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A Hybrid Delphi-AHP Based Analysis of Construction Project - Specific Success Factors in Emerging Markets: The Case of Ethiopia

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Abstract: Literature highlights that the success of construction projects differs in various attributes. However, only a few empirical studies have been conducted to examine the inter-sectorial aspects of critical success factors in developing countries. Hence, this study aims to investigate the comparative analysis of success factors in public and private sectors across the Ethiopian construction industry. A structured questionnaire matrix was prepared based on the hierarchical model developed through a systematic literature review. Then, the present study introduced a Delphi–Analytic Hierarchy Process (AHP) technique to analyze successful attributes in the Ethiopian construction sector. The two rounds of Delphi–AHP survey were conducted through a panel of experts working in different construction firms including owner, consultant, contractor, and academia. The result indicates that the top three ranked critical success factors (CSFs) in the private sector are clear project goals, financial capacity of contractor, and competency of consulting firm. However, CSFs such as adequacy of funds, political environment, and clear project goals are the major CSFs in public construction sector. More so, the findings reveal that there was a consensus among respondents on the rankings of success factors. The study

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PUBLIC INTEREST STATEMENT

The current study examined the potential critical success factors in public and private construction projects with the context of the Ethiopian construction industry. In order to achieve the objectives, a systematic literature review was conducted using pre-defined criteria to select relevant success-related factors from studies published in developing countries. Furthermore, one of the fundamental aims of this study was to test the application of a combination of two distinct methodologies in an investigation related to the construction sector. In this case, a panel of experts were invited to fill a questionnaire prepared based on a pairwise analysis through different factors affecting the success of projects in the Ethiopian construction sector. The findings of this study are believed to be helpful to professionals, contractors, policy makers, and regulatory bodies to understand the most important factors that affect the success of both public and private construction projects.
provides practical implications and key recommendations regarding CSFs to enhance project management performance in the Ethiopian construction sector.

**Subjects:** Engineering Management; Engineering Project Management; Civil, Environmental and Geotechnical Engineering

**Keywords:** Critical success factors; construction projects; Delphi survey; AHP; developing countries

**1. Introduction**

The extent of infrastructure network expansion is a key factor to foster growth and development in low-income nations (Dithebe et al., 2019; Sfakianki, 2019). Recently, the demand of construction of public infrastructure facilities has been increasing as a result of rapid urbanization and poor urban planning in emerging markets such as Ethiopia. As a result, effective policies and strategies are needed to counteract the challenges facing the development of infrastructure projects. According to the World Bank report, the sub-Saharan African region ranks low when compared with the other developing regions in several infrastructure performance indicators (Calderon et al., 2018). The infrastructure development in the region is poor despite the continuous efforts to enhance the current network.

In recent years, the Ethiopian government had been allocating around 58%–60% of the country’s budget to infrastructure development during the span of the first and second growth and transformation plan (Debela, 2019). Most of this budget is allocated to development of road, energy, and water work infrastructures to meet the requirement of the public. Despite this effort by the government and other key stakeholders, challenges such as poor project management performance, claims, disputes, and health and safety concerns are among the major critical problems that affect the success of public projects in the Ethiopian construction sector (Sinesilassie et al., 2018).

One of the critical steps to ensure the successful delivery of construction projects is by identifying and analyzing the critical success factors in project basis. In the past, several scholars studied the success factors in construction projects around the world. However, due to the constant evolution of the construction sector in terms of the construction methodology, availability of technology, and project scope, it is imperative to examine the critical success factors in both public and private construction projects with the context of the Ethiopian construction sector. In contrast, there is still a limitation of studies conducted in Ethiopia, in relation to comparative and sector-specific success factors in construction projects.

Furthermore, prior researchers utilized AHP using its original relative or absolute judgment characteristics as it had been originally developed by Saaty, (1988). For this reason, there is a gap in the CSF literature with respect to testing the relative judgements of professionals in AHP with respect to the Delphi technique. Hence, this study aims to provide a comprehensive inter-sectoral comparative analysis of critical success factors (CSFs) between the private and public construction projects. The paper examines the perspective of key stakeholders including, owners, consultants, contractors, and academia using a hybrid multi-criteria decision technique and Delphi survey in the context of the Ethiopian construction industry.

Due to the involvement of different participants in construction projects, it’s realistic to assume that the hierarchical rankings of CSFs will defer in both public and private sectors, and hence, this was formulated as a hypothesis of the study. The present study outlines comprehensive success factors, which will be helpful to provide key practical insights to ensure better collaboration between participants in construction projects. Furthermore, the findings of the study also show the gap on the perception of stakeholders toward CSFs in private and public construction projects. This in turn will be beneficial for organizations, policy makers, regulatory body, and other
stakeholders to devise project-based action plan to enhance the overall project management performance of construction projects.

The rest of the paper is structured as follows: (1) discusses the background of the study including the assessment of prior literature to identify potential CSFs in both public and private construction sectors; (2) introduces the research methodology and framework including research design, Delphi survey, AHP, and data collection methods; (3) highlights the analysis and findings of the study; (4) outlines the discussion and practical implication of the study; and the last section (5) summarizes the conclusion of the study.

1.1. Background of the research
The definition of the term “success” has been evolved to provide approximate meaning to different contexts. Success, in this study, is defined as the extent to which project goals are achieved as perceived by project participants and key stakeholders in the capacity of contractors, consultants, designers, owners, and academia. CSFs are those attributes which contribute to and is influential for the successful completion of a project (Altarawneh et al., 2018; Tereso et al., 2019). These are the few limited areas where acceptable results ensure successful project performance for a firm (Tripathi & Jha, 2017). Previous studies highlighted that several factors affect the overall success of construction projects in developing countries. These factors vary depending on the location, size, and type of construction projects. A few examples include that Dithebe et al. (2019) examined the CSFs for public private partnership (PPP)-based water infrastructure works in South Africa using factor analysis. Their findings reveal that project viability planning, accountability and transparency, and legal framework are the major CSFs that affect water construction projects.

