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A COMPREHENSIVE ANALYSIS OF HIGH-RISE CONSTRUCTION COSTS IN ADDIS ABABA

M.A. Thesis By

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BY

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APPROVED BY BOARD OF EXAMINERS

The undersigned have examined the thesis entitled “A COMPREHENSIVE ANALYSIS OF HIGH-RISE CONSTRUCTION COSTS IN ADDIS ABABA” presented by Yitref Derbie, a candidate for the degree of Master of Art and hereby certify that it is worthy of acceptance.

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DECLARATION

I certify that this research work titled “A COMPREHENSIVE ANALYSIS OF HIGH-RISE CONSTRUCTION COSTS IN ADDIS ABABA” is my own work. The work has not been presented elsewhere for assessment and award of any Degree/Diploma.

YITREF DERBIE	______________	______________
Name	**Signature**	**Date**

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LISTS OF ABBREVIATIONS/ACRONYMS

AC	Air Conditioning
ANN	Artificial Neural Network
BUA	Built Up Area
BMS	Building Management System
BCI	Building Cost Index
BOQ	Bill of Quantity
CER	Cost Estimation Relationships
CSF	Cost Significant Factor
CSI	Cost Significant Item
CEO	Chief Executive Officer
CPI	Consumer Price Index
CCI	Construction Cost Index
ETB	Ethiopian Birr
FDRE	Federal Democratic Republic of Ethiopia
EiABC	Ethiopian Institute of Architecture and Building Construction
ESA	Ethiopian Statistics Agency
GDP	Gross Domestic Product
GEA	Gross External Area
GIA	Gross Internal Area
HCB	Hollow Concrete Block
HQ	Headquarter
IT	Information Technology
NIA	Net Internal Area
PMI	Project Management Institute
SPSS	Statistical Package for the Social Sciences
UN	United Nations
USD	United States Dollar

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ABSTRACT

There are various occasions when it is important to know the construction cost of high-rise buildings and related cost drivers. Government offices estimate the costs of high-rises for property tax purposes. Private companies like Insurances *estimate costs for the base price, banks and lenders for collateral, project developer for budgeting or related uses. The construction of high-rise buildings in Ethiopia is an emerging sector with technological advancement within a short period of time. In regard, availability of adequate references about the cost and related cost drivers of high-rise buildings rare in Ethiopia in general and in Addis Ababa in particular. The number of high-rises used for analysis are 15 buildings selected with different criterion. Survey questionnaires are distributed to the purposively selected respondents to identify the cost-significant factors. The factual data of 11 high-rise buildings was collected to analyze the unit prices and assess the cost-significant factors of building high-rises. Semi-structured interviews were conducted to strengthen, integrate, and validate the results from the analysis of the factual data and survey questionnaires. Descriptive statistics were employed to analyze the survey data. The first five identified cost-significant factors are the building's height, function, electromechanical systems, ceiling types, and BMS. The study has also estimated the percentage of cost-significant items to the total construction cost and the range of unit prices per square meters. The first three identified cost-significant items that impacts the construction cost of high-rise buildings are architectural, structural, and BMS works having the average percentage of 43%, 31%, and 12% respectively. Furthermore, the study has estimated the unit price to construct high-rise buildings which ranges between 33,000.00 ETB/m2 to 93,0000.00 ETB/m2 with a weighted average of 66,0000.00 ETB/m2.*

Keywords: High-rise buildings, Cost, Cost-estimate, Construction-cost, Estimate

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

The development of high-rise buildings in central areas of cities is increasing day-by-day for the sake of being a solution for the scarcity of land. High-rise buildings play a vital role in defining livable and sustainable cities (Mir M & Aksamija, 2008). As stated by Ali (2008) high-rise buildings (skylines) are becoming important and symbolic. They form a local emblem for cities besides being symbols of industrialized and economically prosperous culture. Skylines are not typically fixed and finished but reflective of continuing social change. High-rise buildings signify an element of economic power and a sign of advantage to the country, and consume a large-number of people with a piece of land.

Addis Ababa, the capital city of Ethiopia most of the time called the "African Capital" due to its historical, diplomatic, and political significance for the continent (Fisher et al., 2018; State University of New York Press, 2009), can perfectly witness the speed of the development of high-rise buildings in big towns. According to population growth projections, the city has had a rapid population growth rate, from 2.9 million in 2010 to 3.86 million in 2022 (CSA, 2013). Addis Ababa city is witnessing increasing demographic expansion due to migration from surrounding rural areas, leading to urban stretch, housing demand, increase in the cost of land. Given this demand, high-rise structures have become a solution (Fasil, 2017). As the cities become dense, the tendency to develop buildings vertically continues in response to the shortage of land and the growing economic needs (Gebremichael, 2016).

With the development of high-rise buildings, an effective cost estimation technique is a main component for budgeting, scheduling, decision-making, valuation, and soon. Despite this, there are many challenges to accurate estimation faced by project managers, sponsors, clients and valuers (De Jong & Van Oss, 2007). The absence of effective cost estimating may affect the success of a construction project completion (Al-shanti, 2003; Ayed, 1997), where it allows owners and planners to evaluate project feasibility and control costs effectively, and enables the project sponsors to decide knowledgeably at the early phase (Cheng et al., 2010; Günaydin & Doğan, 2004). Cost estimates provide a measure against which to control costs (Kadiri, 2016). It can also be used to assess project viability, obtain funding, manage cash flow, allocate resources, estimate the duration and prepare tender prices (Kelly et al., 2002). Studies show that a good-cost estimation enables real estate professionals to get a reliable prediction of replacement costs (Elfahham, 2019; Hansen, 2006).

Despite this, the challenges of cost estimation increase when building heights get higher and higher due to the addition of features and technologies to the construction methodology. To ease this challenge several countries, especially the developed nations have a detailed construction cost index with revisions of monthly, quarterly, and yearly periods (Sources and Methods, 2016).

Construction of high-rise office building costs varied for selected cities worldwide as of July 1, 2019. In the same year, constructing standard high-rise office buildings in New York costs about six thousand U.S. dollars per square meter. At the same time, office to high-rise buildings in Ho Chi Minh cost 834 U.S. dollars per square meter (Statista Research Department, 2022). In Kenya it ranges from 600 to 1000 US Dollar, while in South Africa lies between 800 to 1040 USD per square meter (AECOM SA, 2021).

The construction cost of high-rise buildings in Addis Ababa may not be similar in the global experiences. Even the practice of constructing high-rise buildings is at early age, and studies related to the construction cost per square meter of high-rises not expected to be easily available.

1.2. Statement of the Problem

In the preliminary stage of a construction project in Addis Ababa, there is a lack of available forecasting data, and unstable market conditions which result in inaccurate estimation (Negussie, 2017). According to Akintoye (2000) cited by Negussie (2017) the construction industry, in general, is known for having poor cost estimating & forecasting practices. These imprecise cost estimation practice has led projects to exhibit cost overruns, time extensions, and failure to realize their intended benefit or even from the fact that totally terminated and abandoned before or after their completion due to conflicts among parties Idoko (2008) cited by (Yimam, 2011). Building contractors, cost estimators, project developers, and property valuers always need precise construction cost estimates (Andom, 2008).

