Innovative procurement strategies for the implementation of technology in Ethiopian public client building projects: To enhance project performance.

ACEX30 Master´s Thesis in Architecture and Civil Engineering

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Abstract

Public construction project plays a crucial role in the socio-economic development of Ethiopia, however, the performance of the projects faces significant challenges. Technologies have great potential to enhance the performance of construction projects by addressing the challenges. Public procurnment is a tool for public clients to fulfill their needs, and it plays a crucial role in implementing technologies in public client construction projects. This study aimed to investigate how requirements in public procurement can promote the implementation of technologies in Ethiopian public client projects. Additionally, it sought to identify the main barriers and opportunities to a successful implementation of these technologies by establishing them as requirements in the procurement process. Through a literature study and semi-structured interviews with relevant stakeholders in the construction industry, the knowledge and experience on the subject have been compared and analyzed. The study shows that the existing Ethiopian public procurement directive and other recognized legal documents do not specifically mention the implementation of technologies in public construction projects. Lack of suitable procurnment policy, lack of knowledge and experienced stakeholders with technologies, lack of availability of technologies in the market, and lack of standards, specifications, and guidelines are the major barriers to implementing technologies in public construction projects by establishing them as requirements in the procurement processes. Clearly including technologies or new ideas in the public procurement directives or other legal documents, either as optional or mandatory requirements is the first step to implementing technologies in the public client construction project, and it facilitates their implementation. Furthermore, to address the challenges and successfully implement technologies, the government must Build suitable frameworks to enhance the collaboration among stakeholders and leverage the stakeholders' potential.

Keywords: Requirements, Technology, Public procurement, Construction industry, Public client

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1. Introduction

The preliminary information for this study is provided in this chapter. This covers the background of the Ethiopian public client construction project, the aim, the research questions, and the scope and limitations of the study.

1.1 Background

Public construction project plays a crucial role in the socio-economic development of Ethiopia. These projects have the potential to improve the living standard of the community and the overall growth of the nation. The Ethiopian government has been working on these projects to meet the community's needs and play its part in the country's development. Since 2012, 60 to 65% of the annual capital budget has been allocated to infrastructure developments and the industry contributes between 8 to 10% to the Gross Domestic Product (GDP) of the country (Mengistu et al, 2023). The most typical projects that the public government funds the budget to build new building infrastructure include hospitals, universities, schools, real estate, offices, and industrial parks. However, the success of these building projects on the three main project performance parameters faces significant challenges, time overruns of up to 124%, problems related to quality, and cost overruns of up to 76% (MUDC, 2020).

The first parameter of the project performance is the time of the project, Time overrun in construction project success is the delay in completing and delivering the project based on the contract within the specified time frame (Seman et al., 2023). It occurs when the project requires additional time to complete and deliver the project beyond the initial agreement by the contracting parties and causes delays in the overall project schedule. Time overrun in public construction projects affects different stakeholders in addition to the project, disputes between the parties, cost overrun, poor project quality, and affecting the community benefiting from the project are the main effects. Additional work, inaccurate time estimates, design errors and changes, lack of coherent between drawing and bill of quantity, slow decision-making by the client, and poor planning and scheduling by the contractor are the main causes of time overrun in Ethiopian public construction projects (Gadisa & Zhou, 2020), (Seman et al., 2023), (Demissew & Abiy, 2023), and (Belay et al., 2021).

The second parameter of the project performance is the quality of the project, quality problem in a construction project is defined as a project that doesn't meet one or more of the established standards, specifications, criteria, and requirements during the design and construction phase (Olanrewaju & Lee 2022), and it affects the durability, stability, function, and aesthetic appearance of the built project. The effects of poor quality in public construction projects are increases in the life cycle cost of the project, low productivity, time overrun, client satisfaction, disputes between the contracting parties, and affecting the community benefiting from the project. Poor workmanship, poor quality of materials, low skill and experience of the contractor and consultant staff, poor monitoring, and poor communication and collaboration between the project participants are the main causes of poor-quality Ethiopian public construction projects (Aenet & Maniha, 2023) and (Gadisa & Zhou, 2020).

The third parameter of the project performance is the cost of the project, cost overrun in a construction project is defined as a project where the actual costs of a project exceed the initial

budgeted or estimated cost (Tayyab et al., 2023). It occurs when the project requires additional costs to meet the goal and function of the project beyond the initial agreement by the contracting parties. Cost overrun in construction projects has significant impact on stakeholder satisfaction, project completion, and financial constraints. Lack of knowledge and scope clarity (Sinesilassie et al, 2018), accidents in the construction project, delays in construction, variation Works due to design change or extra work, inaccurate estimation of the cost of the project, and lack of proper documentation are the main causes of poor quality Ethiopian public construction projects (Belay et al., 2021).

To improve the performance of construction projects by overcoming these challenges the Ethiopian government has been doing different activities. Developing and implementing technology in the construction industry is one of the activities that has been done to improve the performance of construction projects. The Ministry of Science and Technology drew up a roadmap to apply technology across several industries, including the construction sector (MOST, 2016). Set goals for the use of technology in the industry as one of the pillars supporting the development of the construction industry over the next ten years (2021-2030) strategic plan, such as focusing more on encouraging bidders to bring technology by including it as a point of evaluation during procurement processes for those who are presented with new and modern technologies (MUDC, 2020). Additionally, The Ethiopian Construction Management Institute was established in 2013 to support and enhance stakeholder capacity by providing training and preparing rules, regulations, standards, and manuals to implement in the construction industry.

Technologies have great potential to improve construction project performance by addressing different challenges. Technology in the context of the construction industry encompasses systems that include different digital technology, devices, products that include manufacturing output, machines, and any combination of resources that are used to accomplish a task, carry out a certain operation, or resolve a problem in the process of construction from feasibility design to demolition (Sepasgozar & Davis, 2018). Currently, different types of technology are being used in the construction industry to improve construction project performance through data collecting, analysis, visualization, communication enhancement, and design and construction automation (Chen et al., 2021). According to the author based on the benefits in the construction project performance, they are classified into five main categories to enhance sustainability, health and safety, work efficiency, productivity, and the overall quality of construction projects. Some of the technologies with benefits are listed below in Table 1.

Table 1.1. Technologies with corresponding benefits in construction project

Types of Technology	Efficiency	Productivity	Quality	Sustainability	Health and Safety	Selected sources
1. 3D Printing	Potential to reduce expenses and labor needs using additive manufacturing.	reduce rework and enable on-site repair in regions with limited human	Manufactured under a controlled environment	Minimize or eliminate waste from production and construction materials.		Li et al., 2022, Chowdhury et al., 2019

		access and resources.				
2. AI	Preparation and management of contract	Provide real-time input and regulation during operation	By providing quality information	Help reduce waste through decision-making on complex issues and energy management.	Monitoring the construction site and safety	Li et al., 2022, European commission, 2021
3. AR and VR	Collaborate the stakeholders, Work inspection, and accurate information collection.	giving a realistic representation of future building and holistic information	detecting and solving defects and errors in the design phase		Improve safety by enabling real-time information	Ahmed et al., 2017, Chowdhury et al 2019., Li et al., 2022
4. Blockchain	Facilitate transparent and confidential information flow	Avoid work delay	Record all essential quality assurance data.			Li et al., 2022,
5. BIM	improves collaboration and communication	Coordination of designs and identification of conflicts, 3-D visualization	By dictating the errors early	Improve design for material savings.	identification, mitigation, and control of hazards in safety.	Li et al., 2022, Chowdhury et al., 2019, McCoy & Yeganeh, 2021
6. Cloud computing	Ensure efficiency and accuracy during design and construction.	Provide virtual, low-cost access to information leveraged by the Internet	Providing accurate 3D data for monitoring the work	Efficient energy consumption throughout operations.		Li et al., 2022, Chowdhury et al., 2019, Mora et al., 2021
7. Digital twins	maximizing equipment usage and site traffic, forecasting inefficiencies and making timely solution suggestions	Track materials, anticipate problems before they happen, and plan for upkeep and repairs.	Early detection and resolving quality concerns	Analysis of energy, moisture, and building performance	recognizing patterns of high risk; forecasting dangers and making remedial recommendations	McCoy & Yeganeh, 2021 Omrany et al., 2023
8. Drone	Accurate data collection and inspections of works that are hard or	Tracking work progress	Detail inspection and generating report	Help reduce carbon emissions with a simple aerial survey.	Monitoring and support for safety	Li et al., 2022, Navigant Construction Forum, 2016, Elizalde, 2022

	impossible to get into					
9. IoT	Construction progress control includes measurement, modelling, and job site monitoring.	Facilitate rapid information flow	Quality assessment and monitoring	allowing for the effective use of energy	Monitor real-time site conditions and worker movements	Li et al., 2022, McCoy & Yeganeh, 2021
10. Modular	Construction efficiency through prefabrication	dividing building operations into smaller tasks and handled by specialist workers.	Manufactured under a controlled environment	Reduced resource waste	increase the quality of construction products by ensuring standards	Li et al., 2022, Akinradewo et al., 2021
11. RFID	Effectively collect and capture information	increased ability to track, trace, and identify materials and equipment	Real-time quality control and improvement of construction operation			Chen et al., 2022, Chowdhury et al., 2019
12. Robotics	Automation improves efficiency across the entire cycle.	Acquiring and validating necessary information	Precise control models and status monitoring	Waste recycling during construction and demolishing		Li et al., 2022, European commission 2021, Shi et al., 2023
13. Unmanned Aerial Vehicles	identification, tracking of progress, and discrepancy identification.	measuring, surveying, and calculating volumes accurately	Visual inspection and damage detection structure of civil work		Manage health and safety	McCoy & Yeganeh, 2021, Arslan et al., 2019
14. Smart helmet	Efficient communication among project participants, location tracking	Enable real-time image data, documentation, and digital information access	Enabling real-time monitoring and improving supervision		Ensuring site worker safety including providing emergency notification	Suresh & Narwade, 2022 and Dolderer, 2023.

Even though technology has a lot of potential to improve construction project performance and the Ethiopian government has been working to overcome industry challenges to apply technology in the industry, the quality of technology implementation in construction projects is still low. Public Procurement is a crucial instrument for public clients to implement governmental policies and strategies effectively. It plays a significant role in implementing technology into public client construction projects by setting requirements in the tendering documents during procurement processes. This is because of the rules and regulations that

govern it, which mandate that the bidder must participate in the procurement and win the bid to fulfill the requested procurement by the client. Tendering requirements and awarding criteria during the procurement processes are critical for the implementation of technology in the industry. However, the current Ethiopian public procurement has gaps regarding requirements and criteria for the implementation of technology in public client projects. Refining the procurement approach is crucial for implementing technology in the projects.

1.2 Aim

General objectives: To investigate and propose suitable procurement requirements for the effective implementation of technology in the Ethiopian public client building project.

Specific objectives: To Identify the gaps in existing procurement, major barriers and challenges, and opportunities to implement technology as a requirement in the tender document during procurement processes. Analyze the existing procurement practice for the implementation of technology and identify the main activities needed to implement technology by setting requirements during procurement processes.

1.3 Research Question

The main research question for this research is:

How can requirements in procurement be suitable to implement technologies in Ethiopian public client building projects, to overcome the current major project performance challenge?

Three sub-questions to answer the main research question:

1. What are the gaps in existing procurement practices for the implementation of technology?
2. What are the opportunities and major challenges to implementing technology in procurement requirements?
3. What activities are needed to implement technology by setting requirements during procurement processes?

1.4 Scope and Limitation

This master's thesis focuses on the construction sector in Ethiopia and how public procurement and requirements of the public client can affect the implementation of technology. Technologies such as tools including equipment and systems and off-site construction products are the focus of the study. The interview respondents were chosen from experience and knowledge regarding public procurement and construction technology and therefore no limitations were done regarding main stakeholders. However, the study that only looked at the experience of BIM technology implementation in various nations was the limitation of it.

1.5 Contribution to Theory and Practice

This study's findings will be useful in optimizing procurement requirements for the implementation of technology in Ethiopian public client construction projects. Through addressing the existing barriers and challenges, the finding seeks to enhance project efficiency, cost-effectiveness, and timely delivery of the project. Furthermore, the result can be used as a basis for, policymakers' recommendations and industry best practices, government bodies, researchers, consultants, and the construction industry in Ethiopia.

2. Theoretical Background

This chapter reviews the literature from a variety of sources and provides a theoretical background on subjects that are relevant to comprehending how requirements and procedures in the public procurement process may impact the adoption of new technologies in public construction projects. Topics like the main stakeholder's role, public procurement, requirements, contract strategies, the current practice of the public procurement processes in Ethiopia's construction industry, technology implementation practice in international experience, and the main challenges of technology implementation are presented to give the reader a broad overview of the subject.

2.1 Construction project stakeholders

Stakeholders are people or groups that have or believe they have, legitimate claims against the substantive aspects of the project. A stakeholder is widely defined as any entity or individual with the capacity to exert influence on or be impacted by the project's objective and success (Heitel et al., 2015). According to Winch et al. (2007), project stakeholders are classified as internal or primary and external or secondary stakeholders based on their level of influence on the project. According to the Author, based on the level and ways of influence some of the stakeholders are listed in Table 2.1.

Table 2.1 Construction project stakeholders

Internal stakeholders		External stakeholders	
Demand side	Supply-side	Private	Public
Client Sponsor Financiers Client’s employees Client’s customers Client’s tenants Client’s suppliers	Consulting engineers Principal contractors Trade contractors Materials suppliers Employees of the above	Local residents Local landowners Environmentalist Conservationists Archaeologist	Regulatory agencies Local government National government

From these clients, design and consultants, and contractors are the main stakeholders who directly impact the day-to-day activity of the construction project.

2.1.1 Client

Client in the construction industry refers to the person or organization responsible for commissioning and funding the design and construction of a facility such as a building, road, or bridge (Challender & Whitaker, 2019). Mostly, the client is the owner of the facility that is being commissioned, although they can also be the intended facility's user. Construction clients play a crucial role in shaping both the construction processes and the final product and they are the drivers of the change and developments of the industry (Lindblad & Gustavsson, 2020), as they are typically initiators and investors of the construction projects (Järvenpää et al., 2022). However, they are not always open to change and develop the industry and can act as barriers to change when a positive and encouraging client is absent, creative solutions are likely to

become less common. Projects should ultimately be designed to meet the needs of the client in terms of their goals, objectives, visions, and aspirations (Challender & Whitaker, 2019). Therefore, clients' requirements must be clearly expressed and understood by themselves and other project participants.

A Public client in the construction industry is a government or public organization on the national, regional, and local level that procures contractors and consultants to provide public goods and services on a non-profit basis (Lindblad & Gustavsson, 2020). Some of these clients are public institutions, municipalities, government agencies, and other organizations that provide public services or infrastructure. Governmental universities, Hospitals, schools, offices, and other related infrastructure are the main building projects of the public client. They are subject to strict regulation on procurement and responsible for the projects being designed and built according to the rules and requirements that the project is to be efficiently performed and used for the intended purpose.

Public clients play a crucial role in implementing government policies, ensuring project sustainability, supporting the change process (Bengtsson & Rosander, 2018), driving innovation, and transforming the construction sector for sustainability, efficiency, and productivity (Lindblad & Gustavsson, 2020). They are immediately impacted by laws and regulations which require them to comply with and public officials implement new regulations to achieve sustainability and increase project performance. To implement government policy, rules, and technology in public projects and ensure project performance public clients adopt suitable requirements and tendering specifications during the procurement process based on the rules, regulations, and standards established by the country (Järvenpää et al., 2022).