In the case of Kenya, Chileshe et al. (2020) investigated the critical success factors in public-infrastructure and housing projects. Similarly, in the Lithuanian context, Gudienė et al., (2013) identified manager’s competence, competence of PM team, project manager coordinating skills of managers, client clear and precise goals by the owner, project value, past experience of the PM team, project manager skill, and efficient conflict resolution of the PM, as the most significant CSFs in construction projects. In addition, Negash and Hassan (2020) highlighted the relationship between the external project environment, intellectual applications, and construction project factors in buildings using the fuzzy Delphi method. More so, Tripathi and Jha (2017) studied success-related factors which influence construction firms in India using structural equation modeling.

The majority of these studies recommended the importance of comprehensive and well-articulated construction guidelines and procurement mechanisms when it comes to project success in the construction industry. Further, these specific cases also confirm the need to examine the extent of differences and similarities in success factors based on the type of the project under various market contexts. To reinforce this argument, Mosley and Bubshait (2016) reveal that although the extent of the problems differs in the private and public sectors, its crucial to ensure the success of construction projects through project-oriented infrastructure development policies and frameworks.

Furthermore, although CSF-related studies have been conducted worldwide, it was found that only a few studies have been conducted in Ethiopia that focus on CSFs that affect overall performance of construction projects. Ethiopia, being one of the emerging markets in the sub-Saharan African region, faces several challenges with regard to the performance of construction projects. Hence, it is imperative to address these challenges by studying the critical success factors in private and public projects across the Ethiopian construction sector and discuss the findings in comparison with other developing countries.
2. Literature review

This section summarizes the systematic literature review and the hybrid Delphi–AHP technique adopted for the study.

2.1. Systematic literature review

A systematic literature review, also known as SLR is a review technique which is used to identify relevant researches using a clearly defined criterion. This review technique has been applied in different CSF-related studies. For instance, Debela (2019) adopted a systematic literature review to select CSFs in PPP projects. However, Sfakianaki (2019) used systematic literature review to categorize success factors for sustainable construction. The purpose of this review was to identify the potential critical success factors, including the methods adopted in developing countries.

The SLR for the current study was conducted in three major stages using online research databases including Scopus, Science Direct, and Google Scholar. The first stage of the SLR, key words such as “Critical Success Factors,” “Delphi and AHP,” and “Developing countries” were used. The return was 419 publications in Scopus and science direct and 311 in google scholar. After a quick review, a total of 148 papers were kept for further scrutiny. In the second stage, inclusion/exclusion criteria were set for content analysis. These criteria include publication Year (between 2012 and 2020), relevancy, location, and language. This time, 66 papers were selected from both databases.

Lastly, a comprehensive and in-depth review of the publications was conducted to classify the type of project, publication date (between 2012 and 2020), methodology used, country, and findings. At this stage, 41 valid journal papers were selected. From this, after neglecting redundant papers that utilized similar approaches, factors, and geographical locations, 14 papers that are conducted in developing countries were shortlisted for questionnaire preparation, and the rest were used throughout the research. Table 1 illustrates the final list of publications regarding CSFs in project-specific cases.

2.2. The hybrid Delphi–AHP technique

The Delphi–AHP technique is a method based on the combination of a Delphi survey and the classical AHP for a more comprehensive research approach. In the hybrid method, the Delphi technique is employed to collect data from a pre-selected panel of experts working in the private and public construction sectors, and the AHP was applied in subsequent phases to determine the relative weightage of the critical success attributes for a multi-criteria decision-making analysis. This technique enables a comprehensive assessment of pre-identified factors and their relationships in a hierarchical-based model (Luzon & El-Sayegh, 2016). The fact that the decision-making process is conducted in multiple rounds of surveys makes it a more accurate analysis technique to examine success factors in construction projects (Alshehri et al., 2015).

The hybrid approach of Delphi technique and AHP covers the ability and usefulness of one method/tool with the usefulness of the other method. In this case, a better and reliable analysis and conclusion can be drawn (Khoshnava et al., 2018). Normally, the Delphi technique helps researchers to avoid random data filled with experts and reach a more common decision. Similarly, AHP allows experts to focus on pairwise factors, instead of taking their attention to multiple factors at the same time. Consequently, by applying both classical techniques, a reliable data analysis can be achieved.

The Delphi–AHP approach is not something new and could be traced in several disciplines and research areas despite the dearth of studies in the construction sector. A few examples include that Vidal, Marle and Bocquet, (2011) examined the relation between complexity of projects and decision making using a combination of the Delphi process and AHP. Chen et al. (2018) applied a fuzzy Delphi technique and AHP to develop key sustainability indicators for campuses in Taiwan.
Table 1. Recent studies related to CSFs in construction projects of developing countries