The study has been trying to find previous research about cost estimation practices of high-rise buildings in Addis Ababa. Though there are studies about the cost estimation of buildings in general, it was not easy to find a study that specifically addresses the cost-estimation and Cost-significant factors of building high-rises in Addis Ababa. The estimation of replacement costs for high-rise buildings poses a significant challenge in practice. Despite available literature, there remains a gap in understanding the specific factors influencing these costs, hindering effective decision-making in urban development.

In other developed and developing countries, there are several written sources, cost indexes, and other forecasting tools. For example in Nigeria, Yemen, Kenya and Abudabi there are construction cost indices across the web (AbuDhabi & Statistic Center, 2015; Kadiri, 2016; The Instiutue of Quantity Surveyors of Kenya, 2019; Vorotyntseva et al., 2018). In study papers of the global and continental levels the building construction prices of many developing nations are included, but finding Ethiopia's row in such publishing is not yet simple (AECOM SA, 2021; Gardner & Pienaar, 2019; Statista Research Department, 2022). Therefore, the purpose of the study is to analyze the construction cost of high-rise buildings in Addis Ababa based on the basic research questions indicated here under.

- What are the cost-significant factors contributing to variations in construction costs for high-rise buildings in Addis Ababa?
- How do these factors differ across different types of high-rise structures?

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1.3. Objectives

1.3.1. General objective;

The general objective of the study is to evaluate the construction cost and cost-significant items of high-rise buildings in Addis Ababa.

1.3.2. Specific objectives;

The specific objectives of the study are to;

1. Identify the cost-significant factors to the construction cost of high-rise buildings in Addis Ababa.

2. Assess the percentage of identified cost-significant items to the total construction cost of high-rise buildings in Addis Ababa.

3. Provide practical recommendations about cost-forecasting strategies in high-rise construction projects in Addis Ababa.

1.4. Significance of the Study

As far as the researcher's knowledge is concerned, study papers focusing specifically on the construction cost of high-rise buildings are less available. Therefore, this may create a chance to make further studies about cost estimation practices of high-rise buildings and it may add something of value to the existing body of knowledge.

Investors and financial institutions can benefit from a better understanding of the construction costs in high-rise projects, aiding in risk assessment and investment decision-making, thereby contributing to economic development in the city and the country.

Furthermore, the study also can fill existing gaps in the academic literature related to high-rise construction costs in AA, serving as a reference for future research endeavors and contributing to the broader field of construction management, property valuation and urban studies.

1.5. Limitation of the Study

Many contractors, consultants or even owners do not agree easily to share the actual cost data with other competing firms. Moreover, most believe that such information usually makes a difference in being more competitive in the market (Shehatto, 2013). For such reasons, this study faces obtaining the detailed cost information from the owners of high-rise buildings.

The economic changes, such as inflation could impact the accuracy of cost assessments, especially when analyzing historical cost trends. Also, the subjective interpretation of the study's findings may introduce bias, impacting the objectivity of the recommendations.

1.6. Study scope

From a budget and time perspective, the study decides to frame the scope mainly by building height, construction progress, year of construction, and geographical location. Accordingly, all the high-rise buildings that fulfil the following criteria are included in the process of the study;

- All high-rise buildings that have storeys between 20 and 40 floors above ground level.
- All high-rise buildings if the current construction progress is completed or at the finishing stage with a signed contract for the remaining works. This criterion is used to include all high-rises with complete cost of information and helps to exclude buildings with partial cost data.

- All high-rise buildings constructed since 2011, and a date of completion shall be within 5 years. This helps to minimize the impact of time-to-cost change and reduces errors of the inflation adjustment to the selected time baseline.
- The study delimited to the three sub-city of Addis Ababa which are **Bole**, **Kirkos**, and **Yeka** since these are the location for most high-rise buildings in Addis Ababa. Besides owners, the giant construction contractors, and consultants of high-rise buildings have either headquarters or branch offices in Addis Ababa and this would facilitate the collection of the relevant data.

1.7. Study design

To achieve the study objectives mixed method of research was employed. The study involves the use of both qualitative and quantitative data. The application of this approach enabled the study to get strong and reliable results (Creswell & Plano Clark, 2007) in (Wisler, 2009). Key Informant interviews are conducted, and survey questionnaires are distributed to respondents.

1.8. Ethical Considerations

The ethical guidelines were in place during conducting the study, which includes keeping the research data confidential throughout the study, the data collected based on voluntary data sources, personal names mentioned if permission obtained in advance only, the aim and methods explained to respondents, and last but not least the confidentiality and anonymity of individual respondents assured.

1.9.Dissemination of the Result

It is EiABC's requirement that a publishable article shall be extracted from the study to complete the thesis work. Therefore, the results from this research shall be published on available platforms to the researchers, learners and otherwise generally benefit society.

CHAPTER TWO

LITERATURE REVIEW

Construction Cost estimating is an essential part of construction projects, where cost is considered as one of the major criteria in decision making at the early stages of building design process (Doğan, 2004). The accuracy of estimation is a critical factor in the success of any construction project. In some cases, a potential overrun may result in changing a project to a design-to-cost task (Feng & Li, 2013).

Subsequently, the cost of high-rise buildings needs to be estimated within a specific accuracy range, but the largest obstacles standing in front of a cost estimate are lack of preliminary information. As such, to overcome this lack of detailed information, different cost estimation techniques are used to approximate the cost within an acceptable accuracy range (Verlinden et al., 2008).

Comprehensive exercises based on detailed and accurate information are required to achieve reliable levels of comfort. For various reasons, however, decisions are often based on inclusive rate estimates, i.e. rate per square meters (m^2) of construction area or rate per unit in number (AECOM SA, 2021).

According to an international report (*Property & Construction*, 2021), the most widely used and quick method to obtain an indication of the construction cost of a building is by the rate/m^2-on-plan method which often referred to as the 'order of magnitude' method of cost estimation. According to the report it is both quick and convenient, but if used indiscriminately and without taking care when calculating, it can be very misleading. The report also concludes the cost comparisons of various buildings are often made by comparing the individual rates/m^2. It also discusses that the cost of a building is expressed in rate/m^2 and the unit cost is ignored, if calculated at all.

Most of the time construction costs are estimated from the construction cost indices (Elfahham, 2019). Having a construction cost range or indices helps to determine the minimum and maximum of building costs based on the parameters set out in cost predictions when required. These cost ranges can be determined with consideration the cost significant items of high rise buildings subject to fluctuations that trend toward increasing over the long term, which make the pricing process challenging job (Kadiri, 2016).

2.1. Cost-Significant Factors of High-Rise Buildings Construction

As stated by Barnes (1971) the implication of the proposition that different values of rates have different degrees of reliability, and, specifically, that the reliability of a product of quantity and rates is an increasing function of its value. By assuming a constant coefficient of variation for each item, he shows that a selective reduction in the number of low-valued items has a trivial effect on the overall estimate reliability. The empirical evidence that backs up favor Barnes' assumption is quite strong, and therefore its essence has been used to develop the significant items method.

"Most of the value of measured work on building projects is contained within 20% of the items in the bills of quantities" was tested by analyzing the prices in 40 bills of quantities. It was found that 78% of the value was contained within the top 20% of items, which broadly confirmed the 80/20 relationship. By restricting measurement and pricing to the most significant items (the top 20% of items) (Cheung, 2005). Construction cost estimation with cost-significant item method has a great benefit due to the shorter forecasting time that is required due to its concentration on fewer items, the improvement in accuracy, the improvement in reliability (because its outputs are derived from data from a large sample) and the flexibility it affords in allowing a move away from average rates towards varying percentage additions for each trade (Allman, 1988).