2.1.2 Consultant

The responsibility of consultants is crucial in the design and management of the project (Borg & Lind, 2014). Consultants, such as architects and engineering firms, play a significant role in providing expertise and technical knowledge throughout the project lifecycle. In Design-Bid-Build (DBB) contracts, consultants work closely with the client to develop the detailed design of the project. The consultants, particularly architects, are responsible for creating the design documents that will guide the construction phase. They collaborate with the client to ensure that the design meets the project requirements and specifications. However, (Borg & Lind, 2014) in Design-Build (DB) contracts, the role of consultants may vary. If the contractor is responsible for both design and construction, consultants may be hired by the contractor to provide design services. In this scenario, consultants work under the direction of the contractor to develop the design in alignment with the client's needs.

According to Anund Vogel et al. (2019), the responsibility of consultants in the construction sector revolves around proposing and implementing new, sustainable technologies in building projects. Consultants are expected to recommend innovative technologies that contribute to smart and sustainable buildings and cities through climate-neutral construction and operation. They are responsible for translating the developer's ideas into functional building designs that align with long-term sustainability goals.

2.1.3 Contractor

The role and responsibilities of the contractors depend on the types of contract strategy. (Borg & Lind, 2014) explore that in the proposed framework for structuring procurement contracts,

the responsibility for detailed design is a key factor in determining the type of contract. In Design-Bid-Build (DBB) contracts, the client hires a designer (architect) who prepares the design, and the contractor is responsible for constructing and delivering the project. The contractor may have the option to choose subcontractors, but the detailed design responsibility lies with the client. However, according to Borg & Lind (2014), Design-Build (DB) Contracts require the client to hires a contractor who performs both design and construction. The contractor may hire subcontractors and architects for the design, and in this case, the contractor holds the responsibility for the detailed design.

Ragab & Marzouk (2021), provides insights into the evolving role of contractors in the context of Building Information Modeling (BIM) adoption and it also discusses how different standard form contracts, such as NEC4 Engineering and Construction Contract (ECC), address these responsibilities by_contributing skillful and careful contributions to the information model. Under the NEC4 ECC contract, the contractor is required to provide information modeling according to the agreed BIM protocol. The contractor's contribution to the model is expected to be carried out with the skill and care normally used by professionals in similar projects. Furthermore, the contractor is obligated to provide insurance for claims made against any failure to perform their model contribution liabilities using the accepted professional standards. Additionally, Ragab & Marzouk (2021), discusses the contractor providing an irrevocable license for the client to use designs and related documents, granting ownership of the model and information contribution, ensuring data integrity, participating in early warning systems, collaborating with other project parties, and maintaining a standard of care in their contributions.

2.2 Procurement

Procurement is the organized process of obtaining goods, services, and other items from third parties based on predefined criteria, usually involving direct transactions or competitive bidding to fulfill the strategic objectives of the organization. The primary goals of procurement are to ensure a safe, timely, and sufficient supply of suitable quality at the lowest feasible cost, to facilitate innovations from and with suppliers, and to provide a competitive advantage to the firm by ensuring privileged access to supply sources (Zijm et al., 2019). The strategic scope of procurement varies depending on the type of the organization's business activities, but all consider the fundamental principles of strategic scope such as financial, legality, supply chain risk, operational, technology, and managing obstacles to change (Lysons &Farrington, 2020).

In the construction sector, procurement refers to the process that takes a project from its inception to its completion, particularly to the contractual framework that allows a client to work with a variety of parties to have a built facility designed, built, and turned over ready for occupancy (Rowlinson, 2022). It is often utilized to select suitable contractors and consultants and to establish agreements by defining their rights, obligations, and working relationships for the execution of various tasks under contract rules, regulations, standards, and general contract conditions (Windapo et al., 2022). When setting the requirement for procurement it considers different mandatory things such as the characteristics of the work, the rules and regulations, and the availability of bidders. The formulation of procurement requirements is a collaborative process considering all members of the project network; consequently, the effectiveness of client procurement in stimulating innovation and bringing about change depends on how the

requirements are comprehended and used throughout the network of participants, resources, and activities (Havenvid et al., 2016).

2.2.1 Public Procurement

Public procurement is defined as the process of acquiring the suppliers, goods, services, and work required by public sector organizations such as central and local authorities to carry out their operations and fulfill their designated functions (Briediene, 2021). National and local governments must go through several procedures when procuring goods and services, and these procedures vary from nation to nation due to the laws and regulations governing procurement (B et al., 2018). Obtaining the desired goods, work, and services at reasonable prices is the primary goal of public procurement (Obwegeser & Müller, 2018). To further the primary goal of public procurement, a variety of socio-economic goals, such as fostering employment growth, enhancing working conditions, providing opportunities for small businesses in the community, preserving the environment, implementing technology and innovation in the industry, and outlawing discrimination against any group are addressed through the use of public procurement (Mengistu et al, 2023). Additionally, Popov et al. (2021), mention Public procurement promotes the use of BIM, fosters innovation and growth, involves small and medium-sized enterprises (SMEs), and optimizes public spending.

The main principles of public procurement in different nations and international organizations are mostly similar. Value for money, openness, economy, efficiency, integrity, fairness, and fit for purpose are the main principles for World Bank procurement (World Bank, 2017). Similarly, Value for money, no discrimination, economic support for the country's development, transparency, accountability, and encourage local producers, companies, and micro enterprises are the main principles of the Ethiopian public procurement directive (FPPD, 2010). Value of money is one of the crucial principles and it is defining "the optimum combination of whole-life costs and quality or fitness for purpose to meet the user requirement", transparency and fairness are also key during procurement to promote the goals of government as a fundamental governance value, ensures accountability, equal opportunity and treatment for the involved party, reduce corruption, and lends significance to the Organization for Economic Cooperation and Development (B et al., 2018), the economic concept considers elements that support value for money, such as sustainability, quality, and non-price features as well as life cycle cost when applicable, fit for purpose applies both the desired result and the procurement procedure (World Bank, 2017), Accountable places a strong emphasis on the need for an efficient control system in public procurement, together with a well-defined and organized chain of authority at each level of the process and being efficient is a quality that is directly tied to initiatives to maximize resource utilization (Sandi &Rohman, 2022). Proper and consistent implementation of public procurement regulations yields efficiency and effectiveness gains for national and local government agencies, businesses, and civil society at large (Lysons &Farrington, 2020).

Public sector procurement must adhere to several laws and guidelines designed to achieve desired social, financial, and economic outcomes as well as public audit requirements (Vaidya et al., 2006). It has an impact on supply chains, markets, and society overall (Ueharais, 2020), and plays a crucial role in transforming governmental policies and strategies into practices by aligning with achieving important public interests. It is used as a means to achieve sustainable development goals (Manta et al., 2022), implement technology and innovation, and encourage the use of safety and health practices in the construction industry (Mengistu et al, 2023). Public

procurement strategies have an impact on the construction industry's performance due to the public sector's greater dominance in the sector (Lindblad & Gustavsson, 2020). Globally due to the different the external and internal forces, public procurement laws and procedures have undergone continuous improvement to stay abreast with innovation and best practices. This continuous improvement has been implemented in the construction industry by establishing suitable requirements in the procurement for the selection of contractors and consultants. The formulation of requirements specifications, business requirements, selection criteria, the signing of contracts and tenders, and the receiving and inspections of work are all included in public procurement (Moe, 2014).

The public procurement processes that have been used in the public sector around the world at all levels of government are quite similar (European Union, 2020), as shown in the figure below.

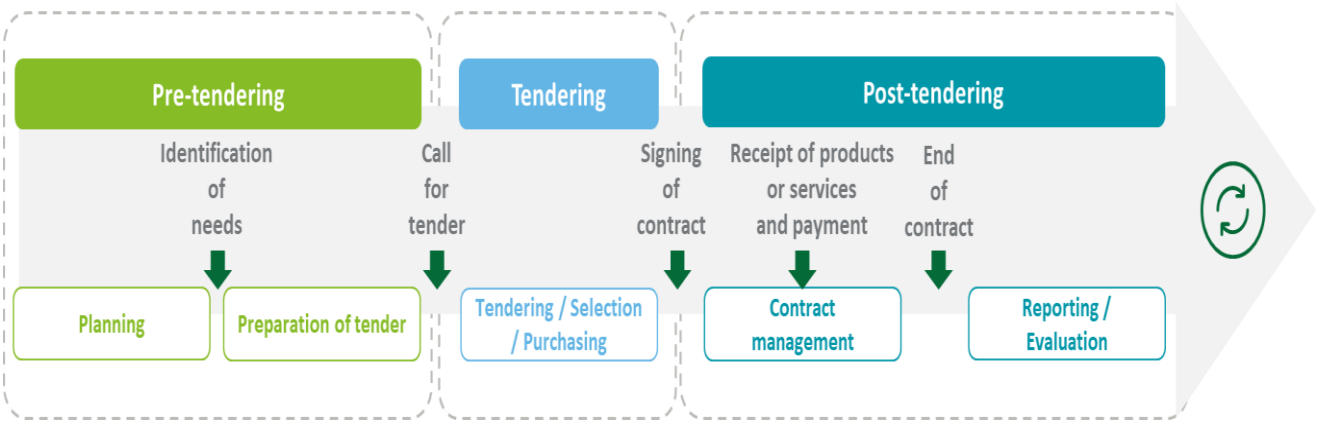

Figure 2.1: the typical public procurement process (European Union, 2020)

Planning is the first step in public procurement processes, it is a baseline to create a comprehensive method for ensuring the effectiveness of product or service delivery and mostly it includes identifying the exact need based on the nature and extent of the product or services that need to be procured (European Union, 2020). The preparation of tender documents is the second step and critical part of the procurement process, and it includes the procurement procedure to follow, the preparation of selection/evaluation, qualification, and award criteria of the bidder, various types of contract specifications, risk/reward mechanisms, and other contractual documents (Kadefors et al., 2020). The tendering process includes collecting and submitting bids by the bidders, closing and opening the bid, evaluating all compliant tenders against the selection and evaluation criteria, and selecting the most suitable bidder. Finally, the contract between the client and the selected bidder is signed by adding the tender document and other required documents as part of the contract document.

2.2. 2 Requirements in Public Procurement

Requirements in procurement are parts of tender documents that are implemented in the entire process, and it is important to ensure the public procurement principle effectively. To procure and fulfill their needs, public clients delegate responsibility to a body that prepares the bid document including different requirements for the construction work procurement, to a department within their own organization, or by hiring a consultant and mentioning the

project's main needs and characteristics. The body is anticipated to have the appropriate expertise in the required fields, as well as sufficient knowledge and experience in the preparation of construction works tender documents, to assist in the proper tender preparation and evaluation based on the rules and regulations.

The delegated body establishes or modifies precise tendering requirements by considering various factors such as compliance with the principle of public procurement, policies, rules, and regulations are the major ones. This is a challenge to the bodies because strict laws prevent the amendment of frequently incomplete criteria, and when the need is complex or unique, or when the public client lacks sufficient knowledge and experience about the new need, it can be challenging to develop appropriate requirements and specifications (Moe et al., 2017). On the other hand, governance, and legal frameworks, need to meet the policies and strategic objectives, and comply with procurement principles in enhancing effective procurement processes are the main challenging factors to establish suitable requirements (Abdullah et al., 2022). In addition to fulfilling the main procurement principles, rules, and law the tender requirements should fulfill different characteristics including requirements be refined iteratively as comprehension of the development content, scope, and goals expands (Hiisilä et al., 2016). When introducing new requirements like technology in the procurement different demand-supply variables should be considered to achieve the desired procurement process. It includes competence and capacity of the client side, the availability of sufficient and competent bidders, and the availability of the desired good or product in the market (Anna et al., 2019).

Technical requirements have major value in evaluating the winner of the tender in addition to financial requirements in the tendering process. Selection and award criteria are the main parameters to select the qualified bidder in the procurement process. Selection criteria, which include the bidder's legal qualification, financial and economic position, and technical and professional ability, are used to establish the minimal conditions for the bidder to participate in the procurement processes. In contrast, award criteria are used to evaluate and select the successful bid among the eligible bidders. The client must specify the relative weighting in the procurement documents that it assigns to each of the criteria chosen to determine the most economically advantageous tender unless this is determined solely by price (European Commission, 2020).

The requirements vary based on the tendering process, in public procurement there are two types of tendering process open and restricted tendering process. According to Moe et al. (2017), open tendering is the most straightforward process, in which all bidders are eligible to participate based on tender notice and established requirements specification without any prior selection processes; bidders are selected and disqualified based on their submitted technical capacity, financial stability, and certification. In contrast, restricted tendering is a two-stage process in which the client selects and invites a limited number of bidders based on some criteria to submit the required documents for the pre-qualification process and evaluate them depending on the documents they have submitted, and the client may develop a required specification concurrently with the bidder prequalification. Restricted tendering is useful when a high level of specialization is needed to perform the work (Lysons &Farrington, 2020). Types of contract strategies are also the main factors in establishing the requirements to select the bidder in the tendering processes.

2.3 Contract strategies

A construction contract is a mutually and legally agreed upon and signed document by contracting parties such as a client with a contractor and or a client with a consultant that plays a significant role in the entire processes and project outcome by managing and minimizing disputes in the project (Celoza et al., 2022). It describes the responsibility, obligation, and rights of each contracting party involved in the project. The contract specifies the scope of work, ways of doing the work, the materials, machinery, and technologies used in the project, payment terms, timeline, and other important details. In the construction industry, different types of contract strategies have been implemented. Design–bid–build (DBB), Design-Build, early contractor involvement (ECI), and public-private partnership (PPP) are commonly used, and the primary differences between them are the delivery method, the reward system, the contractor selection processes, and ways of collaboration (Eriksson et al., 2019). In public procurement, the contract strategies affect the tendering requirement in the procurement process and the implementation of new systems including technology in the construction project.

2.3.1 Design- Bid- Build (DBB)

Design- Bid- Build (DBB) is a construction project delivery system where two parties enter into separate contractual agreements with clients, where clients hire construction and design services independently (Borg & Lind, 2014). Contractors are responsible and take risks only for the construction and delivering a complete project. In contrast, clients take a risk for the design part and hire a designer or architect who prepares a design and completes contract documents based on the client's needs and is responsible for the design part of the project.

In DBB contract strategies the construction documents such as tendering requirements and specifications, equipment, and material usage for the construction of the project are established and specified by the client. The implementation of technology in the construction project through the procurement process is mostly governed by the client. During the feasibility study, planning stage of the project, and preparation of tender documents, clients could analyze the feasibility and decide the types of technology that can be implemented in the construction processes of the project. They are setting as a requirement for the execution of the work and the selection of the contractor in the tendering process.

2.3.2 Design- Build (DB)

Design-Build (DB) is a construction project delivery system where clients hire a contractor that is responsible for both the design and construction of a project under a single Design-Build contract on the standard provided by the clients (Bolpagni, 2013) and the contractor has the power to engage architects and subcontractors for design work (Borg & Lind, 2014). In this delivery system, the client has the option of defining a scope of work and has the opportunity for innovation that is the constructor can offer technical solutions to enhance time and cost efficiency (Eriksson et al., 2019).