| Author                      | Methods used            | Project | Country | Top project success attributes (findings)                                      |
|-----------------------------|-------------------------|---------|---------|-----------------------------------------------------------------------------|
| (Chileshe et al., 2020)     | Descriptive Statistics  | Any     | Kenya   | Community Support, Feasibility of Project, Country Laws and Regulations, Availability of Funding, and Availability of Public Agency |
| (Le et al., 2020)           | Descriptive Statistics  | Any     | Vietnam | Parties understand their responsibilities, Procurement Issues, contractors’ experience and competency, experience of project team members, promote pre-qualification of tenders |
| (Mohammad Omoush, 2020)     | Descriptive Statistics  | Any     | Jourdan | Projects Related Factors, Materials, External Environment, Organizational & Managerial, Human Related |
| (Kavishe & Chileshe, 2019)  | Qualitative Analysis    | Public  | Tanzania | Commitment of Professionals, Site Visit Inspection, Support from Government, and Check and Balance |
| (Bassam Tayeh, Khalid Hallaq, Wesam Alaloul, 2018) | Descriptive Statistics  | Any     | Gaza    | Clear Scope of the Project, Experience of the Design Team, Experience of the Contractor, Closure of Crossing Points, Highly Qualified Technical Staff |
| (Makabate et al., 2018)     | Descriptive Statistics  | Public  | South Africa | Political Influence, Adequate Planning & Goal, Competence of PM, Adequate Funding, and Involvement of Owner |
| (B. Liu et al., 2018)       | Descriptive Statistics  | Public  | China   | Information Clarity, Client’s Timely Response, Adequacy of Resources, Information Diversity, and Disclosure of Results |

(Continued)
| Author                  | Methods used                | Project | Country    | Top project success attributes (findings)                                                                 |
|-------------------------|-----------------------------|---------|------------|----------------------------------------------------------------------------------------------------------|
| (Osei-Kyei et al., 2017)| Case Study                  | Public  | Ghana      | Government Commitment & support, Strong community support, Openness and constant communication, Project profitability and capable private partner |
| (Tripathi & Jha, 2017)  | Structural Equation Modeling| Any     | India      | Top Management Competence, Client Satisfaction, Effective Cost Control Measures, Resource Availability, and Supply Chain. |
| (Mukhtar et al., 2017)  | Structural Equation Modeling| Any     | Nigeria    | Institutional Framework, Availability of Competent Professionals, Effective Project Management, Asset Management, and Appropriate Design |
| (Luo et al., 2017)      | Structural Equation Modeling| Any     | China      | Information, Task, Technology, Organization, Environmental, and Goal Complexity                           |
| (Luzon & El-Sayegh, 2016)| Delphi-AHP                | Public  | UAE        | Quality, Project Cost, Delivery Method, Technical Competency of Firm, and Capability of Production Facility |
| (El-Maaty et al., 2016) | AHP                         | Public  | Egypt      | Efficient quality Assurance & Control, Availability of Sufficient Time for Overall Planning, preparation, Availability of Effective Cost and Budget Control, Effective designs and drawings and Scheduling |
| (Inayat et al., 2015)   | AHP                         | Private | Different Countries | Effective Technical Approval, Adequacy of Funding, Availability of Site Access, Project Size, and Clear Goals/Objectives |
Similarly, Shah et al. (2019) analyze the adoption of cleaner energy technology barriers in Pakistan using a modified Delphi and fuzzy AHP techniques.

Hence, the present study aims to continue the limited effort being taken toward the application of the hybrid Delphi–AHP technique to analyze and compare the potential critical success factors between the private and public sectors in the Ethiopian construction industry.

3. Research framework
This section describes the methods and statistical measures used to analyze the data collected in the study.

3.1. Questionnaire design
The present study utilized the classic relative AHP measurement approach to examine and compare the major CSFs in construction projects. In order to ease the analysis process, the questionnaire draft was organized as a pairwise comparison matrix. The questionnaire has two sections. The first section solicited the demographic information of respondents including organization, gender, professional experience, position, city, type of project, and volume of work (contract amount). However, the second section of the questionnaire contains the hierarchical CSFs based on the pairwise matrix comparison.

The relative weights of each indicator were developed using a nine-point scale comparison matrix as recommended by Saaty, (1990). The scale ranges between 1 = Equal Importance; 3 = Moderate Importance Over One Another; 5 = Strong Importance; 7 = Very Strong Importance; 9 = Absolute Importance; and 2, 4, 6, 8 are intermediate values between adjacent scale values. Prior studies highlighted that using a nine-point scale in CSF studies helps respondents to carry out their judgment intuitively (Gudiené et al., 2013; Hwang & Lim, 2013). Figure 1 briefly presents the research framework adopted for the study.

3.2. Delphi study
Delphi survey is one of the most widely applied techniques to get the perspective of experts and professionals and converge their opinion based on the initial issue raised for a study (Negash & Hassan, 2020). Prior studies reported that a two to three rounds of Delphi study is considered to be adequate to get the required result although the expert panel must reach a certain level of consensus before closure of the Delphi study (Olawumi et al., 2018). For the present study, a two rounded Delphi study was conducted in line with the AHP-based questionnaire survey to collect data from participants in the Ethiopian construction sector.

3.2.1. Experts panel selection
One of the key features of Delphi technique is the selection process of expert panel members. For the current study, purposive sampling was adopted to ensure that the invited professionals are well-informed about AHP and critical success factors in the Ethiopian construction sector. In this respect, different criteria were adopted to carefully select panel experts. These criteria include prior experience in the public and private construction sectors (5 years or more), educational background (Masters and PhD), location of projects, and their prior knowledge and commitment to participate in the study. The final list of participants of the Delphi survey comprised of a diversified group of experts with various professional background such as architects, structural and construction engineers, project managers, educators, and counter-part engineers.

Initially, a total of 85 Questionnaires were sent to the pre-selected experts in the public and private sectors through emails and face-to-face interviews. After 2 weeks, 18 experts from public and 21 experts from private sector responded to the invitation. The number of responses is considered to be satisfactory for such type of study (Alshehri et al., 2015). The demographic information of the panel experts is illustrated in Table 2.
3.3. Analytic hierarchy process

AHP is a powerful mathematical approach which assists in solving a complex decision problem by decomposing it into several criteria in a hierarchical structure (Gudienė et al., 2014; Taherdoost, 2018). It is based on a relative pairwise comparison matrix to prioritize criteria in a certain decision-making situation. AHP has several advantages when compared with other multi-criteria decision techniques. These include (1) the technique is not complicated because it is easier to compare the criteria in pairs than all at a time. It is also well mathematically grounded (Podvezko & Sivilevičius, 2013), (2) it is simple and straightforward, and it breaks down the problem into elements, which helps the problem to be discretely assessed (Hubbard et al., 2010), (3) AHP utilizes weighted factors for the criteria; this provides flexibility because the weighted factors can be modified to reflect changing priorities, and (4) it also provides a transparent and quantifiable way to assess multiple options/criteria.