A study made on Nigerian high-rise office building costs shows that the cost-significant items (CSI) are Electro-Mechanical Units, Preliminaries, Finishing Works, Structural Frames, & Wall Types (Kadiri, 2016) as shown in the following table.

Table 2. 1 *Cost-significant Items*

CSIs	***Mean Values***	***Percentage of Total***	***Rank***
Mechanical Services	194,773,149.51	17.8	*1*
Electrical Services	143,115,697.33	13.1	*2*
Preliminaries	88,641,470.76	8.1	*3*
Floor Finishing's	66,267,790.49	6.1	*4*
Wall Finishing's	55,645,059.44	5.1	*5*
Reinforcements in Frame	45,628,283.87	4.2	*6*
Curtainwalls	44,670,256.49	4.1	*7*
External Works	44,293,668.90	4.1	*8*
Windows	37,798,804.05	3.5	*9*
Reinforcement in Upper Floors	37,245,793.29	3.4	*10*
Concrete in Substructure	30,701,915.92	2.8	*11*
Total Mean Value = N 1,093.0Million			

Note. Adopted from Kadiri, 2016, P.877

According Shehatto, (2013) CSIs' are classified into two major groups, **skeleton phase** and **finishing phase** factors. The study again classifies the skeleton phase & finishing phase factors into a number of variables as shown in the table below.

Table 2. 2 ***Cost-Significant Factors***

1. Structural Phase Factors	Rate /5	2. Finishing Phase Factors	Rate /5
Area of typical floor (90%)	4.5	Type of painting (52%)	
Number of floors in the building (90%)	4.5	Quantity of metal works for protection and decoration (62%)	
Area of retaining walls (75%)	3.8	Quantity of carpentry works (63%)	
Type of building (73%)	3.7	Type of Aluminum works (64%)	
Type of used foundation in the building (72%)	3.6	Number of internal doors (65%)	
Number of elevators in the building (71%)	3.6	Type of carpentry works (65%)	
Type of slab (Solid, ribbed… (71%)	3.5	Quantity of water and sanitary works (65%)	
Length of spans between columns (69%)	3.5	Number of windows (67%)	
Number of columns (65%)	3.3	Quantity of electrical works (68%)	
Number of rooms (59%)	3.0	Firefighting and alarm work (68%)	
Location of project (57%)	2.9	Area of marble works (69%)	
Number of staircases in the building (57%)	2.8	Area of gypsum board and false ceiling (69%)	
Type of contract (51%)	2.5	Type of electrical works (72%)	
		Water & sanitary works (73%)	
		Type of tiling (73%)	
		Area of curtain walls (74%)	
		Volume of Air-conditioning (76%)	

Note. Adopted from Shehatto, 2013, PP. 47, 49

The cost significant factors of high-rise buildings into five major categories, Cost of Land, Materials Used, Finishing Work, Method of Construction, and External Factors (Alaghbari, 2014). These main factors again decomposed into multiple sub-factors as shown under Table 2.3.

Table 2. 3 The Five Main Categories and Their Related Factors

No.	Category	Variables Code	Factors
1	Land Factors	X_{LC1}	Cost of project land.
		X_{LC2}	Relation between project location, services, and transportation.
		X_{LC3}	Relation between project location and job location, and
		X_{LC4}	Land topography.
2	Materials Used Factors	X_{MC1}	Cost of building with stones
		X_{MC2}	Cost of building with red bricks
		X_{MC3}	Cost of building with local bricks (Yagoor)
		X_{MC4}	Cost of building with concrete blocks
		X_{MC5}	Cost of cement
		X_{MC6}	Cost of steel for reinforced concretes
3	Finishing Works Factors	X_{FW1}	Cost of formwork elements and preparing for reinforced concrete works
		X_{FW2}	Cost of plastering works
		X_{FW3}	Cost of painting works
		X_{FW4}	Cost of tiling works
		X_{FW5}	Cost of doors and windows works
		X_{FW6}	Cost of plumbing network and requirements works
		X_{FW7}	Cost of electricity network and requirement works
4	Construction Methods Used Factors	X_{CM1}	Traditional methods used (load bearing walls)
		X_{CM2}	Concrete Frames Used
		X_{CM3}	Using external load bearing walls & central columns
		X_{CM4}	Using new technology and Industrialized Building Systems (IBS)
5	External Factors	X_{EF1}	Materials available in local market
		X_{EF2}	Tools and equipment available in local market
		X_{EF3}	Political condition
		X_{EF4}	Economic condition and fixed exchange money cost
		X_{EF5}	Transportation and fuel cost
		X_{EF6}	Security condition
		X_{EF7}	Established legislations and acts
		X_{EF8}	Administrative procedures and licensing
		X_{EF9}	Projects designs
		X_{EF10}	Projects construction supervision
		X_{EF11}	Executor contractors
Dependent Variable: (Y_{HC}) Cost of Square Meter in Housing Project			

Note. Adopted from Alaghbari, 2014

Although other papers classify the cost-significant factors in different ways, most have similar characteristics with the variables they categorized. Based on conclusion of different reviews, factors that affect the construction cost of high-rise buildings can be categorized as site-related, design-related, material-related, other external factors (De Jong & Van Oss, 2007).

2.1.1. Site-related factors

Site-related factors for the change of construction cost are its location, access, topography, and soil type. It is expected that the cost of the building may increase as the location and site access becomes more restricted. According to (Cunningham, 2013), "The location of the project will influence its cost. High value sites attract high value developments and it is inappropriate to locate low value projects on valuable sites. Local development plans will constrain what can be built on such sites in any case. In general, urban locations are more expensive than their rural equivalents due to higher local wages, costs associated with access constraints, limited space for staff accommodation facilities and material storage, and the additional security measures required."

An analysis of variance test shows that there are significant differences in topography type of different sites and may be attributed to the total cost of projects (Lowe et al., 2006). They stated that costs would increase as topography becomes more severe, however, the rate of impact to costs per square meter may not be significant.

2.1.2. Design-related factors

Design-related factors are the building's height, floor area, function & internal and external shape of the building. The building morphology has a major impact on costs. Building height has a large impact on building costs by (Cunningham, 2013; De Jong & Van Oss, 2007). According to de Jong et al (2007), for every increment of a floor there is an increase of additional cost per square meter due to the construction methodology, the number and type of elevators required, design considerations for load and earthquake and etc. The building size (plot area) also has a considerable impact to the construction unit cost per square meter.

In this regard vertical wall-to-floor ratio has a great impact on cost/m^2. The most economical shape for a building is square. This shape requires the minimum wall length to enclose a given floor area (AECOM SA, 2021).

Cunningham (2013) stated that, larger buildings with simple, rectangular, regular floor plans and elevations will be less expensive per square meter than smaller, complex shaped, curved or angular buildings. However, economies of scale can reduce costs for larger projects, resulting in a lower **unit cost per square meter**.

Regarding impact of buildings function on cost, Cunningham (2013) states that the purpose of a building will have a major bearing on its cost. Housing has a very different cost range to apartments and commercial development. Likewise the cost of providing public amenities such as conference centers, theatres and sports stadia cannot be directly related to the provision of public infrastructure such as hospitals or schools. The cost of each building must be related to its individual design, which may be benchmarked against similar national and international projects.