In the DB contract strategies, the scope of work and general requirements and documents are set by the client and used as tender documents for the selection of the bidder (Bolpagni, 2013). The bidders establish detailed designs, specifications, working plans, and methods to execute the work including equipment, manpower, and technology usage based on the client's scope of work and tendering requirements. In this contract strategy based on the technology being

implemented the client and contractor each have certain roles to play in the implementation of technology in the construction processes. Clients have a crucial role in implementing technology when the technologies need the client's competence and affect the ways of executing activity, documentation, and communication and collaboration between the client and contractors. They do this by setting it as requirements during the tendering processes and by reaching an agreement with the selected contractor when the contractor brings the technology to use in the construction project. In contrast, Technology like smart hallmates, smart watches, and drones that don't need client competence and affect the activities related to the client is only used by alone the contractor to improve the performance and efficiency of the activities, in this case, the contractor could play a crucial role in implementing technology in the construction project without the request and giving permission by the client.

2.4 Requirement in procurement practice for Ethiopian public client construction project

Ethiopia standard Bid Documents (SBD) for Design-Bid-Build (DBB) contracts and International Federation of Consulting Engineers (FIDIC) Conditions of Contract for EPC/Turnkey or Design-Build (DB) contracts have been utilized for Ethiopia public client's construction project procurement processes. These public procurement processes including establishing requirements in procurement are being prepared by following the Public Procurement Directive, ''This Directive is issued by the Ministry of Finance and Economic Development under Article 78/2 of the Ethiopian Federal Government Procurement and Property Administration Proclamation no 649/2009 and Article 19 of the definition of powers and duties of the Executive Organs of the Federal Government of Ethiopia Proclamation No 471/2005/6 (as amended)''. According to the Federal Government of Ethiopia Proclamation No 471/2005/6 In Ethiopia, The Ministry of Finance and Economics Development is responsible for properly implementing, amending, and controlling the public procurement process.

The Public Procurement Directive of Ethiopia (2010) applies to all public bodies and includes all necessary information related to that the clients follow throughout the procurement process. Clause 16 of the directive is one of the contents that covers the procedure of preparation of competitive bidding that applies to standard bidding documents. When preparing bidding documents, according to Clause 16.3 (2) the public clients could ''reproduce the part of the standard bidding documents dealing with the instruction to bidders and the general conditions of contracts in the bidding documents they prepare without making any change thereto, while making any adjustment to the other parts of the standard bidding documents that they consider appropriate to the type and nature of the procurement''. Related to the preparation of the technical specification according to Clause 16.5, The public clients are required to draw up detailed technical specifications, and the technical specifications must be produced in line with the needs of end users and in such a way that it allows for greater competition based on performance, function, technical, or design qualities, and depending on the type of procurement. Similarly related to the setting of criteria for bid evaluation, The Public Body must clearly state the bid evaluation criteria in the standard bidding document's evaluation and qualification criteria section (Clause 16.8 (1)), and the selection of a successful bidder shall be carried out in any of the following two approaches, even though the bid evaluation criteria vary from one type of procurement to another: Setting the minimum technical requirement and

selecting the bidder with the lowest evaluated bid from among those meeting such minimum technical requirements, or clearly indicating in the bidding document the criteria to be used to determine the functional or economic value of the procurement, as well as the relative weight to be assigned to each criterion and selecting the bidder with the highest cumulative result by conducting evaluation based on these criteria (Clause 16.8 (2)).

Standard Bidding Document (SBD) 2011 has been implemented for procurement processes of DBB contracts for Ethiopian public client construction projects. When conducting competitive bidding, public bodies must utilize the Agency's standard bidding documents and follow the procedures outlined in the Federal public procurement directive (FPPD, 2010). Instruction to bidders, bid data sheet, evaluation methodology and criteria, bidding forms, eligible countries, schedule requirements, and contracts including general and special conditions of contract and contract forms are the main sections of the SBD. The instructions to bidders and the bid data sheet outline the factors, techniques, and criteria used by the public body to evaluate a bid and determine whether it has the required qualifications, and no other factors, methods, or criteria should be used. Evaluation methodology and criteria are the most important parts of the SBD for selecting the relevant bidder. It includes legal, professional, technical, and financial qualification criteria and evaluation of bids including determining the successful bid evaluation of the technical proposal, and evaluation and comparison of bid price. All bidders that meet the expected minimum legal and technical requirements are considered for evaluation and comparison based on the bid price they submitted.

According to section three of the SBD, there are four main required criteria that the bidder expects to meet to participate in the procurement process and to evaluate whether the bidder meets or not the biding processes which are legal, professional, technical, and financial qualification criteria and the client establishes the requirement based on the nature and types of the construction work. The legal qualification of the bidder is the first one and it includes mandatory requirements related to the legal aspect of the bidder must be expected to meet in the procurement processes. The professional qualification and capability of the bidder are the second ones that the bidder expects to meet the minimum requirements related to the personnel for key positions for the proposed procurement. Technical qualifications, competence, and experience of the bidder are the third requirement that the bidder expects to meet the minimum requirements and it includes general and specific requirements and equipment for the implementation of the contract. The Financial Standing of the Bidder is the last requirement that the bidder expects to meet the minimum requirements and it includes the financial performance and annual turnover history.

International Federation of Consulting Engineers (FIDIC) Conditions of Contract for EPC/Turnkey have been implemented for procurement processes of DB contracts in Ethiopian public client construction projects. FIDIC procurement procure guide (2011), along with the Federal Public Procurement directive (FPPD, 2010) has been used to prepare tender documents for DB condition contract, which includes a letter of invitation to tender, the form of a letter of tender, instructions to tenderers, employer’s requirements, schedule for completion by tenderers including pricing, information data, general and specific conditions of the contract, and list of additional documents or information to be submitted by tenderers. According to Chapter 13.1.3, the instructions to tenderers are prepared by or on behalf of the employer to suit the specific requirements of each contract, and it provides important information and instructions that will regulate tender preparation, submission, and evaluation criteria and

method of tenders. Evaluation may be largely focused on the tender price. Still, other factors such as completion time, life cycle costs, work quality and serviceability, suitability of construction method, environmental impact during the lifetime of the project, and technology transfer also be important in achieving the best value for the money. When evaluating the tender document, these criteria ought to be quantified and/or assigned a numerical value. According to Chapter 13.1.5, the client clearly outlines the specific requirements that will apply to the tendering processes including the requirement of bidders to meet the bid and evaluation criteria that the bidder met or not. Some of the main requirements that the bidder is required to submit in the procurement process are scope, design, and other technical criteria, applicable technical standards, codes, and regulations, operation and maintenance manual, quality and performance criteria, proposed time program and work schedule, environmental constraints, as-built drawing and other records of the work, key personnel, equipment, facilities for the employer and his representative, testing during manufacture and/or installation and construction.

2.5 Technology implementation through public procurement in the international practice

Based on the strategy of the government, various country have employed distinct approaches to integrating technology within their public client construction projects via public procurement. One of the methods that the country implements technology in their construction project through public procurement is by modifying the legal aspects of the public procurement processes including the structure and policy of the contract, contractual relationships and obligations, and preparing standard specifications or regulations based on the characteristics of technology and country's context (Pérez-García et al., 2021). The European Parliament is one example that plays a significant contribution in the implementation of technology in the construction industry through public procurement in the member states by modifying the EU directive, that is ‘’For public works contracts and design contests, the Member States may require the use of specific electronic tools, such as of building information electronic modelling tools or similar’’ (The European Parliament and the Council of the European Union, 2014). Based on this directive the member states have been applying different strategies to implement different technologies in their construction projects.

Building Information Modeling (BIM) is one of the examples of technology that the member states and other countries across the world have been applying various strategies, based on the country’s context, to utilize in their public construction projects through public procurement processes. Denmark, Poland, and Spain have incorporated BIM into their public procurement directives, while the United Kingdom, Norway, and Lithuania have developed BIM standard legal documents that have been utilized as part of the procurement methodology document (Popov et al., 2021). Denmark and the United Kingdom (UK) have the highest levels of BIM adaptation among the countries (Jiang et al., 2021) &(Bolpagni, 2013). Each country has been following different procedures and doing different activities to implement BIM effectively in their construction projects.

Denmark is considered one of the pioneers among EU countries in terms of implementing BIM by putting in place BIM requirements into public procurement law since 2007 (European Commission, 2019). The government started by running a digital construction initiative from 2002 to 2007 by the Danish Enterprise and Construction Authority to create uniform principles and standards for digital construction projects (Steffensen, 2012). The government

implemented a regulation (1365), that was amended in 2007 (supplemented by the ICT (Information and Communication Technologies) Regulation 1381 in 2011 and the ICT Regulations 118 and 119 in 2013). Adopting BIM requirements for government projects was decided in 2007 and the main BIM requirements are a project web system for the exchange of digital information on building projects, 3D models (BIM) in competitions, design and construction, digital bidding and tendering (based on 3D models), hand-over of relevant, digital information at the end of the building process, and Industry Foundation Class (IFC)-format for data exchange (Bolpagni, 2013). Using BIM has been mandatory in public sector renovation projects since January 1, 2008, in state-supported social housing projects beginning January 1, 2009, and since 2013 in April in national, regional, and local projects, including projects related to social housing (Popov et al., 2021).

The Danish government has included academia and industry in the design and preparation of rules and regulations through consultations and pilot projects. This helps to ensure that BIM requirements are consistent with and relevant to the industry, which can then play an important role in BIM implementation (European Commission 2019). The government made significant investments in research, training, and development to support the implementation of BIM. To support BIM adoption, non-profit organizations such as Bygger Informationsteknologi Produktivitet Samarbejde (BIPS) published several standards to support the development of digital constructions, which include the Danish Building Classification System, 3D Working Method guidelines, and ICT-specifications guideline that help the definition of agreements between the actors concerning digital deliveries (Bolpagni, 2013). In addition, several universities, such as Aalborg University, Aarhus School of Architecture, and the Technical University of Denmark provide courses in interoperability and 3D modelling (European Commission, 2019).

Similarly to that in Denmark, the BIM journey in the UK is driven by the government. In 2011, as an initiator, the UK government launched the government construction strategy (GCS 2011-2015), which marked the beginning of the adoption of BIM in the UK construction industry. This strategy includes mandating fully collaborative BIM Level 2 (i.e. 3D BIM) (with all project and asset information, documentation, and data being electronic) for all publicly procured projects by 2016 (Cabinet Office, 2011). The goal was to enhance the public sector's BIM implementation capability to achieve at least 3D BIM across central government projects by the same year and develop standards and protocols, and different requirements of the client and designers for collaborative work to overcome compatibility issues and ensure unified data usage among team member (Bolpagni, 2013). To achieve the goals the BIM strategy outlined a clear progressive plan of operations over five years. The plan defined vicious strategic areas of work, such as communications with industry and academia, development of tools and standards, and increasing the capability of public clients and increasing the use of BIM on public projects, also it defined a budget and resources for implementing the strategy.

BIM Task Group (BTG) was founded in 2011 by the Cabinet Office and supported by the Construction Information Council (CIC) to support the work of the government strategies for the adoption of BIM in the industry by regulating and initiating (Cabinet Office, 2011). Mainly this group's role is to collaborate with the industry to establish new ways of working and standards, as well as to assist support government departments in adopting the new ways of working and disseminating knowledge to the industry. The group published various BIM-related standards to guide industry partners on how to create, exchange, and use information in

the BIM. Examples of BIM standards include BS1192:2007 for component naming, BS1192-2:2013 and BS1192-3:2014 for design and construction data requirements, and BS1192-4:2014 for data exchange with Construction Operations Building Information Exchange (COBie) (Jiang et al., 2021). The Group also made the British Standards, Publicly Available Specifications, and legal addendum (known as the "BIM Protocol for Revit and Bentley building software) available for free. To build capacity development in the industry, the UK BIM Programme developed a Learning Outcomes Framework (LOF) for BIM, which provides consistent information on 3D BIM to institutions, academia, training providers, and private educators who develop and deliver training courses to professionals in the sector (EUBIM, 2017).

The UK BIM program acknowledged that adapting project requirements was crucial for a transformation of the industry, emphasizing developing standards frameworks by itself was not enough to drive a whole sector transformation, and highlighting the strategic importance of public procurement while communications initiatives also generated important industry engagement (EUBIM, 2017). Between 2012 and 2015, the pipeline of publicly funded projects that met 3D BIM requirements rose dramatically, from around £100 million to more than £9 billion. This gradual increase in the number of public projects requiring 3D BIM was critical for continuously increasing supply chain capability and benefiting the public client (Popov et al. 2021). This result facilitated skill development and learning among the Task Group, public clients, and industry. Since the government successfully achieved the five-year plan, 3D BIM has been a mandatory requirement for all public procurement for UK public construction projects since 2016. During the procurement processes the public client Employer's Information Requirements (EIR), BIM project execution plan, and BIM protocol (annex to the contract) have been applied as BIM procurement documents.

Additionally, the UK government implemented different systems and or activities to address challenges related to awareness, knowledge and experience, standards, and capacity in the BIM implementation in the industry (Jiang et al., 2022). Based on the challenges, different phases of BIM adoption, and levels of BIM diffusion in the industry established responsible groups for specific roles are one of the mechanisms. One of them the UK government established BTG with a budget of about £5 million to solve issues with standards and the working framework (EU BIM, 2017). This group was tasked with defining suitable BIM standards and working methods while considering industry conditions and obstacles. Additionally, the group was to support government departments in implementing new working methods and sharing knowledge with the industry. The LOF was one of the systems that the task group developed to address challenges related to up-skilling of Tier 2, Tier 3, etc suppliers and other stakeholders. LOF offers regular training and technical advice to industry experts by collaborating with industry and academia, and it encouraged suppliers to develop and deliver training that fulfils the skills required for the UK BIM performance levels. To overcome communication issues between the BTG and local regions, communicate the most recent central government requirements, and collect input from local BIM users, the BTG launched the BIM Regions Framework. Furthermore, they function as local networks, providing prompt technical and managerial support to local BIM users (Anne et al., 2018).

The government established the UK BIM Alliance (UKBIMA), which encourages BIM training, learning, and research in undergraduate and graduate education to increase the supply of BIM professionals, in order to raise awareness and develop capacity related to BIM

implementation in the industry through the BIM Academic Forum (Hooper, 2015). Additionally, the Center for Digital Built Britain (CDBB) was established to serve as a BIM researcher, educator, demonstrator, and regulator (Jiang et al., 2022). According to the author, from the tasks, CDBB launched different programs to fund BIM studies and created e-training programs to help high-level decision-makers, middle-level managers, and operation-level BIM users improve their BIM knowledge and skills.

2.6 Barriers to implementing technology as requirements in procurement.

Different stakeholders are involved in the construction project from the planning to the commencement phase, and the effectiveness of the project also depends on the involved parties' capability and collaboration to fulfill their roles and responsibilities. Similarly, successfully implementing technology in the construction project also mainly depends on the availability of standards, guidelines, specifications, technology in the market, and the competency of the stakeholders. Several barriers have been faced in successfully integrating technology into the construction project using public procurement as a tool, particularly by putting specific technology into the tender document as a prerequisite for the bidder to be able to participate or win the bid. Some of the barriers identified and confirmed by researchers are, Charefa et al. (2019) mention lack of national standards, procedures, and guidelines, resistance to change, and lack of expertise personnel are the main barriers. The IPCC (2022) also, mentions lack of appropriate policy, lack of knowledge, high cost, and diffusion of technology as a barrier. Zhang et al. (2018) and Lin et al. (2022) agree on several of the mentioned hindrances and point out the lack of government incentives and promotion and the lack of experienced suppliers, contractors, and designers in the market as a recurring challenge that needs to be handled for implementing technology in the construction projects to be more successful.