Thus, due to the above advantages, the present study formulated the data collection and analysis framework based on the AHP. The basic steps in using AHP are briefly explained in the next section.
Table 2. Demographic information of respondents

| Items          | Number | Percentage |
|----------------|--------|------------|
|                | Public (P1) | Private (P2) | Public (P1) | Private (P2) |
| No. of respondents | 18      | 21        | 100         | 100          |
| Level of education |         |           |             |              |
| PhD            | -       | -         | -           | -            |
| MSc            | 18      | 21        | 100         | 100          |
| Profession     |         |           |             |              |
| Civil          | 11      | 9         | 61          | 43           |
| Architecture   | 1       | 4         | 6           | 19           |
| Construction   | 6       | 8         | 33          | 38           |
| Experience (Years) |         |           |             |              |
| 5–10           | 5       | 4         | 28          | 19           |
| 11–15          | 7       | 10        | 39          | 48           |
| > 15           | 6       | 7         | 33          | 33           |
| Organization   |         |           |             |              |
| Client         | 4       | 3         | 22          | 14           |
| Consultant     | 4       | 10        | 22          | 48           |
| Contractor     | 9       | 6         | 50          | 29           |
| Academia       | 1       | 2         | 6           | 9            |

3.4. Steps to AHP

3.4.1. Step 1—Development of a hierarchical model
The proposed hierarchical model for this study was developed after a systematic literature review and a mini-Delphi study to pre-select CSFs in the context of the Ethiopian construction sector. This model consists of three subsequent levels including the goal, “Prioritization of Critical Success Factors in Public and Private Construction Projects”, placed at the top level of the hierarchical model. The second level encompassed six distinct categories such as external environment, project aspects, project management team, client/owner, contractor, and consultant. These categories consist of a total of 19 CSFs representing both public and private construction projects.

(A) Category 1—External Environment: Every construction project depends on its ability to adapt the external pressure/environment which directly affects the successful completion of the construction projects. This category is comprised of three CSFs/attributes: economic environment, political environment, and social and cultural aspects.

(B) Category 2—Project Aspect: The overall project performance of any construction project depends on the adequacy and availability of funding and the type of project and the availability of technologies adopted in construction projects. Timely provision of monitory resources by the owner helps to ensure success. The project aspect category comprised of factors: adequacy of funds (Resources), project type, project size, and technology and innovation.

(C) Category 3—Project Management Team: Project Management Team is the third category in the hierarchical structure. This category consists of attributes such as commitment of PM team, past experience of PM team, and communication between PM team.

(D) Category 4—Client/Owner: A clear understanding of project goals during the inception and planning stages helps owners to ensure successful completion of projects. Progress of construction projects can also be monitored efficiently when objectives are clearly set out by the
client. In this respect, the fourth category in the hierarchical structure comprised of clear project goals and moderate change orders.

(E) Category 5—Contractor: It is known that project success/failure is directly related to the capacity of the construction company. During contract signing, the contractor is obliged to finish the project as per the specification depicted in the contract document. Furthermore, the contracting firm is responsible for ensuring the safety of its workers, as well as the project. This component consists of factors such as competency of contractor, health and safety management, experience of contractor, and financial capacity of contractor.

(F) Category 6—Consultant: Consulting firms are one of the major stakeholders that play a vital role to the outcome of construction projects. Consultants normally involved at the early stages of the project, and the achievement of high-quality work ensures future market improvement. Hence, Consultant's Track Record, Competency of Consulting Firm, and Cooperation of Consultant are considered as the critical factors that affect the success of projects at every stage of the project life cycle. Figure 2 shows the hierarchical model adopted in this study.

Figure 2. Hierarchical model of the present study.
3.4.2. Step 2—Computation of Eigenvalues (relative weights)

The relative criteria weights for each attribute can be calculated through the pairwise comparison technique developed by Thomas Saaty (Saaty, 1988). The expert responses were then computed by normalizing the data, which is dividing each response by the total column sum inside the pairwise comparison matrix \( A_w = ||a_{ij}|| \), where \( n \) is the number of criteria in the matrix. The matrix elements represent the relationship among the unknown relative weights \( \omega_i \) of each criterion. Eq. 1 illustrates the composition of the principal matrix \( A_w \).

\[
A_w = \begin{bmatrix}
a_{11} & a_{12} & \ldots & a_{1n} \\
a_{21} & a_{22} & \ldots & \ldots \\
\ldots & \ldots & \ldots & \ldots \\
a_{n1} & \ldots & \ldots & a_{nn}
\end{bmatrix} \quad (i, j = 1, 2, \ldots, n)
\]

During the next stage, the influence of each criterion to the level above is represented by the eigenvector, also known as a priority vector. The criteria weights and the eigenvector \( \omega \) are the normalized components of the eigenvector corresponding to the largest eigenvalue \( \lambda_{\text{max}} \) of the matrix \( A \) (Eq. 2):

\[
A.\omega = \lambda_{\text{max}}.\omega
\]

The eigenvector asserts the relative weights of each criterion under each level. It is obtained in an approximate manner by calculating the mathematical average of all criteria (Saaty, 1988). The values found in the eigenvectors reveal the weight of that criterion relative to the total result of the goal. In the process of synthesis, the local, global and the overall priorities will be computed. Local priority vectors are the essentials of the hierarchical structure found with regard to the level from which they appear. These priority vectors are obtained from the pairwise comparison matrices using any of the geometric mean procedure.