2.1.3. The choice of materials

The materials specified and the proposed construction details will have an important bearing on the cost of the project. Buildings which incorporate high quality and/or innovative features are invariably more expensive than those which are purely functional. The choice depends on what the client is willing to pay (Cunningham, 2013). The choice of the material, and hence the cost, may be influenced by factors other than aesthetic qualities. For example, a construction projects may use a steel frame in preference to an in-situ or precast concrete frame in order to reduce overall program durations. Although the concrete option may be cheaper, the shorter program achieved by using steel may offset this initial cost advantage (Hemalatha et al., 2020).

These price impact hugely exhibits on finishing works. For example, if a building that has aluminum curtain wall definitely pays more from a building having Hollow

Concrete Block (HCB) wall. Since the unit cost per square meter of aluminum curtain is much higher than HCB wall (Adewale et al., 2018).

Floor finishing materials have different prices scales and it has a direct price impact on material choices. For example, some building floors are finished with porcelain tiles while other building may be finished with parquet or granite tile which costs above twice of porcelain price. In commercial and industrial buildings, the rate/m^2 will depend greatly on which air-conditioning, security systems, sprinklers, smoke-detection systems, electrical installations, acoustic treatment or other specialized installations are incorporated into the design. The concentration of plumbing installations has a marked effect on the rate/m^2 of the building. The cost of a toilet block per square meter is much greater than that of a house containing one bathroom as the high cost of the bathroom area is spread over the less expensive remaining areas of the house (AECOM SA, 2021).

For advanced and complex commercial high-rise buildings, the cost of Electro-Mechanical Works covers about 20-30% of the total building costs (AbuDhabi & Statistic Center, 2015; Kadiri, 2016).

2.1.4. Other (external) factors

Under this category factors like locality of contractors, market conditions, choice of architects, currency of contract, procurement methods are the other cost factors. In some papers these type of factors are classified as external factors or procurement type and methods, or socio/environmental factors (Alaghbari, 2014; Cunningham, 2013).

2.2. Cost Estimation Methods

Based on different studies cost estimation methods for high-rise buildings can be categorized into several techniques discussed as follows;

2.2.1. Quantitative and qualitative technique

Qualitative approaches rely on expert judgment or heuristic rules, and quantitative approaches classified into statistical models, analogous models and generative-analytical models (A. & & Pelagagge, 2008; O. et al., 2009). Cost estimation technique has been divided into different methods discussed as follows;

2.2.2. Analogy-based techniques

Analogy-based techniques allows obtaining a rough but reliable estimation of the future costs (Kelly et al., 2002). They also stated, it is based on the definition and analysis of the degree of similarity between the new project and another one. Kelly et al., (2002) said that, the underlying concept is to derive the estimation from actual information. However, many problems exist in the application of this approach, such as:

- The difficulties in the measure of the concept of the degree of similarity.
- The difficulty of incorporating in this parameter the effect of technological progress and of context factors.

Analogous estimating is an approximate estimating method that compares costs with similar past projects and which often depends on expert judgment. It can be used in the preparation of the earliest price estimates for the client. In using this method, the estimator should have the relevant experience of estimating the cost of similar projects (Ashworth, 1994). Analogous estimating using the actual cost of a previous, similar project is the basis for estimating the cost of a current project and is frequently used to estimate the cost when there is a limited amount of detailed information about the project. Usually estimators retain their own database of historical project costs from which equivalent or similar cost information may be drawn (Loftus, 1999) cited in (Girma, 2020).

2.2.3. Parametric models

Parametric Models it is a way that cost is expressed as an analytical function of a set of variables (Girma, 2020). The final cost of the project may be influenced by the variables (known also as cost drivers) usually consist in some features of the project (performances, type of materials used). According to Girma, (2020), it is a method of estimating the cost of a project (or part of a project) based on one or more project-based cost factors. the historical bid data is commonly used to define parameters related to the cost of a typical facility construction, such as cost per lane mile, cost per interchange or cost per square meter.

Based on historical cost information, a percentages can also be used to estimate the cost of project elements. Parametric methods are often used in early estimating, such as planning and scoping estimates (Girma, 2020). This method is considered fairly accurate when historical information used to develop the model is accurate. The parametric cost approach relates all costs of a project to just a few physical measures or parameters that reflect the size or scope of the project. For example, the gross floor area of a pre-stress concrete deck surface over water would be a typical overall parameter for a structure such as a bridge over water. Some costs, say for road construction projects, can be expressed in lane/km. with good historical records on comparable structures and associated risks, parametric costing can give reasonable levels of accuracy for preliminary estimates (Barrie & Paulson, 1992). They pointed out that unit measure is the most widely used parameter for cost estimating, bearing in mind the quality (type), width, location and other pertinent factors.

2.2.4. Order of magnitude estimates

An order of magnitude estimate, is an extremely rough cost estimate created before a project has been defined. It is based only on expert judgment and the cost of similar past projects. An estimate of an order of magnitude is often given as a range of costs between - 25% and + 75% of the project's actual cost. Only at the highest levels of decision-making are initiatives screened to see which ones are financially viable.

Intermediate estimates: an intermediate estimate can be created using parametric techniques when a project is defined to a limited extent. Its major objective is to assess project viability based on the broad project concept, much like an order of magnitude estimate. Preliminary estimates: created when a project's deliverables are about half defined, a preliminary estimate uses somewhat detailed scope information to incorporate unit costs. The accuracy of preliminary estimations is sufficient to serve as the foundation for project finance. Some project budgets are authorized based on the preliminary estimate (Girma, 2020).

The Order of Magnitude method is based upon Reported Square Meter costs from a data set of many previous building projects. The Reported Square Meter method that we used for this type of estimates simply uses average building costs across the dataset (Messner, 2019).

2.2.5. Detailed estimating (bottom-up)

Unit price estimates can be compiled when quantities of work items may not be precisely determinable but the nature of the work is well defined (Clough, 1986). It involves estimating the cost of individual work items and the synthesis of cost estimates from resource estimates made at the lowest possible level of work- break down structures (PMI, 2000). The addition of indirect cost: plant and equipment, office overheads, profit, escalation and contingency develop the total estimated project cost (Barrie & Paulson, 1992).

2.2.6. Three-Point Estimates:

Sometimes it is called multipoint estimating assesses cost or duration by applying an average or weighted average of optimistic, pessimistic, and most likely estimates when there is uncertainty with the individual activity estimates (PMP, 2021). Use of three estimates to determine a range for an activity's cost: the best-case estimate, the most likely estimate, and the worst-case estimate.

2.2.7. Preliminary and detailed techniques

Since preliminary approaches are less numerical than detailed methods, both preliminary and detailed techniques have unique methodologies. However, the majority of studies look for a flawless initial approach that produces reliable results. (Ostwald, 2001) outlined commonly methods that are divided into two sets qualitative preliminary methods as opinion, conference, and comparison similarity or analogy and quantitative preliminary methods as unit method, unit quantity, linear regression...etc.

2.2.8. Traditional and artificial intelligence-based techniques

In fact, most of earlier traditional methods fall into one of the following categories; Cost capacity factors, component ratios, time-referenced cost indices, and parameter costs. However, many researches addressed these traditional parametric methods as (Kim et al., 2004; Mahamid & Bruland, 2010) etc.