2.6.1 Lack of adequate policies and laws

In a country, creating policies is a complex process involving many actors and institutions. Policy formulation is crucial in addressing societal issues and achieving goals (Howlett & Mukherjee, 2017). The actors include internal government officials and external entities outside the government (Fitria et al., 2023). This process is linked with governance structures and power dynamics (Craft & Howlett, 2012). It involves advice to decision-makers within a "policy advisory system" (Arshed et al., 2014) and is influenced by knowledge, power, and the involvement of private entities and civil society (Howlett & Mukherjee, 2017). The stages of policy formulation include problem identification, setting agendas, making policy choices, decisions, and implementing (Fleischer et al., 2022). Governments set agendas, define goals, make decisions, and oversee implementation (Yu & Bi, 2019). The participation of various stakeholders is key to effective policies (Mwesigwa et al., 2021).

Government policies can have an impact seldom a positive role as a catalyst or a negative role as a retarder on both the development of technology and the systems they support (IPCC, 2022). The policies may lack the flexibility needed to keep pace with rapidly evolving technological landscapes, leading to outdated regulations that hinder the development and implementation of emerging technologies. The government plays a crucial role in promoting the implementation of technology in the construction industry, through implementing suitable policies and instruments that encourage the adoption of technology, practice, and business models (IPCC, 2022). European Commission (2021), also mentions national and regional policies and

institutions are the primary drivers of technology implementation acceleration and redirection including training and research and development (R&D); demand-pull factors include fiscal and economic support as well as regulatory policy tools; instruments supporting knowledge flows, particularly research-firm technology transfer, can be included in the mix.

The Policies can facilitate the implementation of technology in the construction industry by establishing suitable regulations and financial incentives in the form of grants, loans, or equity, but also by technical assistance such as for creating technology development platforms to support the integration of technology and facilitate collaboration and knowledge sharing between the stakeholders (European Commission, 2021). To implement technology in the construction industry different countries, follow different policy approaches based on the country's context, which can be divided into strategies with horizontal and vertical dimensional (Nygaard and Hansen, 2015). Horizontal strategies are national technology policies that encompass a wide range of sectors and areas and in these strategies, the construction sector may or may not explicitly include whereas, vertical strategies specifically encompass how technology is being implemented in the construction industry, either fully or partially along the value chain cover (European Commission, 2021). Policymakers are responsible for establishing various suitable policies and strategies to develop and implement technology in the construction industry by considering different aspects such as ties between various technologies, the national context, and the market condition for the industry (European Commission, 2021).

Public procurement is one of the key policy instruments that governments employ to implement different policies and systems in a variety of industries, including implementing technology in the construction industry (Lember et al., 2013). The primary objective of public procurement policy, which has multiple goals, is to utilize various strategies to ensure the quality of government services and the utilization of goods and services for the public sector to achieve the desired social outcome (Grandia & Meehan, 2017). This is widely viewed as an appealing and realistic tool for implementing technology in the construction industry (Uyarra & Flanagan, 2009). Public procurement policies, with particular emphasis on regulation or requirements, play a crucial role in facilitating the implementation of technology within the construction project (European Commission, 2021). This involves incorporating technology as a selection or award criteria within procurement documents in the tendering processes.

Despite its strategic relevance, there is still a lack of consistency between policy and public procurement practices (Rolfstam, 2015). There are various obstacles to the implementation of technology in public construction projects, including relatively rigid public procurement regulations such as selection and award criteria of the bid to select the winner, the procurement's lack of market engagement, low competence of procurers, and traditional and poor tendering practices (Grandia & Meehan, 2017). In addition, inadequate risk management throughout the process, corrupt practice, irrational bid evaluation criteria, and improper use of the relevant procurement method are among the procurement-related challenges (Mengistu et al., 2023).

Similarly, in Ethiopia, different policies have been established to develop the construction industry including implementation technology. In 2012, new construction policies were established and the efficient implementation of technology in the construction industry is one of the key policies (MUDC, 2012), In 2016, the Ministry of Science and Technology established a road map to implement technology across several industries including the

construction industry (MOST, 2016), and also in 20220, the government established the next ten year (2021-2030) construction strategic plan such as focusing more on encouraging bidders to bring technology by including it as a point of evaluation during the procurement processes for those who are presented with new and modern technologies (MUDC, 2020).

Despite this, there are still no established requirements or regulations for implementing technology in practice. According to Mengistu et al. (2023), the existing public procurement directives practice also does not consider the implementation of technology in the construction industry. Specifically, Mengistu et al. (2023b) mention the lack of establishing effective strategies (work packaging and budget allocation), Lack of distinct evaluation criteria, unclear alternative bid submission process, lack of clear and simple criteria, and absence of minimum weighting provision are the major obstacle to implementation of technology through public procurement. Currently, there is a lack of experience in the implementation of technology in the construction industry, which means that practical procedures for interpreting and applying rules and legal requirements are missing. This generates ambiguity, making it an obstacle to start implementing technology in construction projects through public procurement.

2.6.2 Lack of supportive guidance and standard

The construction industry, like many others, is subject to various standards, guidelines, specifications, and criteria (European Commission, 2021). Guidelines, standards, and specifications are some of the basic documents used as a reference for the preparation of the tender documents including establishing different criteria and use as a part of the contract document between the contracting parties in the public procurement processes. These documents are developed by recognized bodies (WTO, 2011). They facilitate the implementation of technology (Okpala, et al., 2019) and have different functions. Standards are commonly used as a bassline for defining performance criteria for products, ensuring quality, safety, and continuity, and establishing how individual products should interact with one another or with end-users (Okpala, et al., 2019). Specifications are commonly used for providing detailed requirements for materials, products, or processes and benchmarks for ensuring that the products or services meet the desired quality and performance standards (Masum et al., 2013). Guidelines are used as a baseline for procurement preparation, including establishing different criteria to ensure the procurement principle and successful implementation of the project compliance with relevant laws and standards (European Commission, 2021). To implement technology in the construction project by setting it as a requirement in the procurement document, the specific technology's standard and/or specification or guideline are crucially important to effectively achieve the goal of the procurement process. However, recent studies indicate that a lack of these documents is the main obstacle to implementing technology in the construction industry.

Some of these studies, (Okpala et al., 2019) mention the lack of standards for the technologies affects the diffusion of it in the market and hinders the implementation in the construction project. Oke et al. (2023), also highlight that the absence of standards and specifications for digital technology is contributing to preventing the construction industry’s players from implementing them and resistance to implementation by professionals and expertise is one of them. Similarly, the European Commission (2021), argues the lack of standards for product manufacturers and digital technologies is the main barrier to implementing digital technology specifically BIM, Digital Twins, and Sensors in the construction industry. For the

prefabrication technology, the absence of efficient specifications, norms, guidelines, and information for the planning, designing, and regulation is the hindrance impeding its implementation in construction projects (Zhang et al., 2018). European Commission (2021), highlights that to address the challenges and implement technology in the construction project effectively, establishing effective standards for each technology to easily understand by the stakeholders and utilize it effectively. In the same way, the implementation of BIM in Ethiopia's public construction projects lack of BIM guidelines (Alemayehu et al., 2022), lack of a standard form of contract for BIM adaption, and the lack of BIM regulations and standards (Belay et al., 2021) are the major barriers.

2.6.3 Lack of Knowledge, Experience and Capacity of stakeholders

The success of technology implementation in the construction industry heavily relies on the knowledge, skills, and experience of professionals and experts involved in the industry. According to the European Union (2021), new technology and approaches necessitate new knowledge and abilities, especially with the incorporation of new products, materials, and processes. However, various studies have highlighted a lack of experts and professionals equipped with the requisite knowledge, skills, and experience posing significant barriers to effective technology implementation.

Oke et al. (2023) point out that this lack of skilled and experienced professionals causes a series of problems, including reluctance to adopt new technologies in construction projects, and organizational and procedural change due to the new technology. Similarly, Khin and Kee (2022) mention the challenges faced by professionals who lack knowledge and experience in digital technologies, which hinder them from properly integrating with the existing process and product to fully utilize their benefits. Adekunle et al. (2022), elaborate that it hinders the appropriate use and integration with technology, leveraging current technologies to their full potential for project execution, for construction firms to maximize its multiple benefits, and fostering a mentality of digital transformation. Furthermore, the creation of digital construction platforms, as highlighted by the European Union (2021), encounters obstacles due to the lack of knowledgeable, skilled, and experienced professionals.

Similarly, in the realm of modular construction, Zhang et al. (2018), point out the challenges stemming from the lack of professionals and expertise, particularly in effectively integrating modular techniques into existing frameworks. Xu et al. (2020), elaborate on the challenges involved in properly formulating requirements in the procurement for consultant and contractor selection, properly designing, manufacturing, and installing the modular components, following up the performance, and managing risk. without a deep understanding of the different characteristics and market conditions of the technology established as a requirement in the procurement to implement in the construction project, the procurement process may lead to underperformance or failure due to inefficient contract administration, and control can result in conflicts, delays, and cost overruns. Thus, it becomes imperative for the construction industry to prioritize the development and nurturing of skilled professionals capable of navigating the complexities of integrating technology into the construction industry.

The experience and capacity of construction contractors and consultants are crucial factors for the effective implementation of technology in the construction industry. However, the lack of capacity and experience with the technology of the organization are barriers to effectively implementing technology in the construction industry in various ways. The lack of capacity

includes the financial, equipment, manpower, and working capital aspects of the company. The experience of the construction companies also includes the organization experience and professional experience working in the organization including in a project and organizational levels. The professional's experience in terms of technology implementation, have the experience or exposure to the design or implementation, and monitoring of the technology according to its features. According to Oke et al. (2023), construction companies typically depend on thin profit margins in order to win project bids; as a result, their ability to invest in and adopt new technologies is frequently limited. Additionally, the absence of a digital culture within the organization has led to inadequate frameworks for implementing digital technologies and little to no budgeting for technology. Zhang et al. (2018) also noted that the industry's lack of awareness and experienced construction stakeholders involved in the industry may result in the inefficient implementation of technology including the high cost and poor quality of prefabricated buildings.

According to Mengistu and Mahesh (2020), in the Ethiopian construction industry, the capacity and experience of the contractors and consultants such as weak management practices, limited technological knowledge, and limited availability of working capital are the major challenges to the development of the industry. Similarly, lack of technical knowledge of client organization, weak relationships among the stakeholders, and insufficient skilled manpower are also challenges in the industry. These challenges also lead to barriers to implementing technology in the construction industry.

2.6.4 High cost and low market diffusion

The cost and diffusion of technology in the market contribute to the successful implementation of technology in the construction industry. However, different studies show that the higher cost and the insufficient availability of technology in the market create their own barrier to effectively employing technology in the construction industry. According to the European Commission, (2021) and Lu et al. (2018), the cost of technology such as the cost of equipment and software is the barrier to implementing it in the construction project. In addition to these Oke et al (2023), point out that the implementation and maintenance cost of the technology is also the main hindrance to effectively implementing it in the construction project. On the other hand, Ikuabe et al. (2022), mention that initial and maintenance costs are not a barrier for all technology some technologies are not expensive, but the expense of personnel training is an additional barrier to implementing the technology. Yap et al. (2021), also argue that the cost of personal training including how to install, maintain, and effectively work with technology has contributed to hindering the effective implementation of technology in the construction industry.

Similarly, Knobloch and Mercure (2016), point out that the insufficient diffusion of technology in the construction market is one of the barriers to the efficient implementation of technology in the construction industry due to several factors. These include cultural and organizational resistance by society and institutions, low awareness about the benefits of the technology, and the high cost to implement due to no or low competition between bidders. Lee & Borrmann (2020), mention that the implementation rate of technology, especially digital technology in the industry is correlated with the advancement of other technologies. Due to the strict principle of public procurement, insufficient diffusion of technology in the industry led to a barrier to implementing technology in the public construction project by setting the technology

as a requirement in the procurement processes. These barriers mainly have two effects: they raise the project cost or force the procurement process to be canceled due to insufficient bidders participating in it.

Summary

Public clients are the the main drivers of the implementation of technology in their construction projects through the public procurnment process. Even if the client is the driver, the procurnment directive, rules, and regulations they follow are key points to allow or not establishing technology as a requirement in the bid document during the procurnment process. Public procurnment directives, rules, and regulations facilitate or barriers to the implementation of technology in public client construction projects. Although the procurement directive and other legal documents permit the use of technology in public client construction projects, the inclusion of such a requirement in the bid document is contingent upon several factors. These include the availability of the technology or a suitable bidder in the market, the presence of informed and experienced stakeholders, and the availability of standards, specifications, and guidelines surrounding the technology.

Governments have an important role in tackling these problems by developing appropriate laws, rules, and procedures to support the implementation process. Successful technology implementation in the construction industry requires stakeholder participation. The government also plays a key role in enhancing the collaboration among stakeholders and allocating different tasks for valuable stakholders to implement technologies in the construction project by addressing the challenges.

3 Methodology

This chapter explains the methods utilized in this study as well as the efforts made to meet the study's objectives. It discusses why the research strategy and approach were chosen, as well as how the literature review and interviews were conducted, and ethical considerations.

3.1 Research Approach

A qualitative research strategy was employed in this study, it focuses on verbal and visual description rather than focusing on the value of quantities and variables in the collection and analysis of data (Bell et al., 2022). According to the author, this research strategy is more suited for gathering in-depth and detailed information by employing instances from social reality to obtain clear and direct knowledge of a social situation to create a broad perspective. According to Bell et al. (2022), the research questions were developed with varied degrees of precision to adhere to the qualitative approach and seek an understanding of the subject. To develop a comprehensive grasp of the topic, data was also gathered through the review of existing literature and many interviews.

An abductive approach or systematic combination has been employed to achieve the objectives and research questions (Dubois & Gadde, 2002). Theory and empirical evidence are studied in this research process, circling back and forth to effectively understand and cover the study. According to the author, the abductive approach is advantageous since it expands one’s knowledge of the subject and helps reconcile theory and reality by integrating the initial literature study with interviews. Bell et al. (2022), also point out that due to the iterative engagement enabling theoretical development is one of the advantages of this approach.

3.2 Literature Review

In the initial phase of the study, a review of existing literature regarding public procurement and technologies in the construction industry was conducted. The goal was to collect information and understanding about the subject, as well as an overview of prior study results and areas that require additional examination. Before the interviews, a preliminary assessment was conducted to provide a foundation of knowledge on the issue and broaden perspectives on policies and characteristics of public procurement, requirements in the procurement, contract strategies, the current public procurement practice in Ethiopia, the international practice implementing BIM in the construction industry, the challenges organizations face regarding technology implementation.