The final priority weights can be aggregated using the geometric mean method (GMM). In this method, all priorities from individual experts are synthesized into a single priority criterion for decision-making (Chen et al., 2018; Gudienė et al., 2014). GMM is used to calculate the total priority estimate of each criterion considering all levels of the hierarchical model (Yadav & Jayswal, 2013).

Hence, if the hierarchical model consists of more than two levels, the overall priority (global weight) of one factor with regard to the goal is the successive product of the relative weights (local weights) obtained at each level of the hierarchy (Shah et al., 2019; Srdevic et al., 2011). Therefore, the final priority vector reproduces the relative importance of the factors with respect to success of the project.

Eq. (3) and (4) show the geometric mean for synthesizing individual priorities.

\[
(a_1, a_2, a_3, a_4, \ldots, a_n) = \left( \sum_{i=1}^{n} a_1 \right)
\]

So,

\[
G(a_1, a_2, a_3, a_4, \ldots, a_n) = (a_1, a_2, a_3, a_4, \ldots, a_n)^{1/n}
\]

where \( G \) is the geometric mean of each priorities, \( a \) is the priority weight given by an expert, and \( n \) is the number of respondents.

Then, the global weight of each parameter is calculated as shown in Eq. 5.

\[
G.W_{p,i} = W_{F,i} \ast W_{C,i}
\]
where i is the level of the hierarchy, \( W_f \) is the local weight of factor, and \( W_c \) is the local weight of category

3.4.3. Step 3—Checking consistency of judgements

After computing the global weights using GMM, it is imperative to determine the consistency of respondents’ judgements using consistency index (Gudienė et al., 2014). The consistency index (C.I.) measures the consistency of expert opinions using \( \lambda_{\text{max}} \), which is calculated by summing the product of each element in the eigenvector. The degree of consistency of each individual expert’s judgement is calculated by using the formula (Eq. 6):

\[
CI = \frac{\lambda_{\text{max}} - n}{n - 1}
\]

(6)

where \( \lambda_{\text{max}} \) represents the maximum eigenvalue of matrix \( A_w \) and n is the number of the criteria

The level of the consistency of matrix \( A_w \) could be computed using the calculated CI in the evaluation matrix compared with a randomly generated index R.I. found in the same row of the inversely symmetric matrix (Saaty, 1990). Then, the consistency ratio (C.R.) is referred to as the ratio of CI calculated in a particular matrix to the mean value of random index (R.I.). The formula for the computation of C.R. is shown in Eq. 7.

\[
\text{C.R.} = \frac{\text{C.I.}}{\text{R.I.}}
\]

(7)

The AHP authenticates a C.R. to measure the consistency of experts’ judgments arranged in pairwise comparisons through the survey output. A C.R. value above 0.10 indicates that the expert is considered to provide reasonable response to the questions (Kil et al., 2016). The C.I. value examines the consistency of a certain matrix of order “n” to determine how much inconsistency has occurred in a pairwise matrix.

3.4.4. Step 4—Ranking of CSFs

Finally, priority values and rankings of the significant factors for overall project performance were determined for each expert. The level of agreement (\( \chi^2 \)) values for the rankings was calculated to ascertain the level of association between experts hailing from the same organizational background (Inayat et al., 2015). Priority values of experts from the same type of organization were only averaged if the calculated value of \( \chi^2 \) was more than the critical value at a 95% level of confidence.

The final rankings for the categories in level 2 are determined by computing the global weights. However, the rankings for the factors in levels 3 are determined through local vector weights. From the hierarchical structure, it can be clearly shown that the relative weight of the higher level factors significantly affects the relative weights/rankings of the lower level attributes (Hwang & Lim, 2013).

4. Findings

This section summarizes the analysis and major findings of the present study. The data were analyzed using Expert Choice 11 software package.

4.1. Analysis of category (level 2) factors

The first part of the Delphi–AHP analysis focused on comparative investigation of both sectors in the Ethiopian construction industry. The data were analyzed in two rounds of Delphi survey. Based on the first round of the Delphi–AHP analysis, the private sector tends to rely on the effect of major stakeholders including owner (30.8% of influence), contractor (21.6% of influence), and consultant (23.4% of influence) on the success of construction projects. However, in public construction
projects, apart from owner (21.7% of influence) and contractor (20.3% of influence), project-related factors are considered to be influential with 20.3% in the public sector. Table 3 summarizes the first round of Delphi–AHP analysis of categorical (Level 2) CSFs in the hierarchical model.

In the second round of the Delphi–AHP analysis, there was no major change in the decision of experts in private projects (Table 4). Nevertheless, experts in the public sector re-assessed their primary perception and decided that project-related factors are the most influential factors in public infrastructure projects followed by contractor and consultant. Recent studies reveal that factors such as project planning including project feasibility, supply chain, and delivery methods are a few of the critical factors that affect success in public infrastructure projects (Dithebe et al., 2019; Sinesilassie et al., 2018). The second round of Delphi–AHP analysis results is summarized in Table 4.

### 4.2. Analysis of success attributes (level 3)

The objective of this study is to examine the top CSFs which affect the success of construction projects in the Ethiopian construction industry. The Delphi–AHP analysis is organized based on private and public construction sectors.