Recently, new methodologies based on the idea of parametric models based on computerized techniques like artificial intelligence, which try to replicate human intelligence, have been proposed. Examples of these methodologies include artificial neural networks (ANN), fuzzy logic, etc., where it stills under research and development especially in construction sector (Dogan, 2005).

2.3.Construction Cost Estimate Categories

There are probably as many different estimating procedures as there are contractors (Clough, 1986). The study classifies the construction estimating into two major types according to their functions which are:

- Approximate (Preliminary) Estimates.
- Fixed-Price (Detailed) Estimates.

2.3.1. *Approximate (preliminary) estimates*

Conceptual or preliminary estimates are generally used by the owner of a project to determine the approximate cost of a project before making a final decision to construct it. The preparation of conceptual estimates requires a clear understanding of what an owner wants and a good "feel" for the probable costs (Hinze, 1999). Summarizing Clough (1986), the general contractor may wish to compute an approximate cost of work normally subcontracted, either to serve as a preliminary cost in its bid or to check quotations already received from subcontractors.

2.3.2. *Fixed-price (detailed) estimates:*

Detailed estimates sometime called final, definite, or contractor's estimates (Serbanoiu & Grădinaru, 2020). Detailed estimates are the most accurate estimate because the available information consists of working drawings, detailed specifications, and subcontractors and supplier price quotations. Detailed estimates include direct and indirect cost estimates of materials, labor, equipment, engineering, support staff, insurance, bonds, taxes, allowances, contingencies, and profit (Holm, 2018).

Holm (2018) says that detailed estimates are generally prepared by contractors prior to submitting bids on competitively bid contracts. A detailed cost estimate includes the cost of materials, labour, equipment, subcontracted work, overhead, and profit. To prepare project estimate, the estimator conducts a breakdown of the proposed project into the necessary operation required to complete the project. As far as possible, the operation or items appear in the estimate in the order that they will be performed in the project. This reduces the danger of omitting the costs of one or more. The fixed price estimates can be classified into two forms which are widely used in the construction industry (Chiang & Waier, 2007). These are:

a) Lump-Sum Estimates.
b) Unit-Price Estimates

2.3.3. Lump sum estimate

Lump-sum estimates are applicable only when the nature of the work and quantities involved are well defined by the bidding documents. Lump-sum estimating requires that a quantity survey or quantity takeoff be made. This is a complete listing of all the materials and items of work that will be required. Using these work quantities as basis, the contractor computes the costs of the materials, labor, plant, subcontracts, and overheads. The sum total of these individual items of cost constitutes the anticipated overall cost of the construction. Addition of a markup yields the lump-sum estimate that the contractor submits to the owner as its price for doing the work (Clough, 1986).

2.3.4. Unit Price Estimate

The Unit Price estimating approach is focused on identifying a cost for the materials, equipment, and labor for each of the components within a building. The costs of different projects with a specified design, the project cost can be broken down into components at different levels of complexity to estimate costs. For the purpose of calculating the overall construction cost, the unit cost for each item in the bill of quantities must be determined. Although other elements may be chosen for the decomposition, this approach is relevant to both design estimates and bid estimates (Othman, 2016). The final cost is determined by multiplying the bid cost per unit by the actual quantity of work that is installed by the contractor. Thus, the price that the owner will pay to the contractor is not determined until the project has been completed, when the actual quantities are known.

2.4.Cost Estimation Practices in Ethiopia

2.4.1. Building construction in general

The detailed (bottom-up) estimating is the most practiced techniques in estimating the cost of a building projects (Andom, 2008; Girma, 2020). It involves estimating the cost of individual work items and the synthesis of cost estimates from resource estimates made at the lowest possible level of work-break down structures. Andom (2008) has ranked the cost estimation techniques from the most common to the least used methods as bottom-up estimating, three-point estimating, parametric estimating, and analogous estimating.

The practice of contractors shows that cost estimates are predominantly prepared at tendering phase to fix rates for new tender projects and during construction phase to fix rates for variation works. Most contractors use detailed cost estimating methodology for estimation of tender and variation costs (Negussie, 2017).

Clough (2011) in (Negussie, 2017) says that the decision to bid involves a study of many interrelated factors. Some of factors are related to contracting parties, project complexity, contractors' capacity and terms of contract set forth and market conditions. The main technique used by the contractors is detailed estimating technique where the costs of construction (labor, material, plant, subcontractors) are established and to which an allowance for overheads and profit is added. Negussie (2017) says that the contractors prefer to use detail estimating since they believe that the competitive tender are better suited to detailed estimating and there is lack of familiarity with other technique that requires sound data of previous projects which they do not have.

2.4.2. High-rise constructions in particular

The development of high-rises differs from buildings with lower or medium height with its incorporation of additional cost elements, technologies, construction methodologies, and soon. The foundations of high-rise buildings support very heavy loads due to this deep bearing piles and floating foundations are also used. The commercial and office functions require a high degree of flexibility. High-rises have additional cost for the vertical transportation, their increased wind loadings and heavier frames, the risks associated with their uniqueness, the potential interest in including elective security and safety enhancements in response to possible risks, the larger capacities of plant and distribution systems together with the increased pressures/hydraulic breaks that are required to deal with the increased vertical distances (Craighead, 2009; De Jong & Van Oss, 2007). Due to these additional features the construction costs per unit square are relatively high. The cost estimation practices and methodologies commonly applied for low or mid-rise buildings may not suit for cost estimation of high-rise buildings (De Jong & Van Oss, 2007).

2.5. Definition of Terms

It is important to discuss how researchers define the related concepts and terminologies.

2.5.1. High-rise buildings

Multistory building tall enough to require the use of a system of mechanical vertical transportation such as elevators. Generally, a high-rise structure is considered to be one that extends higher than the maximum reach of available fire-fighting equipment (Wisler, 2009). A 'tall building' with multi-story structure in which most occupants depend on elevators [lifts] to reach their destinations (Challinger, 2008). According to Challinger, (2008) the most prominent tall buildings are called 'high-rise buildings' in most countries and 'tower blocks' in Britain and some European countries. The terms do not have internationally agreed definitions. However, a high-rise building can be defined briefly as follows:

- Any structure where the height can have a serious impact on evacuation (Challinger, 2008).

- For most purposes, the cut-off point for high-rise buildings is around seven stories (Hall Jr, 2005). Sometimes seven stories or higher define a high-rise and sometimes the definition is more than seven stories or the definition may state in terms of linear height (feet or meters) rather than stories.

- According to the (Ottawa Council, 2003), High-rise is a building having ten stories or higher.

In conclusion, the high-rise buildings this study considers are buildings having the minimum and maximum number of storeys 20 and 40 respectively above the ground floor level.

2.5.2. Construction cost estimate

Cost

In project control and accounting, cost is the amount measured in money, cash expended or liability incurred, in consideration of goods and/ or services received (AACE, 2022). It says that from the perspective of overall cost management, cost can refer to any resource commitment to strategic assets, including financial, human, physical, and time resources.

Estimating

Estimating is a complex process involving collection of available and pertinent information relating to the scope of a project, expected resource consumption and future changes in resource costs, synthesizing this information through a mental process of visualization of the constructing process for the project. This visualization is mentally translated into an approximation of the final cost (James, 2003).