Nonetheless, due to the study's abductive methodology, an iterative strategy for doing the literature review was employed, as recommended by Dubois & Gadde (2002). This indicates that the literature review was conducted in cycles throughout the investigation and that new methods and perspectives had to be investigated and included in the study when new observations were made. ARCOM, Chalmers database, Google Scholar, and Scopus were used to find the literature research by searching relevant keywords to the subject. These keywords include construction industry, public procurement, construction technology, and requirements. The search was conducted with a critical review of sources, primarily focusing on the quality and time of literature.

3.3 Interview Study

Since qualitative research is the strategy of this study, according to Bell et al. (2022), interviews are commonly employed in the research which can serve as the sources of primary data. For this study, semi-structured interviews were used due to the flexible process. This allows interviewers to go deeper into study-related themes and ask new questions that follow up on interviewees' responses, as well as modify the sequence or wording of questions on subjects that are more interesting and relevant to the study (Bell et al., 2022).

To get relevant and necessary data for this semi-structured interview, the professionals for the interview were chosen from different construction stakeholder organizations such as public clients, consultants, contractors, regulatory bodies, and university experts and based on their work positions and experience related to the subject of the study such as work on related to procurement and technologies. In the following Table 3.1, the names of the interview respondents, their stakeholder, their roles, and their years of experience in the sector are listed in the order that the interviews were conducted. Each interview was conducted based on the same questions with little adjustment based on the organization where the interviewer works. The interview questions are primarily about existing public procurement practices, gaps or challenges in adopting technology in public construction projects through public procurement processes, and technology diffusion in the industry.

Table 3.1 Profile of the interviewees who participated in the interview study

No.	Name	Stakeholder	Role	Years of Experience
1	Arega Bekele	Contractor	Technical Manager	25
2	Asteway Assefa	Regulatory (regional level)	Civil Engineer	14
3	Asegedew Yemane	Public Client	Contract Administrator team leader	32
4	Astedweyne Tilahun	Consultant	Contract Administrator	10
5	Kidasse Kefybelu	Regulatory (Federal level) and Ethiopian BIM society	Structural engineer	11
6	Biniyam Woldeatzke	Private Consultant	Contract Administrator team leader	17
7	Yared Nigusa	Regulatory (Federal level)	Construction technology development	15
8	Yonas Minalu	Addis Ababa University	Technology-Industry linkage Director	15
9	Yossef Zelalem	Public Client	Construction Engineer	17

3.4 Ethical Considerations

This study considers different ethical aspects. Adhere to the four ethical principles in addition to the impact of data protection legislation and copyright and sharing of data proposed by Bell et al. (2022), which mean “avoidance of harm; obtaining informed consent; protection of

privacy through confidentiality; and preventing deception" (p. 111) are some of them. Furthermore, especially in the empirical portion, the research was carried out in complete compliance with the General Data Protection Regulation (GDPR). Every interviewee was briefed on the goal of the investigation and requested permission to share their profiles and roles, along with any information deemed pertinent to the study. Quotations from the interviews are associated with the individual names and profiles of the participants, and permission to publish the final report was requested. Getting permission to record the interviews was another of the top considerations. Finally, the results and proposals made fall under Chalmers University of Technology's ethical viewpoint.

3.5 Analysis of empirical data

Data from the interviews were analyzed using a thematic analysis approach. This approach means that the data acquired from the interviews is analyzed to discover themes (Bell et al., 2022). The interview findings were transcribed to ensure that the interviewees' viewpoints were kept free from the authors. To discover them, I followed the techniques outlined by Bell et al. (2022). Reading the transcriptions for several times to familiarize with data was the first steps. Secondly, different colours were used to assign codes, so those with related information on the topic received the same code. Current procurnment practices in the public client construction project, current activities in the country to implement technology in the industry, challenges, and opportunities are the main themes for the code. In order to identify the themes of the collected data, the third stage is to begin analyzing the codes more broadly and searching for patterns within them. Reviewing the themes and subthemes that were discovered is the fourth phase. This was accomplished by combining themes where it is clear that they overlap and running a comprehensive dataset check to make sure there is sufficient data to support them. The fifth step involved precisely defining the theme by giving it a name and providing definitions. I iterated through the analytical process, repeating some steps as I became more familiar with my themes. The final step listed by Bell et al. (2022), is to write the results of the analysis in the report. This was completed once my topic analysis was satisfactory, and the result was presented in Chapter 4.

The authors believe that it was a strength including interviewees from the main stakeholder's organization and those who have knowledge and experienced in the construction industry. In contrast, finding the necessary respondents was the limitation. To avoid being restricted to the perspectives of experts, conducting additional interviews would have been one way to improve the study. More responses, particularly from senior government officials employed by public clients and regulatory organizations, would have improved the study and provided a more comprehensive understanding of the topic from the construction industry's perspective. It was challenging to find respondents who were interested in taking part and had experience with the top. the constraint was difficulty in locating new responders.

3.6 Overview of Ethiopia's administrative systems

Ethiopia, officially the Federal Democratic Republic of Ethiopia, is a landlocked country located in the Horn of Africa region of East Africa. The population is about 120 million people, urbanization rate is 22.7%. Addis Ababa is the capital city of Ethiopia. The official language is Amharic. The country is classified into eleven regions: Afar, Amhara, Benishangul-Gumuz, Gambela, Harari, Oromia, Tigray, Sidama, Somalia, South-West Ethiopia, and Southern

nations, nationalities, and peoples Region. Addis Abeba and Dire Dawa are two cities with federal significance that are on par with the regional levels. Bahir Dar is the Amhara Region's capital city and the country's second-largest city.

Figure 3.1 Ethiopian Geographical Map

According to the Ethiopian constitution (1987), The administrative framework of the Ethiopian government is structured as a federal parliamentary republic. This system combines elements of federalism and parliamentary democracy, distributing power between the central government and regional states while being governed by elected representatives. The Prime Minister is the head of government, elected by the House of People's Representatives (Hope), and holds executive power. The responsibilities include forming and leading the Council of Ministers, implementing policies, and overseeing the federal government's administration. The council ministers are the federal government's executive branch and comprise ministers who head various government departments and agencies. The Council is responsible for proposing legislation, implementing federal laws, and managing the day-to-day operations of the government. Ministers are responsible for national policymaking and implementation in areas under federal jurisdiction. They ensure compliance with federal laws and regulations and coordinate with regional officials on issues that require a unified national approach. Specific ministries, such as the Ministry of Health, Ministers of Urban and Infrastructural Development, Ministry of Education, Ministry of Finance, etc., have distinct mandates.

Similarly, Regional officials, including regional presidents and regional executive council members, manage the administration of their respective regional states. The regional executive

council is the executive branch of the regional government, and it comprises people who head various government departments and agencies at the regional levels. They function similarly to the federal Council of Ministers but at the regional level. They establish some regulations, procedures, and work plans considering the regional context based on and aligning with the federal government. Specific Bureau, such as the Bureau of Health, Bureau of Urban and Infrastructural Development, Bureau of Education, etc., have distinct mandates.

The Ministry of Urban and Infrastructure Development is one of the federal government departments responsible for urban development and construction works in the country. According to Proclamation No. 1263/2021, some of the major powers and duties.

- Initiate policies, strategies, and laws that ensure sustainable competitiveness of urban and construction and infrastructure sustainable development.
- Formulate and implement regulations, directives, procedures, and programs to ensure sustainable urban and construction.
- Provide capacity-building to the regions and other stakeholders in the sector.
- Prepare the work plan and distribute it to the regions, support, and follow up the works to be done according to the plan and evaluate the performance.
- Follow-up that necessary control is carried out on regulation of construction works and procurement in any sector; follow-up construction work standards are issued and that they are complied with.
- Provide support in the preparation of designs, construction contracts and supervision of construction works involving buildings financed by federal budget; provide support for the development of appropriate organizational set-up, working procedures and human resources required for implementation of building codes and standards in urban centers.

The Bureau of Urban and Infrastructure Development is one of the regional government departments responsible for urban development and construction works in their regions. Some of the major powers and duties.

- Formulate and or amend and implement some regulations and procedures applied in the region by considering the context.
- By adding certain activities to the work plan provided by the Ministry of Urban and Infrastructure Development, they establish a plan for the work that needs to be done in the region and distribute it to its administrative structures.
- Similar to the Ministry of Urban and Infrastructure Development, the Bureau follows up and evaluates the work plan in the region, provides capacity building and that necessary control is carried out on regulation of construction works and procurement in any sector; follow-up construction work standards are issued and that they are complied with.
- Provide support in the preparation of designs, construction contracts and supervision of construction works involving buildings financed by regional budget; provide support for the development of appropriate organizational set-up, working procedures and human resources required for implementation of building codes and standards.

The Ministry of Finance is one of the federal government departments responsible for financial aspects. According to Proclamation No. 1263/2021, ensuring the establishment of

a procurement and property management system of the Federal Government and following up its implementation is one of the major duties.

Government clients include the Ministries of Education, Finance, Health, and Agriculture, the Governmental Housing Corporation, and other governmental agencies, including their branches, that build infrastructure to facilitate their services.

4 Interview Findings

Interviews performed during this master's thesis provided significant insights into current procurement practices, the current state of technology, challenges and opportunities implementation issues, and how to require it in procurement. The respondents have in most cases agreed on the current procurement practice and challenges of technologies. However, the opinions differed to some extent regarding the policies including procurement policies, standards, and directives that could be barriers to the implementation of technologies. The following chapter brings up this and other factors such as types of technology, market diffusion, awareness, and knowledge, and how laws and regulations affect procurement, stakeholder engagement, availability of technology as well as communication and collaboration between the stakeholders.

4.1 Current practice in the public client construction project

According to the respondent, some technologies are currently being implemented in a few public construction projects. However, these technologies have been implemented not by following the public procurement processes, but by a political decision that is the client directly contracts with the contractor who has the technology to build the building project (Assefa and Nigusa), also, few private companies have applied BIM technology in the public construction project in their initiative only in the design phase for clash detection, integration, and coordination (Kefybelu). According to Assefa, Tilahun, Yemane, and Zelalem, no public clients with experience include technology as a requirement in the bidding document in the procurement process. Not many contractors have worked on the construction project where technology was implemented.

4.1.1 Necessary documents to prepare a bid document

''If the client has a qualified expert with experience in the preparation of a bid, they can prepare the bid document themselves, if not, they employ a consultant company to prepare the bid document on their behalf. The regulatory body which is Urban and Infrastructural Development may also prepare it when the client requests due to the shortage of financial or other reasons." Asteway Assefa.

Assefa, Tilahun, Yemane, Zelalem, and Woldeatzke mention that in the body preparing the bid document various guidelines and standards are used as a reference or input to establish and prepare appropriate requirements and assessment methodology in the bidding document. Standard Bidding Document (SBD) For Procurement of Works (2011), Federal Public Procurement Directive (2010), Directives for the Registration of Construction Professionals and Contractors (2013), Standards, specifications, and additional directives or amendments prepared by the finance or other regulatory bodies are used as a reference or guideline.

Standard Bidding Document (SBD) For Procurement of Works (2011) is a document that explains in detail the overall procurement process from the invitation to bid to the end of the contract and it is to be sold to the bidder who is eligible and wants to participate in the procurement (Assefa, Yemane, and Zelalem). According to the respondents, various requirements such as selection and awarding criteria, evaluation methodologies, special conditions of contracts for each project, general conditions of contracts, instruction to bidders, and working methodologies are specified in this document. They state that the body preparing

the tender document may make modifications depending on the project's specifics, except the bidder instructions and general contract conditions.

The Federal Public Procurement Directive (2010) has been used as a reference to prepare the bidding document. Assefa, Yemane, and Zelalem mention that when preparing a bidding document, the requirements in the bidding document must consider the principle of public procurement. They mention that achieving maximum value for money, ensuring accountability and transparency, supporting the country's economy, non-discrimination, and encouraging local producers, companies, and micro enterprises are the principles of public procurement. Yemane and Zelalem mention that we use this document to determine whether to use open or restricted bidding when planning procurement and producing the bid document. On the other hand, Assefa and Woldeatzke mention that the body that prepares the bid only prepares the bid document and does not determine open or restricted bidding, but the client determines this. Assefa, Yemane, and Woldeatzke mention we use this directive to prepare the bid document including the extent to set different requirements, to amend parts in the standard bidding document including in the national and international bidding. Assefa, Yemane, and Zelalem also mention that by using this directive as a reference we determine the duties and responsibilities of the contract parties. This directive is used as a guide during the preparation of the bidding documents such as the invitation to bid, bidding document, instruction to bidders, technical specification, bid form and price schedule, general and special conditions of contract, setting of criteria for bid evaluation, modification of bidding documents, and evaluating bids and selecting the successful bidder (Assefa, Tilahun, Yemane, and Zelalem). The respondent notes that the directive states that all bidders who satisfy at least 70% of the technical requirements are deemed to be qualified for the requirements and will move forward to the next stage of tendering; all other bidders are eliminated from consideration during the bid processes.

Directives for the Registration of Construction Professionals and Contractors (2013) is another standard used as a guideline to determine the eligible bidders who participate in the bid based on their level (Assefa, Yemane, and Zelalem). The minimum manpower and equipment requirements in the bid document are also set based on this standard (Assefa, Yemane, Tialhun, and Zelalem)

Amended and/or new directions prepared by the public procurement authority and Urban and Infrastructure development, standards, and specifications are also considered when developing the bid document, which includes establishing bidder requirements (Assefa, Tilhun, Yemane, and Zelalem).

4.1.2 Selection criteria

Before setting different criteria in the bid document the design, list of work, and detailed work requirements such as the quality, how the work should be done, and other various needs that need to execute the project are determined (Tilahun and Yemane). Zelalem also agrees and points out that for a non-governmental financed project, a Term Of Reference (TOR) is prepared first based on the project's nature, purpose, scope, and characteristics, followed by the requirements. After determining the engineering cost estimation of the work, the technical requirements are set by considering the estimated cost, scope, and characteristics of the project. However, if the project could be executed by contractors licensed grade six (general contractor grade 6, licenses are issued to contractors involved in the Ethiopian construction industry from

grade one to grade ten, with grade one being the biggest grade and grade ten being the smallest grade contractor) and less than no need to prepare technical criteria only financial criteria be used for selection and awarding criteria (Assefa, Tilahun, Yemane, and Zelalem)

The respondent mentions that all the technical requirements are set in section 3 evaluation methodology and criteria of the standard bid documents. Additionally, Yemane mentions that '*'we have included some criteria in working methodology based on the characteristics of the work which is how the specific parts of the works should be executed and also improve the methods of communication''.* They mention that five requirements such as legal qualification, professional qualification, equipment qualification, general and specific work experience, and financial standing of the bidder are commonly used to evaluate the technical selection criteria of the bidder. According to Assefa, Bekele, Tilahun, Yemane, and Zelalem these criteria especially manpower, equipment, and financial standing requirements are determined based on the qualification of the minimum eligible bidder participating in the procurement processes. They mention that the minimum eligible bidder is also determined based on the engineering cost estimation of the project and matching the contractor's grade that the bidder allowed to participate in what amount of project cost listed in the Directives for the Registration of Construction Professionals and Contractors (2013). However, considering the scope and complexity of the project may set additional manpower and equipment in addition to the minimum requirements that the contractor is not expected to fulfill when issuing the work license and mention in the bid that the bidder can be fulfilled by rent and required to attach the agreement (Assefa, Yemane, and Zelalem).