**Table 3. Comparison of categorical CSFs in private and public projects (first round of Delphi–AHP result)**

| Private construction projects (1st Round) | Public construction projects (1st Round) |
|-----------------------------------------|----------------------------------------|
| Category                                | Relative weight | Percentage (influence) | Category                                | Relative weight | Percentage (influence) |
| Owner                                   | 0.308          | 30.8%                  | Owner                                   | 0.217          | 21.7%                  |
| Contractor                              | 0.216          | 21.6%                  | Project-related factors                 | 0.203          | 20.3%                  |
| Consultant                              | 0.234          | 23.4%                  | Contractor                              | 0.212          | 21.2%                  |
| Project-related factors                 | 0.124          | 12.4%                  | Consultant                              | 0.172          | 17.2%                  |
| External environment                    | 0.067          | 6.7%                   | External environment                    | 0.111          | 11.1%                  |
| Project management team-related factors | 0.052          | 5.2%                   | Project management team-related factors | 0.073          | 7.3%                   |

**Table 4. Comparison of categorical CSFs in private and public projects (second round of Delphi–AHP result)**

| Private construction projects (second round) | Public construction projects (second round) |
|---------------------------------------------|---------------------------------------------|
| Category                                    | Relative weight | Percentage (influence) | Category                                | Relative weight | Percentage (influence) |
| Owner                                       | 0.317          | 31.7%                  | Project-related factors                 | 0.254          | 25.4%                  |
| Consultant                                  | 0.199          | 19.9%                  | Contractor                              | 0.219          | 21.9%                  |
| Contractor                                  | 0.192          | 19.2%                  | Consultant                              | 0.169          | 16.9%                  |
| Project-related factors                     | 0.150          | 15%                    | External environment                    | 0.153          | 15.3%                  |
| External environment                        | 0.081          | 8.1%                   | Owner                                   | 0.136          | 13.6%                  |
| Project management team-related factors     | 0.062          | 6.2%                   | Project management team-related factors | 0.068          | 6.8%                   |
In private construction projects, the potential CSFs are clear project goals (weight = 0.238), moderate change orders (weight = 0.101), competency of consulting firm (weight = 0.090), financial capacity of contractor (weight = 0.076), and consultant’s track record (weight = 0.074). However, commitment of PM team (weight = 0.018), project type (weight = 0.016), social and cultural aspects (weight = 0.013), project size (weight = 0.012), and communication between PM team (weight = 0.011) resulted in the lowest ranking during the first round of the Delphi survey (Figure 2).

When it comes to public construction projects, experts perceived that clear project goals (weight = 0.165), adequacy of funds (resources) (weight = 0.121), financial capacity of contractor (weight = 0.104), competency of consulting firm (weight = 0.083), and political environment (weight = 0.073) as the top CSFs in the Ethiopian construction industry. Similarly, the bottom ranked success factors in public sector are project size (weight = 0.083), communication between PM team (weight = 0.083), health and safety management (weight = 0.083), project type (weight = 0.083), and social and cultural aspect (weight = 0.083). Figure 2 illustrates the first round of Delphi survey results of both the private and public construction sectors.

During the second round of the Delphi survey, experts were asked to re-evaluate their initial perception considering the overall perspective of other fellow experts in the construction industry. In this case, only a few changes have been made on the top five CSFs for private construction projects. Consequently, clear project goals (weight = 0.254), financial capacity of contractor (weight = 0.082), competency of consulting firm (weight = 0.081), adequacy of funds (resources) (weight = 0.074), and consultant’s track record (weight = 0.066) become the top five CSFs in the private sector (Figure 3). Consequently, since only a few changes were recorded in global as well as local weights of Level 2 and Level 3 factors, the final rankings are made based on the summary analyzed in the second round of the Delphi survey.

Clearly, the result indicates that owner/client-related factors are deemed as the most critical attributes that affect the success of private projects in the Ethiopian construction sector. The result supports the notion that client is known to be the dominant stakeholder when it comes to private projects (Gebremariam & Dinku, 2018). In the current Ethiopian construction setting, the private sector plays an important role in the development of market complexes, service sector, and industrial projects (Ethiopian Ministry of Finance and Economic Development (MoFED) Report, 2017). Thus, among others, the successful completion of construction projects mainly relies on the overall capacity and efficiency of clients.

**Figure 3. First round of Delphi-AHP result for private (left) and public (right) construction sectors.**
Similarly, experts working in the public infrastructure sector also gave the chance to assess their prior perception regarding CSFs in the second round of the Delphi survey. Hence, based on the respondents’ opinion, adequacy of funds (resources) (weight = 0.133), political environment (weight = 0.092), clear project goals (weight = 0.09), competency of contractor (weight = 0.089), and technology and innovation (weight = 0.086) ranked as the top CSFs in public projects.

The experts made major changes during this round of the Delphi–AHP analysis. All prior top five success attributes were changed in position and the professionals now agreed that project-related factors and external environment factors are considered to be relatively more important than other categories in the public construction sector.

5. Discussion and implication
This study explored the major success-related factors in private and public construction projects based on the opinion of experts in the Ethiopian construction sector. The analysis in the last section of this paper presented the decision of those experts based on the Delphi–AHP method. Hence, the practical implications of the output including recommendations for both sectors are given below.

5.1. Common CSFs in both private and public sectors

5.1.1. Adequacy of funds (resources)
The result indicated that “adequacy of funds (resources) is one of the common top ranked CSFs in both private and public construction sectors. The results coincide with the findings of (Chileshe et al., 2020; Mukhtar et al., 2017). For instance, Mukhtar et al. (2017) reported that availability of funding and effective financial management is crucial for the success or projects, although proper regulations need to put in place to ease the coordination among stakeholders (Chileshe et al., 2020).