Cost estimating

Cost estimating is the predictive process used to quantify, cost, and price. Cost estimating is a process used to predict uncertain future costs (AACE, 2022). It states, a goal of cost estimating is to minimize the uncertainty of the estimate given the level and quality of scope definition. It also says the outcome of cost estimating ideally includes both an expected cost and a probabilistic cost distribution. The accuracy of cost estimation is increased by using past reference cost data as a predictive procedure (where applicable). By serving as the foundation for budgets, cost estimating and cost control share the objective of increasing the likelihood that the actual cost outcome would be the same as expected. Cost estimating involves developing an approximated estimate of the costs of the resources needed to complete project activities in which the estimator considers the causes of variation of final estimate for purposes of better managing the project (PMI, 2000).

Construction-cost

Costs involved in turning a design plan for materials and equipment into a project that is ready for startup but not necessarily in production operation, including all direct and indirect costs; the sum of field labor, supervision, administration, tools, field office expense, materials, equipment, taxes and subcontracts (AACE, 2022).

2.6. Building Rate Overview in Africa

According to different studies the cost of buildings across different countries of the continent have different cost ranges based on building types & locations (AECOM, 2018). AECOM publishes a study named "Africa Property & Construction Cost Guide" in 2018 which sets a cost rate for different building categories of 15 African countries as shown in Table 2.4.

"The data in the figure summarizes the approximate estimated building costs for different types of buildings in various locations in Africa. Rates are based on projected 1 July 2018 costs and provide an indicator for the expected building cost rates during 2018. Exchange rates are as at 1 April 2018. Rates include the cost of appropriate building services, e.g. air-conditioning, electrical, etc., but exclude costs of site infrastructure development, parking, any future escalation, loss of interest, professional fees. These rates are of an indicative nature and therefore the qualifications dealt with elsewhere in this publication would apply. These are estimated costs only and should be considered in the context of acceptable building standards in each relevant country. These standards, both at a technical level and pertaining to quality, do vary from country-to-country. Therefore, the building costs must be seen as being for the normal standards prevailing in each particular region (AECOM, 2018, P. 51)".

Table 2. 4 *Africa Building Cost Comparison*

	US DOLLAR											
Building Type	**Angola Luanda**	**Botswana Gaborone**	**Ghana Accra**	**Kenya Nairobi**	**Mozaimbique Maputo**	**Nigeria Lagos**	**Rwanda Kigali**	**Senegal Dakar**	**South Africa Johannesbu**	**Tanzania Dare Salaam**	**Uganda Kampala**	**Zambia Lusaka**
Residential (US $/m²)												
Average Multi Unit High Rise	1,665	1,032	1,850	770	1,294	2,520	1,232	1,300	978	811	839	1,189
Luxury Unit HighRise	2,700	1,458	2,200	1,144	1,646	3,495	1,645	2,045	1,442	1,082	1,344	1,756
Individual Prestige Houses	5,025	2,194	2,100	1,404	1,764	3,070	1,770	3,120	1,408	1,165	1,586	1,718
Commercial/Retail (US $/m2)												
Average Standard Offices High Rise	1,840	1,091	1,700	1,040	1,235	2,520	1,515	1,330	1,092	993	1,190	1,329
Prestige Offices High Rise	2,810	1,826	2,500	1,804	1,470	3,495	1,915	2,170	1,408	1,258	2 014	1,718
Major Shopping Centre (CBD)	2,645	1,518	1,400	874	1,470	3,490	1,405	1,745	1,075	926	994	1,308
Industrial (US $/m2)												
light Duty Factory	1,675	972	1,000	754	850	1,395	1,135	1,195	472	744	829	573
Heavy Duty Factcry	3,738	1,494	1,250	1,196	1,294	1,880	2,020	1,915	531	1,331	1,334	648
Hotel (US $/key)												
3 Star Budget	232 200	155,566	325,000	378,560	147,003	345,000	209,400	175,000	189,713	140,941	442,900	295,144
5 Star Luxury	446 000	502,216	455,000	655,200	270,485	630,000	501,000	412,000	337,268	332,540	772,500	518,601
Resort Style	642 600	560,891	570,000	780,000	529,209	765,000	670,000	520,000	Not available	439,400	936 785	Not available
Other (US $/m2)												
Multi-storey car Park	1,528	759	850	494	850	1,800	865	1,125	333	593	577	405
District Hospital	**Nol available**	**Not available**	1,700	1,040	2,940	2,515	**Not available**	**Nol available**	2,192	**Not available**	1,324	2,702
Primary & Secondary Schools	**Nol available**	**Not available**	1,100	910	1,150	**Not available**	**Not available**	**Nol available**	613	**Not available**	1,051.00	735.00
(As at 1 April 2018) US$1=	AOA 217.00	BWP 9.53	GHS 4.41	KES 100.00	MZN 61.65	NGN 360.00	RWF 870.00	XOF 535.00	ZAR 11.86	TZS 2290.00	UGX 3705.00	ZMW 9.55

Prices esclude land, site works, professional fees, tenant fit-out and equipment, Rates exclude GST/VAT. Hotel rates inclure FE & E

Note: Adopted from Africa Property & Construction Cost Guide, p. 52)

The construction costs for high-rise buildings ranges between 800$ to 2,000$ per meter square based on building types and regional locations of Africa (AECOM, 2018; Bah et al., 2018; Statista Research Department, 2022).

2.7.Use of Building Rates per Unit Area

According to AECOM (2018), construction cost estimation is complex. Comprehensive exercises based on detailed and accurate information are required to achieve reliable levels of comfort. For various reasons, however, decisions are often based on inclusive rate estimates, i.e., rate per square meter (m2) of construction area or rate per unit in number. The most widely used method of quick approximate estimating to obtain an indication of the construction cost of a building is the rate/m2/on-plan method. The "order of magnitude" method of cost assessment is another name for this. It is undoubtedly quick and convenient, but if utilized carelessly and without considering the building area and rate, it may also be quite deceptive. The unit cost is frequently not computed and the cost of a structure is given in rate/m2. This rate per m2 is then used as the sole yardstick for the building costs.

A well-defined unit rate per meter square is important to assist insurance companies and property owners in making quick estimations about the probable possession of the property (Altus Group., 2014).

Unit rates are used as basis or indicative figures by government offices, service providers, contractors, and consultants in the common activities of building estimations (Tanzania Public Procurement Regulatory Authority, 2010).

Time and costs are considered substantial success factors in building construction projects. In Germany, early cost estimates are provided by multiplying the cost indicator with the gross floor area (Stoy & Schalcher, 2007).

2.8. Area Measurement of High-Rise Buildings

The purpose of knowing the method of measurement is to provide precise definitions to permit the accurate measurement of building sizes (areas and volumes) and the description or specification of materials on a common and consistent basis. This may be required for valuation, management, planning, taxation, sale, letting, or acquisition (Degefa & Woldeyohannes, 2017). They state that it is better to be familiar with international practices of area measurement for a clear and acceptable use of rates.

Different local and international studies and standards have similar measurement codes with slight differences in method applications. Most of the papers this paper assesses classify building measurements as follows (Degefa & Woldeyohannes, 2017; Messner, 2019);

1) ***Gross external area*** (GEA); is the area of a building measured externally at each floor level. It includes the wall thickness and external projections, areas occupied by internal walls (whether structural or not) and walls (stairwells, lift wells, chimney breasts, columns, piers, etc.), but excludes the lift rooms, plant rooms, tank rooms, fuel stores, whether or not above roof level, and open-sided covered areas (which should be stated separately).