Only the legal requirement is the mandatory requirement which is the bidder should fulfill all requirements listed in this section if not the bidder is considered as rejected from the tendering process, but all other requirements are evaluated based on weightage rate (Assefa, Bekele, Yemane, and Zelalem). The body that prepares the bid sets the weight of each requirement listed in the bid including the necessary document that must be fulfilled to get full scores by considering the characteristics of the requirements and the procurement directive. Therefore, the evaluation of the requirements is based on the pre-established weight of the requirement. Even if the bidder incorporates additional items from the stated bid criteria that benefit the project, it will not be given a different result or advantage (Assefa, Tilahun, Yemane, and Zelalem).

Sometimes some mandatory requirements or criteria are included in the bid documents as bidder requirements that are not mentioned in the standard bidding document or procurement directives, this is done by political decisions (Bekele). Assefa and Zelalem, also point out that at the level of the Amhara region, there was a directive on 27/2009 that was implemented in the construction tendering process, and this was determined by a political decision to involve small and micro-organized associations in the construction work that is the contractor should be given 10% of the work as a sub-contractor for these associations. The purpose is for these associations to be able to work, gain experience, adapt to the industry, and upgrade their level. These guidelines should be included as a part of a mandatory requirement in the bidding document when the client prepares the bid. The bidder must submit their willingness and which part of the work they will provide in writing along with the tender documents. If the bidder does not include this information the bidder considers it a rejection in the bidding process. Yemane also agrees with the above respondents, and he mentions that government projects are

done with the money founded by the government, so the government issues different policies, guidelines, and directives at different times so that the money is used for the intended purpose.

4.1.3 Awarding criteria

Assefa, Bekele, Tilahun, Woldeatzke, Yemane, and Zelalem mention after evaluating the technical criteria, according to the procurement directive at least three bidders should meet technically to proceed to the next process which is to open the financial proposal of the bidder, if not the bid must be canceled. All the financial proposals that are submitted by the bidder who meets the technical requirements are open, and the committee that assesses the bid selects the winner after necessary verification and reviewing the proposal. For the government-funded project, the bidder with the lowest price is chosen as the winner. However according to Zelalem for a non-governmental funded project, the bid winner is picked based on the highest value of 70% technical requirements and 30% financial proposals.

4.1.4 Practice of including technologies in the bid document as a requirement

''Even if the public procurement directive is open to additional requirements or criteria, based on my experience so far, I have not seen additional criteria or requirements established by the client or consultant in the bid document. Only use as usual way and just use based on the five key requirements.'' *Assefa.*

''*If the technology is available fully in the market and has the necessary standard or information about the technology. In that case, the procurement directive and other laws are not an obstacle there is no rule that these should be the only tender requirements, as long as it is believed that it will improve the project's performance with time, cost, and quality because the client is the owner of the project.'' Zelalem.* Because the public procurement directive is open to establishing new requirements in the bid documents, there is no restricted list of requirements mentioned in the directive.

Assefa, Yemane, and Zelalem point out that the public procurement directive, as well as other directives and legislation that has been used to prepare the bidding documents as a guide, doesn't mention the implementation of technologies in the construction project as a bidder requirement and other methods. But also the law of procurement directive does not allow to mention of specific technology, tool, or product specifications in the bidding documents for public procurement when the technology or tools are not fully accessible in the market (Assefa). Additionally, Yemane says *''Right now, our main focus as the client is on how quickly the projects can be completed and start servicing the community as soon as possible using the usual ways rather than searching and implementing technologies in the construction projects setting in the bid document as a bidder requirements''*.
In the open competitive tendering processes technology has never been included as a requirement in the bidding document. But they are including various modern machines as required criteria (Bekele). Technologies like tools such as smart helmets and drones can be included as requirements in the equipment part of the bid document if the tool's specification is accessible (Zelalem). On the other hand, Assefa and Bekele, state that technology like prefabricated is not specified as a condition in the standard bid document to determine and evaluate whether or not a bidder can participate and meet the requirements. Because of the design, specifications, and work techniques included in the bid document, whether prefabricated or not, all bidders are already known prior to the establishment of participation, selection, and award criteria.

The Ethiopian Construction Management Institute was issued a tender to build a new building for the Center of Excellence project, in the bid document implementation of BIM is one of the requirements to participate the bidder in the bid as a mandatory requirement (Kefybelu). However, the tender was canceled due to the bidders complained to the body authorized to manage the public procurement by informing them that the criteria requested by the client were outside the public procurement guidelines. Then the public procurement agency ordered the client to cancel the bid.

Additionally, Assefa and Nigussa mention that in competitive bidding, there has not been experience with set technologies as a requirement in the bidding document to implement the technology in the public construction project. However, there is an experience of direct contracting with contractors who have the technology by political decisions. Due to the necessity of the project to be completed within a short pared of time by understanding the benefits of the technology that improves the performance of the construction project (Assefa and Niguas). The respondent mentions that OVID Group has built two governmental apartment building projects in different locations by implementing Kumkang Aluminum framework technology through direct contracting by political decisions and the method of the contract was DBB. OVID built the first 5 G+12 (five buildings with Ground plus 12 floors) apartment project in Addis Ababa city by direct contracting with the Federal Housing Corporation. Due to the good performance result of the Addis Ababa Project, The Amhara Regional Housing Corporation made a political decision for direct contracting with the contractor to build a total of 2 G+12 (two buildings with Ground plus 12 floors) and 2 G+13 (two buildings with Ground plus 13 floors) apartments at Bahir Dar city (Assefa and Nigusa). The main purpose of the implementation of this technology was to build the apartments in a shorter period. ‘’*For the Bahir Dar project, the initial contracting agreement was to be completed within six months but due to the current situation and shortage of cement in the market it took eight months and the cost was less than around 3% compared with the actual market.” Assefa.* The contractor's capacity and good project management systems in the project were the main reasons for the project's success (Assefa). In addition to *that, the client* paid attention to the project, and due to this the material or other things that the contractor needed, and the client supported as soon as possible and also there was no budget problem (Assefa).

Similarly, the Amhara building works construction enterprise has tried implementing Schnell home technology in some public client construction projects, such as G+1 (Ground plus one floor) office buildings, directly contracting with Amhara Regional Bureau of Urban and Infrastructural Development (Assefa). Amhara Building Works Construction Enterprise is a governmental enterprise of the Amhara regional state and is a grade-one licensed contractor. Assefa Mentions the main purpose of constricting by implementing this technology was to build the office building to reduce construction time by 30% compared to the normal work methods and reduce cost by 20%. However, the contractor could not complete the work according to the contract due to the lack of production of the technology coming from the company's financial problem.

4.2 Current Activities to develop and implement technology in the construction industry

The implementation of different technologies in the construction industry is mostly influenced by the country's technological development, especially the implementation of digital technologies are depends on the the level of digitalization in the country.

4. 2.1 Technologies development at a Country Level

Ethio Telecom doing different activities to realize digitalization in Ethiopia or achieve ‘’Digital Ethiopia 2025’’ in the Ethiopian calendar or 2032 Grigorian calendar (Assefa and Nigusa). The respondent mentions the organization currently doing different activities such as building different infrastructures including digital infrastructures, implementing emerging technologies, implementing cloud and data solutions, and implementing online systems including e-procurement.

Similarly, the Ethiopian artificial intelligence institution was established in 2020 to promote data-driven AI systems at the national level to enhance efficiency and productivity data management in all sectors (Minalu and Nigusa). The respondent mentions that they are implementing by connecting different systems and technologies through doing different research and identifying the problems related to data management in the different sectors.

4.2.2 Technologies Development in the Construction Industry

At present, various technologies are created in our country and imported from abroad. Nigussa

4.2.2.1 Government Activities

‘’Due to the problem of construction project performance and the lack of construction technologies in the industry, there are different activities that have been done to adopt and implement technologies in the industry.” Nigusa.

The government has established policies, strategies, roadmap, manuals, and standards to develop and implement technologies in the construction industry (Assefa, Nigusa). Establishing the Construction Industry policy in 2012, establishing the construction road map (2021-2030), and establishing the Directives for the Registration of Construction Professionals and Contractors (2013), and are some of them. According to the respondent, empowering professionals working in the construction industry, building systems for facilitating to development of the industry, supporting the technologies development and implementation in the industry, and facilitating collaboration among stakeholders in the industry are some of the construction policies established by the government. Building a modern construction industry by implementing modern technologies and establishing suitable systems in the industry is one of the current road maps of the construction industry.

According to (Assefa and Nigussa) to facilitate the development of the construction industry including the implementation of technologies in the industry the government established the Ethiopian Construction Management Institute (EPMI). The institute has delegates to prepare necessary standards, guidelines, and manuals that are implemented in the industry. In addition to these building capacity includes giving different trainings for the professionals working in the industry. The Ministry of Urban Development and Infrastructural (MUI) also established a

department at the federal and regional levels that is responsible for technology development in the industry. The department has 29 positions at the federal level and an average of 14 positions at the regional level based on the size of the region's.

According to Minalu, courses related to technologies are being added to the curriculum for university students majoring in civil engineering at the degree and master's levels in order to educate them about the technologies. Most of the time they learn about construction machinery or equipment, and common software like Autocad Etaps, Rivate, and SAP, but there is a gap in terms of teaching new emerging technologies it depends on the lecturer's competence and the availability of the technology in the country (Minalu). The respondent mentions most large universities have a department called research, technology transfer, and university-industry linkage (RTTUIL), the main objective is to do research and transfer to the industry related to technology that solves the problems in the construction industry. Therefore various research and new discoveries are made in the field of technology that could improve the construction industry. There is a procedure that universities should provide community service to the community including government institutions around them and thus, they provide necessary training and support. ''*Mostly when construction stakeholders, especially government institutions, request us to provide capacity-building training for their professionals, including technology, we provide it based on what they want."Minalu.*

The implementation of BIM in the construction industry is one of the pillars included in the construction roadmap (2020-2030), and last year the BIM standard was prepared by the Construction Management Institute, and it was approved by the concerned body based on ISO 19650 (Kefybelu). According to the respondent, the standard includes 18 different necessary templates, guidelines, documents, and checklists. The guidelines and the templates are adopted from Hong Kong. This is because Hong Kong's guidelines and templates are suitable to use in comparison to other nations, as per the ISO 19650 standard.

Some public organizations in Addis Ababa are trying to follow digitalized systems for the procurement processes from the invitation to bid to the awarding contract (Assefa and Zelalem). Zelalem specifically states that the majority of international non-governmental organizations employ digitalized platforms for procurement operations such as payment and reporting. The client notify this procedure for the bidder in the invitation to bid document and the bidder follows based on it. On the other hand, Minalue and Woldeatzke mention that in the Addis Ababa municipal the check and approval processes of the design of buildings are taking place through the online system. it is done by online platform, that is the soft copies are sent instead of hard copies, after the directive that enforces this system established by the municipality.

Nigusa mentions that other activities done by the government are; The companies or individuals are allowed to import the raw materials used to make the technology or technologies duty-free. Additionally, sometimes the government provides incentives for the technology owners. For example, Addis Abeba municipality gives land to OVID Group to use for the manufacture of technologies. MUI especially organizes various events, meetings, and workshops to create awareness for stakeholders about the benefits of technology for the industry, and by inviting technology owners and suppliers to share and introduce their technology to the stakeholders including the benefits and the ways of implementing it in the industry (Assefa and Nigusa). For some technologies that develop in the country the Ethiopian standards and quality of agency give them quality assurance for the new technology (Nigusa).

Even if the procurement directives do not allowed using direct contract but some governmental organization have built their building project by implementing modern technology through directly negotiating with contractors who have well-developed technology (Assefa and Nigusa).
Additionally, the MUI and EPMI prepare and give different types of training to the professionals who work in the construction industry, mostly working in the regulatory body to enhance their capacity (Assefa, Kefybelu, and Nigusa). The respondents mentioned that EPMI has been giving training to the different professionals who work in the regulatory body as well as university lecturers about BIM technology for the last 7 years.

4.2.2.2 Activities of private companies for the implementation of technologies

Different companies or organizations have been trying to develop and implement technology in their organization and construction projects by understanding the benefits of the technology. Most of them have learned from the experience they have seen when they go abroad (Minalue).

OVID Group is among the companies that have embraced and integrated technology into their construction projects. The technologies that the company has been utilizing in its building projects are Kumkang Aluminum framework technologies and BIM (Kefybelu, Minalue, and Nigusa). The company has implemented BIM in the Federal Housing Corporation project in Gerji project Addis Ababa for the design phase, particularly for coordination, clash detection, and integration purposes (Kefybelu). Kumkang Aluminum framework technology is another technology that the company has been utilizing in different construction projects, including government projects (Assrfa and Nigusa). According to the respondents for the first time, the company took the experience of the technology from South Korea and brought it to the country. This is because the technology supplier company which is Kumkang company has introduced the technology to various African countries and has started providing it to the countries by holding a contract and OVID group is one of them that has been made a contract. After developing it properly they implement it in their own real estate development project. The company is currently building all of its own real estate developments using this technology. Additionally, the company has implemented this technology to build two public organization projects (Assefa and Nigusa). The two organizations were directly contracted with a contractor who has this technology and the contractor built their building project for them by using this technology. This decision stemmed from their recognition of the technology's effectiveness, observed in the contractor's previous real estate projects. Reducing construction time is the primary benefit of the implementation of this technology.

According to Assefa and Nigusa, the Amhara Building Works construction enterprise is the other construction company that has adopted and implemented new technology in the construction industry. The technology that the company implemented in the industry is called Schnell Home Technology. Schnell Home Technology is A modular construction and made with prefabricated panels that are assembled and completed on-site. The company brought this technology to the country mainly by developing and introducing the technology to the stakeholders and then contracting with the clients who want their building project to be built using this technology to build their projects using this technology. Originally, when the management members of the company went to South Africa for experience exchange, they wanted to adopt the technology because they could see the benefits and other characteristics of the technology. After that, the company contacted the main provider that is of Italian companies and brought it to the country. The company modified and adopted the technology by

considering the country's context by building manufacturing plants. After properly developing, the company built one G+1(Ground plus one floor) office building for their own use and also used it as a sample or pilot for promotion to the market. The company attended the events and workshops organized by MUI and explained to the stakeholders the importance and general status of the technology. The regional government has established a committee with various experts to study the benefits and standards of technology (Assefa). Based on the committee result the technology could reduce cost by 20% and reduce construction time by 30% compared to the normal methods of work, and also it could build up to G+4 (Ground plus four) building projects. After that, some government organizations including Amhara Regional Urban Development and Infrastructural gave office building projects to the contractor using direct contracting to build their project by this technology, and construction projects were trying to build using this technology (Assefa). However, some of the raw materials are imported from out of Ethiopia, and due to this, there was a challenge for the company related to hard currency (Assefa and Nigusa). Due to this reason, only certain projects are completed but most of the projects are terminated, which are the projects that were being done using this technology.

Menalue also mentions there are efforts to implement post-tensioning technology in the construction industry, particularly for building and bridge construction projects. There were one or two companies that launched and applied this technology, but different efforts are now being conducted to ensure its widespread application in the sector. The technology improves efficiency, reduces cost, replaces rebar, and reduces time.