Nevertheless, literature highlighted that the success of infrastructure projects is affected by the availability and extent of allocated budget including the availability of resources such as competent professionals, materials, machinery, and equipment’ (Dithebe et al., 2019). When it comes to low-income countries, ensuring the availability and adequacy of project funding throughout the project life cycle help to improve the overall project management within the project team (El-Maaty et al., 2016).
5.1.2. Clear project goal
The other common success factor in both sectors is clear project goal. It is imperative to denote that having a precise project goal paves the way for proper design, procurement, and coordination between project team (Hwang & Lim, 2013). A recent study by Aneesha and Haridharan (2017) reported that the client’s negligence to have an adequate front-end planning is arising from the failure to undertake proper feasibility study in construction projects. In this context, recent studies also reported that imposing political motivation during goal inception, allocate inappropriate time for project planning, poor project management, and change orders are among the major challenges in the Ethiopian construction sector (Gebremariam & Dinku, 2018; Sinesilassie et al., 2018).

Project goal often relate to the outcome of the assignment. In Singapore, recent studies reported that realistic obligations and adequate project objectives and scopes help to ensure success in construction projects (Hwang & Lim, 2013; Kog & Loh, 2012). In Ghana, (Osei-Kyei & Chan, 2017) argued the importance of project scope definition during the early stages of the project life cycle. In India, Tripathi & Jha, (2017) asserted the importance of organizational commitment in relation to project goal. In addition, the authors reported the positive relationship between clear project scope and organizational success. In conclusion, all previous studies conducted in different parts of the world agreed the importance of clear project goals and scopes to certify successful completion of construction projects.

5.2. Private construction projects
The private construction business sector is thought as one of the fundamental enablers in the development of emerging markets (Mukhtar et al., 2017). Basically, the private construction sector involves in financing self-capital expenditure, establishing market share and involvement in job creation, as well as entrepreneurship schemes (Debela, 2019; Dithebe et al., 2019). This study identified financial capacity of contractors, competency of consulting firm, and consultant’s track record as the top distinct success drivers to the private construction sector. In these respect, the private sector initiatives such as inducing co-financed market-based programs and ensuring collaboration among construction organizations help to improve the overall performance of project management and in turn lead to infrastructure development (Calderon et al., 2018). Based on the findings, the recommended actions to be taken for the top five CSFs in private construction projects are highlighted in Table 5.

5.2.1. Financial capacity of contractor
The Delphi–AHP result indicates that financial capacity of contractor is the second top influential factor in private sector with a relative weight value of 0.082. Construction firms are expected to be competitive in terms of finance, man power, and related resources to service in the current competitive construction business environment (Gudienė et al., 2014). Similarly, Negash and Hassan (2020) reported that having a consistent financial monitoring and evaluation within an organizational structure reduces inconsistencies and cost overruns, and these lead to a healthy financial standing of construction firms.

5.2.2. Competency of consulting firm
The result reveals that competency of consulting firm (relative weight = 0.081) ranked third in the analysis of private construction projects. Competency of consulting organizations can be viewed in the dimensions of knowledge, functionality, technical, and value/ethical aspects (Gebremariam & Dinku, 2018). These dimensions enable organizational fitness to given project scope and complexity of projects.

5.2.3. Consultant’s track record
The fifth CSF in the private sector is consultant’s track record with the relative weight of 0.066. The consulting firms experience and track record has been considered as having an influence in project success (Kog & Loh, 2012). This suggests it is imperative to ensure that the top management assign/hire their experienced employees from previous successful projects to work on the future once.
5.3. Public construction projects
In recent years, there is a growing initiative of the PPP in construction projects, particularly in infrastructure, real estate, and housing sectors (Ke et al., 2010). Despite the growing initiative to improve the overall performance of public infrastructure projects, the public sector is still associated with low efficiency, fragmentation, and weak collaboration among stakeholders (J. Liu et al., 2016). The African Development Bank Group (2017) report suggests that the close partnership of the private and public sectors is an important enabler in emerging African countries (Manai, 2017). The recommended actions for the top ranked CSFs in public sector are shown in Table 6.

5.3.1. Political environment
Political environment (relative weight = 0.092) was ranked as the second influential success attribute in the Delphi-AHP study. The result coincides with the findings of (Makabate et al., 2018; Mukhtar et al., 2017; Osei-Kyei et al., 2017). For instance, Mukhtar et al. (2017), in the Nigerian construction sector, reveal that a stable political environment including government’s initiative to encourage the private sector to participate in major developmental projects is essential for success in the construction industry. The findings also pressed the importance of constant dialogue between stakeholders to provide legal structures, improve collaboration among project team, and strict guidelines to properly manage project budget (Dithebe et al., 2019).

More so, Debela (2019) recommended that government’s role to influence public awareness creation of through public–private sector partnership helps to improve technical competency of

Table 5. Critical recommended actions for top five CSFs in private construction sector

| CSFs in private construction projects | Recommended actions |
|--------------------------------------|----------------------|
| Clear project goals                  | • Provide sufficient time for planning and feasibility study  
                                      | • Ensure detailed project layout including funding requirements  
                                      | • Recruit a project management consultant to assist planning |
| Financial capacity of contractor     | • Improve the procurement process  
                                      | • Choose compatible delivery and contract methods  
                                      | • Develop a mechanism to closely work with financiers and suppliers |
| Competency of consulting firm        | • Organize consistent and multi-sectorial trainings to improve skill and professionalism of employees  
                                      | • Develop recruitment, performance monitoring, and incentive mechanisms  
                                      | • Jointly work with academia institutions to ensure capacity development programs |
| Adequacy of funds (resources)        | • Ensure design efficiency including design alternatives  
                                      | • Find different financial schemes to cover project cost  
                                      | • Allow enough contingency fund during contracts  
                                      | • Evaluate proposed key project objectives before commencement |
| Consultant’s track record            | • Manage and re-evaluate previous project experiences to pinpoint firm weakness and take measures  
                                      | • Formulate a database to record firm’s overall project-based performance to facilitate future procurement process |

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construction firms and attracts international funding agencies. In this sense, government should ensure the involvement of these local construction organizations in major infrastructure projects.