2) ***Gross internal area (GIA):*** The gross internal area is the area of a building measured from the internal face of the perimeter walls at each floor level. It includes the spaces occupied by internal walls (whether or not they are structural) and partitions, service accommodations like restrooms, showers, and changing rooms, columns, piers, whether freestanding or projecting inward from an exterior wall, chimney breasts, lift wells, stairwells, etc., lift rooms, plant rooms, tank rooms, fuel stores, whether or not they are above roof level, open-sided covered areas (which should be stated separately), but excludes open balconies.

3) ***Net internal area (NIA):*** NIA is the usable area within a building measured to the internal face of the perimeter walls at each floor level. It includes the

perimeter skirting, kitchens, any built-in units or cupboards taking up usable space (subject to the height exclusion below), partition walls or similar dividing elements, open circulation areas and entrance halls, and corridors, but excludes the restrooms and related lobbies (although additional measurements may be needed for shops where they are either greater than the usual staff requirements considering the type and size of shop). Other than those used for trade processes, it is also apparent that more restrooms, cleaners' cupboards, lift rooms, boiler rooms, tank rooms, fuel stores, and plant rooms have been added. Stairwells, lift wells, those portions of entrance halls, atria, landings, and balconies used in common or for the purpose of essential access, corridors, and other circulation areas where used are also included in this.

In conclusion of this paper's assessment of different studies, the GEA is the preferred method of measurement for calculating building costs for the purpose of total cost estimation (Degefa & Woldeyohannes, 2017).

Once you know the estimated square meter and an approximate square meter value, you will then be able to estimate the total cost of the building. In different practices, larger buildings have a lower cost per square meter than smaller buildings due to the crews learning the construction methods and being more productive, along with the ability to get lower material costs due to the quantities purchased. Additionally, there is less facade normally per floor space and there is less overhead per unit of cost, which lowers prices. Due to all of these factors, the unit (per square meter) cost of a larger building is lower, even though the absolute cost of the building will be higher than a smaller building (Messner, 2019).

2.9.Time Considerations

Time is money'. – Benjamin Franklin (Villers & Mieder, 2017).

As time progresses, it is typical for costs to escalate, at least in most economic conditions. This is commonly referred to as inflation, and we gauge how quickly costs are rising by tracking the prices of a number of different products over time. The most typical measure of inflation is the Consumer Price Index (CPI), which is calculated from a typical basket of goods that an average person may buy, e.g., food, gas, etc. (Messner, 2019).

Messner, (2019) states when we estimate projected building costs, there are similar cost escalations that occur, however, these price increases are largely focused on the rising costs of construction labor and building materials. Therefore, it is more accurate to consider cost escalation by calculating the escalation of a construction-related 'basket of goods' which to the CPI but focused on construction and mostly known as the Building Cost Index (BCI) or Construction Cost Index (CCI). Messner, (2019) describes that the BCI contains typical products and labor for building construction; the material cost index measures the cost of building materials, whereas the CCI covers infrastructure including roads, bridges, and buildings.

Cunningham, (2013) says value for money is perceived within a time and location context. Construction activity is highly sensitive to changes in economic outlook and activity in the local and national economy. Construction activity is cyclical and flourishes in times of general economic growth and suffers during economic downturns. Contractors generally win contracts in competition and profit margins reflect the amount of work available at the time. When demand for construction work is high, contractors typically experience supply and capacity constraints, labor shortages, which result in rising price levels.

Market outlooks at global and local level no constant prices of goods and services throughout all time changes. Every time there is a change of prices due to physical, social, political and economic reasons like material scarcity, instability, supply and demand and etc. (Bagus et al., 2014; Thompson, 2009).

Thompson, (2009) describes inflation as a measure of the general change in the price of goods. It is crucial to distinguish between changes in the level of inflation and changes in prices. If inflation declines but is still positive, then prices are still rising, but more slowly. If and only if inflation is negative, prices are declining. Deflation is the term for falling prices or negative inflation. Thus, inflation only provides information about the pace of price change and not about the level of prices themselves.

As Thompson, (2009) says the change of prices which is called inflation/deflation is calculated and adjusted with price indices.

The total cost of a project is the sum of all costs covered from start to project closure. The duration of project implementation may cause to inflation, and variation costs. The statistics centers and agencies in different countries consistently compile Construction Cost Indices (CCI), based on the prices of a group of building materials and construction services commonly used during the construction process. The figures thus calculated constitute a time series that provides a measure of changes in the cost of construction over time (Statistics Center of Abu Dhabi, 2021).

Therefore, in every step of price analysis an adjustment by a cost index should be taken into consideration to reach at the approximate current value. The cost indices for different consumer goods are available with local and global studies or statistical institutions (Bagus et al., 2014; Finch, 2016; *Cost Inflation Index*, 2022; Thompson, 2009).

2.10. Construction Cost Index

A cost index will be used at some time by those who frequently work with construction cost estimates. Most people look up a few values in the tables, do some simple math, and then use the resulting factor to make the appropriate modification when using cost indices. The desired adjustment is often a change in costs over time at a place or costs between locations, frequently with a time adjustment (Report to the City Council, 2017; Sources and Methods, 2016).

As stated on Report to City Council (2017), the use of construction cost indices is much more extensive than just these common applications, making it a very strong tool. For some building types, such as residences, the U.S. government creates indexes, such as price indices for dwellings. They are employed by the government to create price deflators for gross domestic product (GDP). They recognized many years ago inherent problems unique to construction indices (p. 09).

It is critical to keep in mind that a cost index uses a range of values to calculate the price movement of certain items over time and/or space. In order to interpret the outcomes of using the index, a fundamental comprehension of the theoretical construct is helpful. In conclusion the cost index is a tool to move past time prices to the intended date based on base prices (Statistics Center of Abu Dhabi, 2021).

When we perform cost estimates for building projects, we will focus on using the CCI. If you compare CCI values for two periods in time, then you can transition relative economic values between these times with a simple calculation of ratios (Messner, 2019).

2.11. Use of Indices for Price Adjustment- Case of Ethiopia

The Ethiopian Statistics Agency (ESA) releases consumer price indices (CPI) on a monthly, quarterly, and yearly basis for different categories of goods and services. The ESA has been utilizing CPI on a monthly basis at Addis Ababa level since 1963, at country level since 1996, and at country and regional level since 2000. Four country- and regional-level CPIs were published in 2000, 2006, 2011, and 2016 (ESA, 2020).

The ESA (2020) states that the country and regional level CPIs are 12 in number (nine for regions, two for Addis Ababa and Dire Dawa, and one for country level). All twelve indices are divided into two major groups: food and non-food indices. The non-food index has eleven major divisions, namely: alcoholic beverages; cigarettes and tobacco; clothing and footwear; house rent; construction materials; water; fuel and power; furniture, furnishing, household equipment, and operation; health; transport; communication; recreation, culture; education; restaurants and hotels; and miscellaneous goods and services. On the other hand, the Food Index has 10 classes. These are: bread and cereals; meat; fish and seafood; milk, cheese, and eggs; oil and fats; fruits; vegetables and pulses; sugar, honey, and chocolate; food products and non-alcoholic beverages (p. 12).

In March 2022, FDRE's Ministry of Finance issued a cost inflation index to be used in the estimation of capital gain tax during property transactions (Cost Inflation Index, 2022). The inflation index has basically been prepared for the past 20 years since 2001 for the sole use of capital gain adjustments in property taxes, as shown in Table 2.5 below. As discussed in the previous section, these types of price indices are used to make adjustments to prices in the past or present for any intended purpose (Hill, 2004).