According to Kefybelu ZIAS Architecture and Engineering PLC is the other company that Uses BIM in the design phases for clash detection, Integration, and coordination purposes. The company is an international company, it has implemented the technology by taking the experience from abroad and by fulfilling necessary tools and giving training to the employees on their own initiative. The respondent mentions that the company used this application for the Abrehot Library construction project, a governmental project. Additionally, the respondent notes that the Ethiopian Construction Works Corporation is also doing necessary things to implement BIM, such as purchasing the full package of the BIM software and giving training to its employees.

Additionally, the Ethiopian BIM Society (EBIMS) was established in 2018 by professionals to facilitate the implementation of BIM in the construction industry (Assefa and Kefybelu). Most of the members are professionals who work in consultant companies and the association mostly works with consultants (Kefybelu). ‘’*We have been creating awareness for different construction stakeholders by preparing different events. But now we understand that giving awareness alone is not enough, so we are thinking of providing training about the standard and workflow for professionals working in the construction industry. We participated as an association in the preparation of the BIM standards*’’ *Kefybelu*. Some public clients have information about BIM even if they don’t know the details, but most of the contractors don’t have any information about the technology and they don’t think that they are part of this implementation (Kefybelu).

4.3 Challenges to implementing technologies

According to Assefa, Menalu, and Nigusa currently, numerous technologies are produced and/or adopted in the country, particularly in universities, private companies, and technical institutions, and imported from other countries. However, not much has been effectively

implemented to solve problems in the construction industry at the national level. Due to several challenges, the majority of them are ineffective beyond promoting the technologies to the stakeholders.

'' it is always difficult to implement the technology properly if policy, legal framework, and standards are not developed in advance and insufficient availability of technology in the market''.Minalu.

4.4.1 Lack of suitable policy

In our country, there is no problem in preparing policies, strategies, directives, and legal framework, the main problem is the implementation of them on the ground. Therefore, there are different policies, legal frameworks, and directives related to the development and implementation of technologies in the construction industry, but the proper implementation of policies, strategies, and legal framework is the main problem. Sometimes, the policies, strategies, and laws issued by the government protect their own advantage instead of putting the benefit of society first by considering the reality.'Nigusa.

The Ministry of Urban and Infrastructure Development collects annual reports from organizations involved in construction-related activities, including those conducted within the industry. Universities and colleges, government agencies working on building projects, and other regulatory organizations providing assistance through training and similar tasks are the main ones.

''We need to know where we are now and understand what our problems are by doing project evaluation" is the first step to establishing relevant policies and applying relevant activities, but this does not apply in our country." Yemane.

Most of the time the policies and strategies are established based on the reports that are collected by different means, rather than a detailed assessment of necessary data or inputs in the industry such as the capacity of professionals, consultants, and contractors and market conditions for the established policies and strategies (Assefa and Nigusa). Due to this sometimes the established policies and strategies have limitations to achieve the intended purpose. Commonly the government and stakeholders explained that most construction projects have performance problems, but the main causes and solutions of these problems for each project have not been studied in detail, so it is not well known where the industry is and what the main problems and their solutions are, due to this the established policies and strategies have gap to address them (Minalu and Yemane). As a result, there is no established policy or strategies to develop and implement a specific list or types of technologies that could enhance the construction project performance by addressing the current critical problems (Assefa). However, if a company has the capacity to develop new technologies on its own, the police are encouraging and open to entry into the market, and the government is attempting to help it through various means commonly allowed duty-free (Assefa and Nigusa).

Additionally, Assefa and Nigusa point out that most of the time the government introduces the technology by organizing workshops and events after the introduces the technology for a while, they leave it to the owners to do as they wish rather than support them or invest by established appropriate policies to develop and spread in the market and implement in the industry. The respondent mentions that there is a lack of established policies and strategies to support the technology developers or owners through financial and other things and make the technologies well developed and spread in the market.

The lack of clearly included technologies and new ideas as mandatory or optional requirements in the standard bid document and public procurement directive is another obstacle to efficiently implementing them in public construction projects (Assefa, Bekele, and Yemane). They mention that even if the public procurement directive is open to including technology as a requirement in the preparation of bid documents, the body that prepares the bid document does not want to take responsibility by including it as a requirement and they follow the usual ways. Tilahun, says that *''When a mandatory law is passed, people take it as an obligation and do different things and solutions to implement it." Otherwise, the people do in as usual ways."*

4.4.2 Lack of Standard and Specification

''Most of the time, when new technology comes if the laws, standards, and also specifications are not prepared in advance according to the country's context, it faces various challenges and it leads to failure. The government often tries to issue laws and procedures when faced with challenges." Menalu.

Assefa, Kefyebelu, Menalu, and Nigusa mention that a lack of standards and specifications of the technologies are obstacles to implementing them in the construction project. The flexibility of technologies and the emergence of new technologies every time, the standards and legal framework in the country are not enough to consider this situation. There is a gap in the timely preparation of standards and specifications for the technologies that are adopted and implemented in the county. It is difficult to use the technology in a construction project without adequate standards and specifications by taking risks and accountability. The technologies that have been implemented in the construction industry including Kumkang Aluminium framework and post-tensioning technologies don't have standards and specifications due to the Ethiopian Building Code Standard (EBCS) being published before they came into the country. These technologies have been implemented according to the standards and specifications which are based on the country they come from.

4.4.3 Lack of commitment

The lack of government commitment is the main problem in developing and implementing technology in the construction industry, due to different reasons including having an interest or need or not wanting to take responsibility and do something new. (Assefa, Bekele, and Nigusa). According to Bekele's point of view, as a result, most higher-level officials such as top leaders and policymakers do not have a construction background. They lack awareness of the benefits of construction technologies. The respondent points out that even if construction sector leaders have advisors with construction backgrounds, convincing them to change and make a difference in the industry is challenging. Similarly, Nigusa mentions most of the organizations are led by persons who are assigned politically, that is they haven't a construction background. They are not doing properly related to improving the industry rather they mostly doing political issues. These factors create many consequences for effectively implementing the existing policies and strategies and establishing the most appropriate policies and frameworks to improve the industry.

Additionally, according to Assefa and Yemane, the construction regulatory body that is Urban and Infrastructure development at all levels is responsible for implementing the policies, strategies, and procedures, modernizing the industry through organizing the stakeholders but

due to lack of commitment, they have not applied the responsibility properly and the relationship and collaboration between the stakeholders are weak. There is a problem in identifying the stakeholders, their relationships, and who works for whom (Nigusa). Most of the time the stakeholders do things by following the usual way rather than creating or developing and applying new things in their construction project.

4.4.4 Lack of awareness and attitude to implement technology.

"It can not be deployed unless the policymakers, regulatory, public clients, consultants, and contractors acknowledge the benefits of technology for enhancing construction performance and establish technology-specific plans and standards in place. This factor contributes to the failure of technology implementation due to several challenges." Bekele.

A lack of awareness is another obstacle to effectively implementing technology in the construction project (Bekele, Tilahun, and Yemane). Bekele points out it may be one of the reasons that many technologies are not implemented in the construction project. Most of the owners of the contractor companies are not professional, and due to this there is a lack of awareness about the technology, and they do not want to implement by tracking risks and they want to work as usual (Bekele, Tilahun, and Zelalem). Additionally, Tilahun mentions that most of the clients do not have enough understanding of the benefits of technology, so instead of taking responsibility and implementing it in their construction project, they want to work in the usual way. In contrast, ‘*'lack of awareness is not the problem, we have been trying to create awareness for the main stockholders about the benefits of the technology by preparing various events, meetings, and workshops and inviting the technology developers and suppliers to share the benefits and experience about their technology. But they do not want to take responsibility to implement it."Nigusa.* On the professional level, there is good acceptance of the technologies because they understand the current challenges in the industry and the importance of the technologies in the industry (Bekele).

''If the benefit of the technology is proven and it is available in the market, professionals and organizations want to use it even if there is no mandatory law to implement." Bekele.

There is a problem in accepting new things including technologies and the client must accept the technology to implement in the construction project (Yemane). *''In our country, new things are implemented by trust, meaning that, the clients have the experience of implementing new technology in their projects if the technology has been successfully implemented in others' projects.'' Kefybelu*. Additionally, ''If I tell the owner to implement some useful technologies in our company or project, the owner refuses to implement it until he is aware of the benefits and sees it from others.'' Bekele.

4.4.5 The Lack of Knowledge and Experience

''Technology is constantly changing and evolving, which means that professionals must also upgrade their competence to use the technology properly.'' Minalu.
''There is not much assessment of the work done, technologies, the capacity of professionals and construction companies, rather than report that we have provided this much training, we have provided this much capacity building, and we have this many technologies."Nigusa.

There is a gap in competence for currently emerging technology for all stakeholders, such as how to properly use, how to construct, how to design, how is the procedure, how to check the quality, how to follow the work.'' Assefa.

Professionals working in the construction industry do not have much of a gap in general construction activities competence, but there is a competence gap connected to emerging technology due to the lack of exposure to working on projects where technologies are integrated (Assefa, Bekele, Woldeatzke, Yemane, Zelalem). Nigusa points capacity buildings and various training are widely offered especially for professionals who Work in the regulatory body, but the problem is in terms of putting the knowledge and the experience exchange into practice quickly. *''When the pieces of training are prepared, a need assessment is done at the beginning about the type of topics that are better to provide. However, the trained professionals either leave the office or change their position without servicing as they were trained. ''Nigusa*.

In contrast, Minalu mentions there is a gap regarding competence, no system helps a person to learn new things and upgrade his competence after graduating, the person just builds the trends with the work he or she has done. The respondent mentions that the Ministry of Urban and Infrastructure Development is preparing a law to address this issue by requiring the professionals involved in the construction industry to undergo various types of training to improve their competence and move from one level to the next level.

''When we ask the indigenous contractors, they tell us that we have the capacity, but practically they have financial and management problems such as manpower, site or work, finance, time, and other resource management.'' Nigusa.

The lack of competence and capacity of contractors is a barrier to implementing technologies in the construction industry (Assefa, Bekele, Nigusa, and Zelalem). Most contractor companies are owned by non-intellectuals or professionals; they do not understand that the industry needs anything but to make money and most of them do not think much about institutional excellence (Bekele, Minalu, and Zelalem). The technical managers lead the construction part however they do not manage and control the financial parts and are not decision-makers (Bekele). Due to this and other things the contractor does not want to work outside of his usual routine by taking risks if he is not forced (Bekele and Zelalem). In addition to that most of the contractor companies have weak capacity, especially in the current economic crisis of the country, most of the contractors find it difficult to implement technologies as desired due to their limited capacity (Minalu). Similarly, the top leaders of government clients do not have a construction background and they are decision-makers in the organizational activities (Tilahun and Zelalem). Even if they are a source of finance and power to implement new systems and technology in their construction project to improve the performance through the public procurement process, but they are not willing to decide by taking responsibility (Yemane and Zelalem). Most of the professionals and top leaders who work in public clients do not want to include new requirements in the bid document by taking responsibility that is not clearly mentioned or included in the public procurement directive, standard bid document, and other necessary documents that are used as a reference to establish the requirements in the bid document (Assefa and Zelalem)

In contrast, most of the consultant companies are led by professionals, and they are relatively better at accepting new systems and practicing, but they have financial problems (Assefa and Nigusa).

4.4.6 Lack of technologies in the market

''When setting technology as a requirement in the bid document we consider the reality, the availability of technology in the market. It is from the point of view that the industry is still infant, but we don't set technologies as competitive criteria due to the lack of sufficient technologies in the market.'' Zelalem.

According to the respondents, a lack of developed technologies on the market is the main obstacle to implementing the technologies in the Ethiopian construction industry. This leads to a lack of standards and specifications for technologies as well as a lack of knowledge among stakeholders regarding the technology (Tilahun). Currently, some technologies are used by some companies in the industry, but this is not sufficient to set this technology as a requirement to implement in the construction project due to the lack of sufficient bidders to participate by fulfilling the requirements in the bidding process that have those technologies in the market, or technology, or suppliers of the technology (Assefa, Nigusa, and Tilahun).

4.4 Opportunities

The respondents identified several opportunities based on their beliefs that facilitate to implementation of technologies in the construction project. Even if there are some limitations the government has given attention to technology, by understanding the benefits of it to improve construction performance (Assefa).

''We can easily apply the technologies that have been applied in other countries and are effective by simply learning and experiencing about the methodology, how they follow, and what activities are done." Minalu. The respondent mentions even if it is not at the required level, public organizations and universities have good relationships. As universities are government-owned, they support whatever they are asked by the industry as much as they can, but still based on the initiative of the organizations.

''The problems we are facing with the projects, that is a very high time and cost overrun, and the economic poverty we are facing now makes it difficult to continue with these problems. Therefore this is an opportunity to find solutions including implementing new systems and technologies in the projects to solve the current problems." Kefybelu. The respondent mentions the existence of some companies that doing different activities to implement different technologies in their construction projects, for instance, for BIM implementation ZIAS, OVID, and ECWC.

5 Discussion

To meet the aim of this master's thesis, this chapter discusses the knowledge of technology implementation in public procurement as well as challenges and opportunities to develop and implement technologies in public construction projects through public procurement processes. The discussion analyses core results from the empirical study that influence the implementation of technologies in public construction projects. The main stakeholders' competency and their possibility to contribute to implementing technologies, the availability of technologies in the market, the impact of public procurement processes, and policy and legal aspects are discussed.

5.1 Public clients

Public clients play the most crucial role by implementing technologies in the construction project and enhancing the performance by setting as a requirement in the bid document during procurement. Lindblad & Gustavsson (2020), agree with this and mention that accepting the technology and collaborating with the main stakeholders involved in the project are the most important parts for effectively implementing it in the construction project. Besides demanding and including as a requirement, based on the characteristics of technologies the client has the chance to assign responsibility and decide how the collaboration will function throughout the project based on the procurement directives.

Clients are a source of finance and have a responsibility to improve their construction project performance by implementing technologies or new systems in their construction projects through the procurement process (Yemane & Zelalem). Järvenpää et al., (2022) mention that public clients adopt suitable requirements and tendering specifications during the procurement process to ensure construction project performance by implementing government policies based on the rules and regulations. Additionally, the clients are the first benefit when the technology is properly implemented in their project. It is one of the best results to ensure that their own construction experts get adequate training about the technology. Similarly, the clients prepare and provide necessary training and give different support for the construction contractors, which improves collaboration between them and helps to implement the technology properly. The study indicates that the client's participation is critical to the successful implementation of technology in their construction projects. The implementation starts by clearly deciding on the types of technologies based on the benefits that shall be implemented in their construction project and including the necessary information in all important documents that are useful as a bid document in the procurement processes.

5.2 The availability of technologies in the market

The availability of the technologies in the market is crucially important to the successful implementation of technologies in construction projects. It includes the availability of contractors and consultants who have or use the technologies or suppliers who supply to the industry. According to the respondent, only a few developed technologies are currently available in Ethiopian's construction market, which is handled by some companies. Additionally, Assefa mentions that there is experience in the implementation of technologies in public client construction projects but the procedure is direct contracting due to the lack of sufficient bidders. This procedure violates the public procurement principles such as ensuring

equal opportunities, value of money, and fair competition among the bidders. Therefore, this practice is not acceptable in the public procurnment process because it violates the principles. Both the literature and the respondents describe the lack of sufficient technologies in the market as an obstacle to implementing technology in construction projects especially, in public projects through the public procurement processes. One of the issues in public procurement processes is a shortage of sufficient bidders who participate in the bid that has the specified technology or fulfills the requirements requested in the bid document.

