.33 Pairwise comparison matrix for the alternatives with respect to Availability of materials

Availability of material	DBB	DB
DBB		
DB		

Table 4.34 Pairwise comparison matrix for the alternatives with respect to availability of technology

Availability of technology	DBB	DB

DBB		
DB		

Table 4.35 Pairwise comparison matrix for the alternatives with respect to Influence of law and regulation

Influence of law & regulation	DBB	DB
DBB		
DB		

		N	%
cases	Valid	79	%
	Excluded	0	0
	Total	79	1oo%

Selection criteria of project delivery system

Reliability Statics

Cronbach's Alpha	N of item
0.719	19

Performance Parameters of PDM

Reliability Statics

Cronbach's Alpha	N of item
0.798	15

List of abbreviation used in Table 2.1, Table 4.13-4.15 and Table 4.36

C.E-client experience

C.C-client capability

C.I- client involvement

Ri-risk distribution

Qu- client requirement for quality

Co.- client requirement for cost

Sch- client requirement for schedule

C.D.C-client design control

Re-responsibility

P.S-project scale

P.C-project cost

P.T-project type

S.C—scope clarity

F-flexibility

D.S-dispute severity

C.M-competition in market

A.M-availability of material

A.T-availability of technology

I,L&R-influence of law and regulation