5.3.2. Competency of contractor
The fourth ranked CSF in public projects is competency of contractors with a relative weight of 0.089. Firm competency in the construction business environment is characterized by technical, financial, and managerial aspects of an organization (Abdullah et al., 2018). Any construction organization involved in major developmental infrastructure projects must ensure financial and technical capacities prior to procurement, equipped with machineries and devise project oriented and dynamic organizational structure to stay in the competent market (Aneesha & Haridharan, 2017).

Prior studies also confirm the need for mapping frameworks to enhance organizational competencies to ensure competitiveness in the market (Kog & Loh, 2012; Murphy & Nahod, 2017). For instance, Hosseini et al. (2017) highlighted the need for skilled personnel, as well as competency between stakeholders to improve project management in mega infrastructure projects in Iran (Hosseini et al., 2017). However, Inayat et al. (2015) suggested that competency of stakeholders involving in a certain project is one of the top influential factors that affect success in construction projects.

5.3.3. Technology and innovation
Based on the findings, technology and innovation (relative weight = 0.086) is ranked as the fifth top factor which influence the success of public sector in the Ethiopian construction context. In most

| CSFs in public construction projects | Recommended actions |
|-------------------------------------|----------------------|
| Adequacy of funds (resources)       | • Ensure efficient utilization of fund from donor agencies  
|                                     | • Place effective project control and monitoring schemes in developmental infrastructure projects  
|                                     | • Encourage local construction firms to engage in public sector  |
| Political environment               | • Choose appropriate project delivery to ensure tangible public benefits  
|                                     | • Place political motives aside and focus on public requirement  
|                                     | • Encourage the public sector and facilitate financial difficulties  
|                                     | • Develop PPP schemes to facilitate infrastructure development  |
| Clear project goals                 | • Engage the public during project planning and decision phase  
|                                     | • Study economic value (benefit) of projects to select the right infrastructure projects  |
| Competency of contractor             | • Provide sufficient professional as well as managerial trainings to improve competency  
|                                     | • Work in Joint Ventures and other collaborative methods  
|                                     | • Find different financial sources  |
| Technology and innovation            | • Devise technology adoption policies and guidelines  
|                                     | • Provide consistent trainings and courses to stakeholders  
|                                     | • Engage universities to include technological courses in curriculums and capacitate both the undergrad and graduate students  |
cases, previous literature reported that inefficient technological infrastructure is an inhibitor to project success when it comes to low-income countries (Akerere and Moses, 2016; Nasila & Cloete, 2018). This is due to the fact that infrastructure projects in these countries are construction with major budget constraints and are mainly dependent on the requirement of funding agencies such as the World Bank (Tagesse & Dinku, 2017).

Nevertheless, the impact of technology and innovation in developmental infrastructure projects cannot be overemphasized (Mosley & Bubshait, 2016; Olanrewaju et al., 2020; Olawumi & Chan, 2019). For instance, the popularity of building information modeling (BIM) adoption in certain emerging markets such as Nigeria, Tanzania, and South Africa paves the way for future introduction of new technological advancements in major public infrastructure projects, particularly in the sub-Saharan African region (Ezeokoli et al., 2016; Kekana et al., 2020). Moreover, the initiative of the Ethiopian government to implement BIM in certain public projects in the near future encourages local construction firms' to associate BIM, as well as other technologies in their own organizational structures (Getachew & Jekale, 2018).

6. Conclusion
The purpose of the study was based on the comparative analysis of project-specific success factors in private and public construction projects. To achieve the objectives, a comprehensive hierarchical model was developed based on the systematic literature review conducted in developing countries. The hierarchical model is then used to develop a structural questionnaire draft to collect empirical data from panel of experts based on a hybrid Delphi-AHP technique. Based on the findings, the top ranked CSFs in the private construction projects are clear project goals, financial capacity of contractor, competency of consulting firms, adequacy of funds (resources), and consultant’s track record. However, CSFs such as adequacy of funds (resources), political environment, clear project goals, competency of contractor, and technology and innovation are the major CSFs in public construction projects.

Based on the findings, the relative weight of CSFs for private construction projects ranges between 0.254 (clear project goals) to 0.011 (project size). Similarly, for the case of public construction projects, adequacy of funds (resources) ranked first with a relative weight of 0.133, whereas project type ranked last with a corresponding relative weight of 0.013. Further, the results outline that clear project goals and adequacy of funds (Resources) are the common CSFs in the top five rankings by professionals in both sectors. Hence, the findings reveal a consensus on the rankings among experts in the private and public construction sectors.

The contributions of the study to the body of knowledge and practical implications are expressed as follows: (1) this study demonstrated the application of Delphi-AHP technique in critical success factor studies within the construction industry, (2) for the first time the paper examined the CSFs in public and private construction sectors in the Ethiopian construction industry, (3) the other significant contribution of this study is that it provides theoretical and practical insights, including key recommendations to enhance the project management practices within the Ethiopian construction sector. Further, the study expands the efforts of CSFs studies in emerging markets, particularly in the sub-Saharan Africa, a region known to have inadequate and inefficient infrastructure development.

This study also has a few limitations. In terms of project types, the current study employed the generalized concept of projects was used during the analysis although it is common to implement such a notion in prior studies. In this regard, future studies may focus on the comparative investigation of CSFs considering different types of projects such as residential, commercial, industrial, etc. In addition, although the implementation of a large sample size was adopted to accommodate the diversity of experts, it still has flaws to get various perspectives of professions. A suggestion for future research could be systematically choosing appropriate and diverse number of experts for participation and the long-term success factors of construction projects should be
studied. More so, further studies on the introduction of Delphi–AHP technique in the construction industry would be a good area of exploration.

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