The procurement will not be as successful as intended if there are not enough bidders participating in the bid who meet the requirements or have the requested technology in the bid. Zelalem points out that setting technologies as a requirement in the bid document considering, the availability of the technology, is essential to implement it in the public construction project. Knobloch & Mercure (2016), agree and mention that insufficient availability of technology in the market causes bids to be canceled or excessive project costs due to the insufficient number of bidders submitting their bid proposals and little competition among bidders.

The lack of availability of technologies in the market creates several effects that related to the proper implementation of the technologies in the construction project. This is associated with a lack of exposure to or understanding of the general advantages and practical applications of technology. Tilahun mentions a lack of standards, guidelines, and specifications for the technologies, as well as a lack of professionals and companies that experienced the technology's implementation, as the effects of the lack of availability of technology in the market. On the other hand, Knobloch & Mercure (2016), point out that cultural and organizational resistance by institutions and low awareness about the benefits of technology are the result of the low diffusion of technologies in the market. Due to these effects, the organization and the professionals may not want to implement the technology in their construction project by setting it as a requirement in the bid document and taking responsibility.

5.3 Requirements in the bid document for public procurement.

The project's focus areas and method of operation are determined by the procurement process. In addition, the procurement specifies how cooperation and responsibility sharing will happen. Public clients follow the public procurement directives to fulfill their needs or procure goods or works through the procurement processes. Both the respondent and the literature mention that when preparing a bid document for a public client, the body in charge of the bid document should adhere to and make use of the stringent laws, regulations, procedures, and legal documents that govern public procurement. Different mandatory and/or optional requirements in the bid document that are used to determine the eligible bidders to participate in the bid and selection or evaluation criteria for the bidder in the procurement process are established in compliance with the public procurement principles, laws, and regulations. Anna et al., (2019) mention that when introducing new requirements like technology in the procurement different demand-supply variables such as competence and capacity of the client side, the availability of sufficient and competent bidders, and the availability of the desired good or product in the market should be considered to achieve the desired procurement process.

Assefa & Zelalem point out that the current Ethiopian public procurement directives are not a barrier it is open to establishing new requirements including technology as a requirement in the bid document if there are enough bidders that meet the criteria. On the other side, Mengistu et al., (2023) mention the existing public procurements directive practice doesn't consider the

implementation of technology in the construction industry such as lack of clear and simple criteria and a lack of distinct evaluation criteria. Similarly, Assefa, Tilahun, & Yemane mention that the lack of clearly included technologies and new ideas as mandatory or optional requirements in the public procurement directives or in other legal documents that are used as a reference during the preparation of the bid document, is an obstacle to its implementation in a public construction project due to the fact that the body that prepare the bid document does not want to take responsibility by including technology as a requirement but rather follow the usual ways. Popov et al., (2021) point out that the incorporation of electronic tools like BIM into the European Union Public Procurement directive by the European Parliament as optional requirements to apply in the member estate plays a significant role in facilitating the adoption of BIM and other electronic tools throughout the European member estate.
Furthermore, the respondent mentions that the implementation of modular types of technology does not need to be set as a requirement in the bid document because the design and working methods are clearly defined and all bidders are aware of them. However, the necessary equipment and manpower that are important to install the technology are set out in the bid document. Additionally, Zelalem mentions that technology like a drone, smart halmate, and other similar types of tools can be set as a requirement in the bid document in the equipment section.

The study indicates that the body that prepares the bid document has established different requirements in the bidding document for the public procurement process based on the clearly defined requirements in the public procurement directives and other necessary legal documents that are used for the preparation of the bid document. Modifying and establishing technologies as requirements either mandatory or optional in the public procurement directives and other legal documents that are used as a reference for the preparation of the bid document is important to start and facilitate the implementation of technologies in public construction projects. The requirements set in different legal contract documents based on the characteristics of the technologies.

5.4 policy, law, and regulation

Policy is a key tool that facilitates the creation, development, and implementation of technologies in the construction industry. By establishing suitable policies and instruments that encourage the adaption and development of technology, practice, and business models, the government plays a crucial role in promoting technology implementation in construction project. The respondent mentions that there are not many issues with policymaking. However, the policies and regulations that are issued are based on reports rather than a detailed assessment of necessary data and inputs in the industry such as the capacity of professionals, consultants, and contractors and market conditions for the established policies and strategies. These cause limitations and fail to achieve the intended purpose of the established policy in the construction industry when it is implemented. Howlett & Mukherjee (2017), point out that establishing policy and strategies is a complex process involving many actors and influenced by knowledge, power, and the involvement of different actors, and these affect the formulation of suitable policy for the intended purpose. When making policy, it is critical to understand the specific circumstances of the country and industry through a detailed study of the underlying problems, challenges, and possibilities in the performance of construction projects, market conditions, and related activities, including the stakeholder capacity and level of engagement, in order to develop an appropriate policy that achieves the intended goal.

Assefa, Minalu, & Nigusa mention that a lack of established policies and strategies to support the technology developers or owners through financial and other means and make the technologies well developed and spread in the market. Even if numerous technologies are produced and or adopted in the country by different bodies, due to financial constraints the technologies are not well developed and implemented in the construction industry. The current policy encourages and allows entry into the market if a company has the potential to create new technologies on its own and the government is striving to assist it through several widely allowed duty-free channels (Nigusa). Based on the respondents, there are no policies and procedures to encourage or support the owner who could adopt technology but is unable to develop and implement it well in the construction project correctly owing to lack of capacity, particularly lack of finances. Furthermore, they state there is no clear policy or procedure in place to support the initial cost of the technology including buying the technology and giving training for their employees about it by financial means and other related aspects for private construction companies. European Commission (2021), points out that the government plays a crucial role in developing and implementing technology in the construction industry by establishing suitable policies and strategies to encourage technology developers and low-capacity construction companies through financial incentives in the form of grants, loans, or equity, but also by providing technical assistance such as for creating technology development platforms to support the integration of technology and research firm technology transfer.

Public procurement is one of the key policy instruments that governments employ to implement different policies including technology in the construction industry. Grandia & Meehan (2017), agree and point out that the primary objective of public procurement law is to utilize various strategies to ensure the quality of government services and the utilization of goods and services for the public sector to achieve the desired outcome. However, the respondent and Mengistu et al. (2023), mention the current public procurement law has not mentioned or considered the implementation or usage of technology or new ideas in the public construction project through procurement processes. Additionally, Grandia & Meehan (2017), mention there are various obstacles to the implementation of technology in public construction projects, including relatively rigid public procurement regulations such as selection and award criteria of the bid to select the winner, the procurement's lack of market engagement, and traditional and poor tendering practices. Without amendment or the establishment of a suitable public procurement policy, it is difficult to effectively implement technology in the public construction project through the procurement process. There is a lack of experience in the implementation of technology in the construction industry, which means that practical procedures for interpreting and applying rules and legal requirements are missing. This generates ambiguity, making it an obstacle to start implementing technology in construction projects through public procurement. Shaping the public procurement law, such as adding technology or new systems and allowing for their implementation, helps the integration of technologies into public construction projects via procurement processes.

5.5 Standard, Specification, and Guideline

Guidelines, specifications, and standards are basic documents used as a reference for the preparation of the tender documents including establishing different requirements and use as a part of the contract document between the contracting parties in the public procurement processes. Depending on the type of technology, guidelines, specifications, and standards of the technology are required to properly design and/or define a requirement in the bid documents, as well as implement it in the construction project through the procurement process.

Okpala, et al. (2019), pointed out that specifications and standards have many functions, and they facilitate the implementation of technology in construction projects.
The respondents note that the lack of standards and specifications for the technologies are obstacles to implementing them in the construction project. Menalu further mentions the lack of standards and specifications for modular or precast types of technologies are barrier because the Ethiopian Building Code Standard (EBCS) was published before they came into the country. Belay et al. (2021), argue and point out that in Ethiopia, the lack of standard form contracts for BIM adaption and the lack of BIM regulations and standards are the major barriers to implementation of BIM in public construction projects. The European Commission (2021), point's that the lack of standards for product manufacturers and digital technologies is a barrier to implementing digital technology specifically BIM, Digital Twins, and Sensors in the construction industry. Similarly, Zhang et al. (2018), mention that for prefabrication technology, the absence of efficient specifications, norms, guidelines, and information for planning, designing, and regulation is the hindrance impeding its implementation in construction projects.
It can be challenging to implement technologies in public construction projects by including them in the bid document during the procurement process if the technology does not have the required standards, specifications, or guidelines. The absence of guidelines and standards for technologies also affects their market diffusion, makes it more difficult for the players in the construction industry to use them, and creates resistance to professional and expert implementation, which makes it more difficult to use them in building projects. To effectively address the challenges and implement technology in the construction project, clear standards, specifications, and other legal documents must be established for each technology. These legal documents should be easily understood by stakeholders and utilized effectively.

5.6 Knowledge and Experience

Both the respondents and the literature emphasize that the knowledge and experience of professionals involved in the construction industry with technology play a key role in implementing the technology properly in construction projects. These include properly designing according to the standards and specifications, set as a requirement in the bid document based on the characteristics of the technology, allocating the responsibility for the contracting parties, using and or implementing the technology, and effectively monitoring the activities. However, the lack of knowledge and experience with technology is a barrier to the implementation of technology in construction projects. The respondent highlights that there is a lack of experience and understanding regarding developing technologies, including how to design and utilize them appropriately, as well as how to monitor their quality and follow construction projects. These create barriers to the implementation of technologies through procurement processes by including the technology as a requirement in the bid document due to the lack of attitude and lack of properly establishing necessary legal documents. The literature makes clear that one of the main obstacles to the effective implementation of technology in the construction industry is a lack of professionals with the necessary skills and experience. This includes a reluctance to implement new technologies, which hinders them from properly integrating with the current process and product to fully utilize their benefits, and the inability of construction organizations to fully utilize the technologies for project execution.

By involving all main stakeholders preparing and giving continuous relevant training for the professionals that involved in the construction industry is needed to address the issues and

implement them properly in the construction industry. In the case of in Denmark and the UK, different institutions and universities played the main role in the implementation of BIM in their construction industries by giving different trainings for the professionals who work in the industry about BIM. in Ethiopia, despite its weakness, universities have a connection with stakeholder organization that drive the industry. Strengthening these connections will help universities train industry professionals and provide them with the necessary knowledge and experience for the implementation of technologies.

6 Conclusion

This study aims to investigate and propose suitable procurement requirements for the effective implementation of technology in the Ethiopian public client building project to enhance project performance. The major findings of this study show that different factors affect the successful implementation of technology in the public client construction project through the procurnment process. This section discusses the main conclusions based on the research question and recommendations for future studies.

Public construction projects play a crucial role in the socio-economic development of Ethiopia. However, performance issues such as time overruns, quality problems, and cost overruns in construction projects are significant challenges to achieving the intended purpose of the projects. Inefficient design of works, poor planning and schedule of works, lack of collaboration and communication between the involved parties, weak project management, and low productivity are the main challenges. Technologies have great potential to enhance construction projects by addressing these problems through data acquisition, analysis, and visualization, improving communication, and automation of design and construction. Enhance sustainability, health and safety, work efficiency, productivity, and the overall quality of the project are the main benefits of the technologies.

Public procurnment plays a significant role in implementing technology into public client construction projects by setting as a requirement in the bid documents during procurement processes. However, implementing technologies in the public client construction project is not straightforward because these organizations fulfill their needs through a public procurnment process and the requirements that are applied in the entire process must meet various rules, regulations, procedures, and public procurement principles. Therefore, to implement technologies in public client construction projects through the procurnment process, it is necessary to incorporate them as requirements in the bid document or other parts of the contract document based on technology characteristics. This requirement necessitates suitable rules, regulations, or procurnment directives that allow or mandate the inclusion of such technologies.

- What are the gaps in existing procurement practices for the implementation of technology?

To implement technologies into public construction projects by establishing them as a requirement in bid documents through the procurnment process, the requirements must comply with the public procurnment directives, rules, regulations, and other recognized legal documents. However, the current public procurement directives and other legal documents, which have been used for preparing bid documents and establishing requirements for identifying bidder participation, as well as for bidder selection and awarding, do not account for technology implementation through the procurement process. This gap leads to public clients and professionals who are responsible to prepare bid documents do not want including technologies as a requirement in the bid document during the procurnment process by taking responsibility.

- What are the opportunities and major barriers to implementing technology in procurement requirements?

To successfully implement technologies in the public construction project by incorporating them as a requirement in the procurnment process faces several changes. One major barrier is

the lack of a suitable procurement policy. This issue arises from the public procurnment directive do not mention or consider the implementation of technology in the public construction industry as an optional and mandatory requirement. This creates uncertainty and makes it challenging to begin integrating technology into public construction projects using public procurement process.

The second barrier is the limited availability of technology in the market. Without enough availability technologies in the market or bidders with technological capabilities in the industry, it becomes challenging to implement these technologies while ensuring equal opportunities for all bidders, fostering sufficient competition between the bidders, and complying with other public procurement principles.

A third barrier is the lack of necessary standards, specifications, and other legal documents of technologies, which act as guides or references for the preparation of bid documents and their implementation in construction projects. These documents are crucial based on the characteristics of the technologies for providing information and procedures to users, on the design process, required activities for implementation, and effective monitoring and implementation of technologies in construction projects. In the context of a country's industry, establishing standards, specifications, or other necessary legal documents for technologies is crucial for the successful implementation of technologies in public construction projects.

The fourth barrier is the lack of knowledge, especially practical experience in the industry with technology implementation in construction projects, and it prevents technologies from being included in procurement. Without the necessary knowledge and experience with technology, it is difficult to properly design the works, set the requirements in the bid documents and evaluate them, distribute the responsibility to the contract parties, implements them, check the quality, follow up the work, and manage the claims effectively. Furthermore, Construction projects involve various stakeholders such as clients, consultants, and contractors. The knowledge and experience of these stakeholders with technologies are crucial for the successful implementation of technologies in the construction project.

- What activities are needed to implement technology by setting requirements during procurement processes?

To implement technologies in the public client construction project, it is essential to clearly integrate them into public procurement directives or other legal documents, either as optional or mandatory requirements. This is the initial step to facilitate the implementation. The government must address the gaps and barriers hindering the integration of technologies in such projects through the public procurement process by establishing a suitable framework and platforms to promote collaboration among stakeholders, including academia. This is essential to tackle these gaps and challenges, with the government accountable for this responsibility. An academic institution, in particular, can play a vital role in creating awareness, sharing knowledge and experience with industry stakeholders, conducting relevant research within the industry, and establishing standards, specifications, and other legal documents of technologies.

Moreover, the government must have a deep understanding of the construction industry's current state, including the capacity of the stakeholders, and the main problems and challenges of the construction project performance. This insight can be gained through conducting

valuable research within the construction industry. Subsequently, the government should implement appropriate solutions based on this research, which may involve establishing effective policies, laws, and regulations or creating customized systems to address identified problems and challenges. A crucial aspect of this process is the implementation of valuable technologies that directly target the industry's problems and challenges, thereby enhancing both construction project performance and the overall industry. While all technologies contribute to enhancing construction project performance, priority should be given to those that address the industry's major problems and are most essential in resolving them.

- Future works and development

A further detailed investigation of suitable frameworks to enhance collaboration and communication among key stakeholders in technology implementation for public construction projects would be beneficial.

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