Table 2. 5 *Cost Inflation Adjustment Index*

Fiscal Year	Annual inflation Index by percentage for Non-Food Items (National Bank of Ethiopia)	Cost Inflation Index (CII)
2002	0.3%	Base Price = 100
2003	0.2%	100.2
2004	2.2%	102.4
2005	4.4%	106.8
2006	7.1%	114.5
2007	13.5	129.9
2008	12.5	146.2
2009	23.5	180.2
2010	18.2	213.4
2011	21.8	259.9
2012	22.7	318.9
2013	14.6	365.5
2014	10.6	404.2
2015	8.0	436.5
2016	8.1	471.8
2017	7.5	507.2
2018	15.8	761.1
2019	11.9	657.2
2020	15.8	761.1
2021	16.4	885.9
2022	28.1	1,134.8

Note: Adopted from FDRE Ministry of Revenue, Circular Letter Dated 09 April 2022, Ref. No. 3.1/384/14)

2.12. Lessons Learned

Diverse Estimation Methods: The construction industry employs various cost estimation techniques, such as analogy-based methods, parametric models, order of magnitude estimates, detailed estimating, and three-point estimates. Each method has its strengths and weaknesses, and the choice depends on project specifics and available information.

High-Rise Building Challenges: Estimating costs for high-rise buildings involves unique challenges due to additional elements, technologies, and construction methodologies. The methodologies commonly applied for low or mid-rise buildings may not directly translate, emphasizing the need for specialized estimation practices.

Area Measurement Importance: Accurate area measurement methods, including Gross External Area (GEA), Gross Internal Area (GIA), and Net Internal Area (NIA), play a crucial role in cost estimation. The choice of measurement method affects the precision of cost calculations.

Time and Inflation Considerations: Considering time and inflation is vital in construction cost estimation. Construction Cost Indices (CCI) and Consumer Price Indices (CPI) are valuable tools for adjusting costs over time, reflecting changes in the economy and preventing inaccuracies in estimates.

Local Context Matters: Building rates in Africa exhibit regional variations, emphasizing the importance of understanding local contexts and standards when estimating construction costs.

In summary, adopting a methodologically diverse, context-aware, and clear-definition approach, while considering time and inflation factors, is essential for accurate and reliable construction cost estimation.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter discusses the methodology used to attain the objective of the study. It provides the information about the research design, sampling, questionnaire development, data collection, and analysis instruments.

3.1. Research Design

The research design is selected based on the objectives of the study, the available data sources, the cost of obtaining the data, and the availability of time (Saunders et al., 2009). A mixed research method was used with both quantitative and qualitative data types. The mixed method enabled the study to get more quality data and reduce the disadvantages while gaining the advantages of each data type (Baker, 2010). The data have been collected by survey questionnaires and data collection forms from professionals of building owners, consultants, and contractors.

Upon obtaining the desired data, checking and sorting has been done. The data then analyzed for the validity and conformity of the information obtained through the overall research work followed by thorough discussions to draw a conclusion and recommendations. The research design and procedures to achieve the study objectives can be summarized as shown in Figure 3.1.

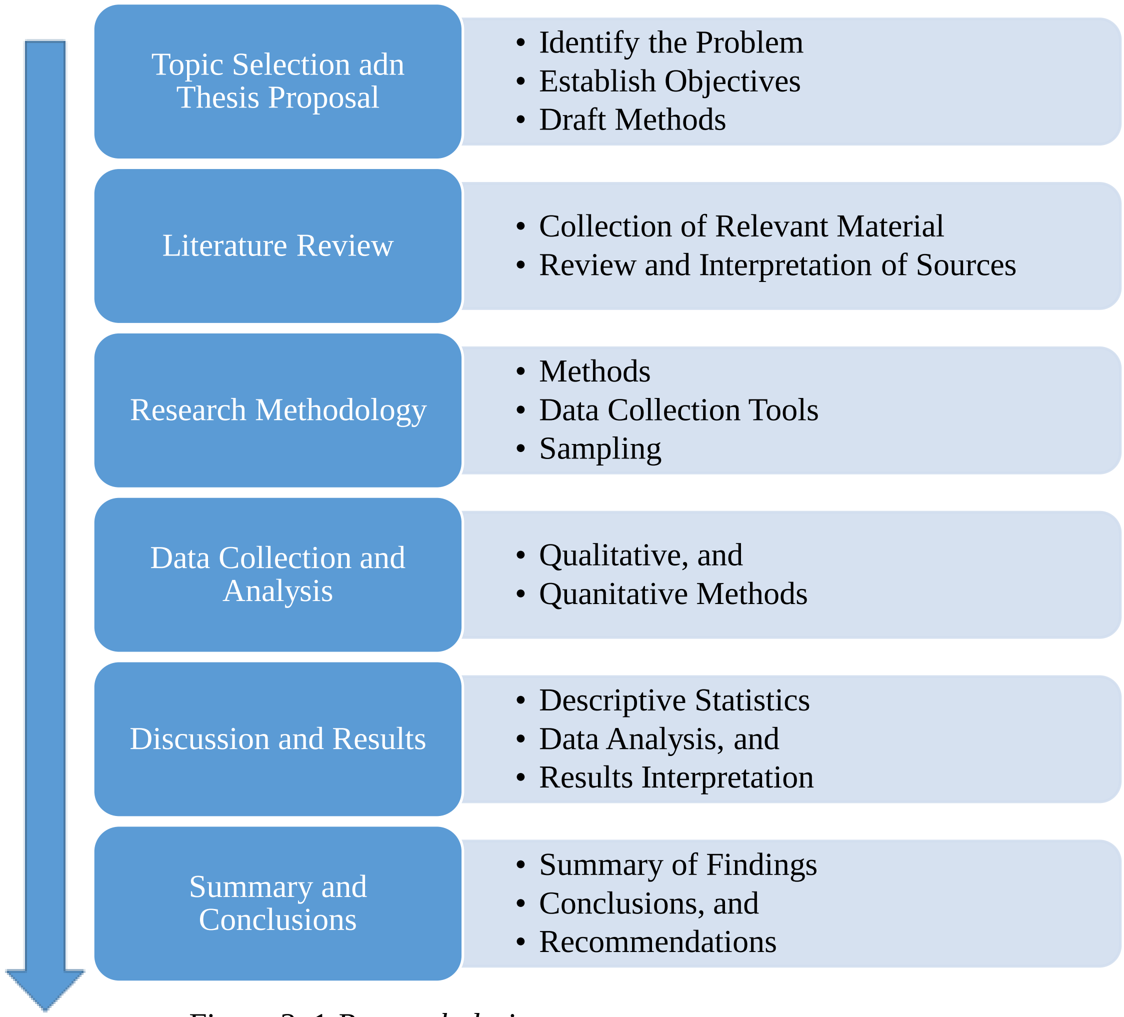

Figure 3. 1 *Research design*

3.2.Description of the Study Area

The study area selected was high-rise buildings found in Addis Ababa. The study area, AA, was selected due to its significant concentration of high-rise buildings, which is relevant to the research topic. As the capital city of Ethiopia, it provides a representation of the country's urban development. Further, the researcher’s familiarity with the area and established professional contacts can facilitate access to information and data collection. The distribution high-rise buildings assessed by the study are shown in the figure 3.2.

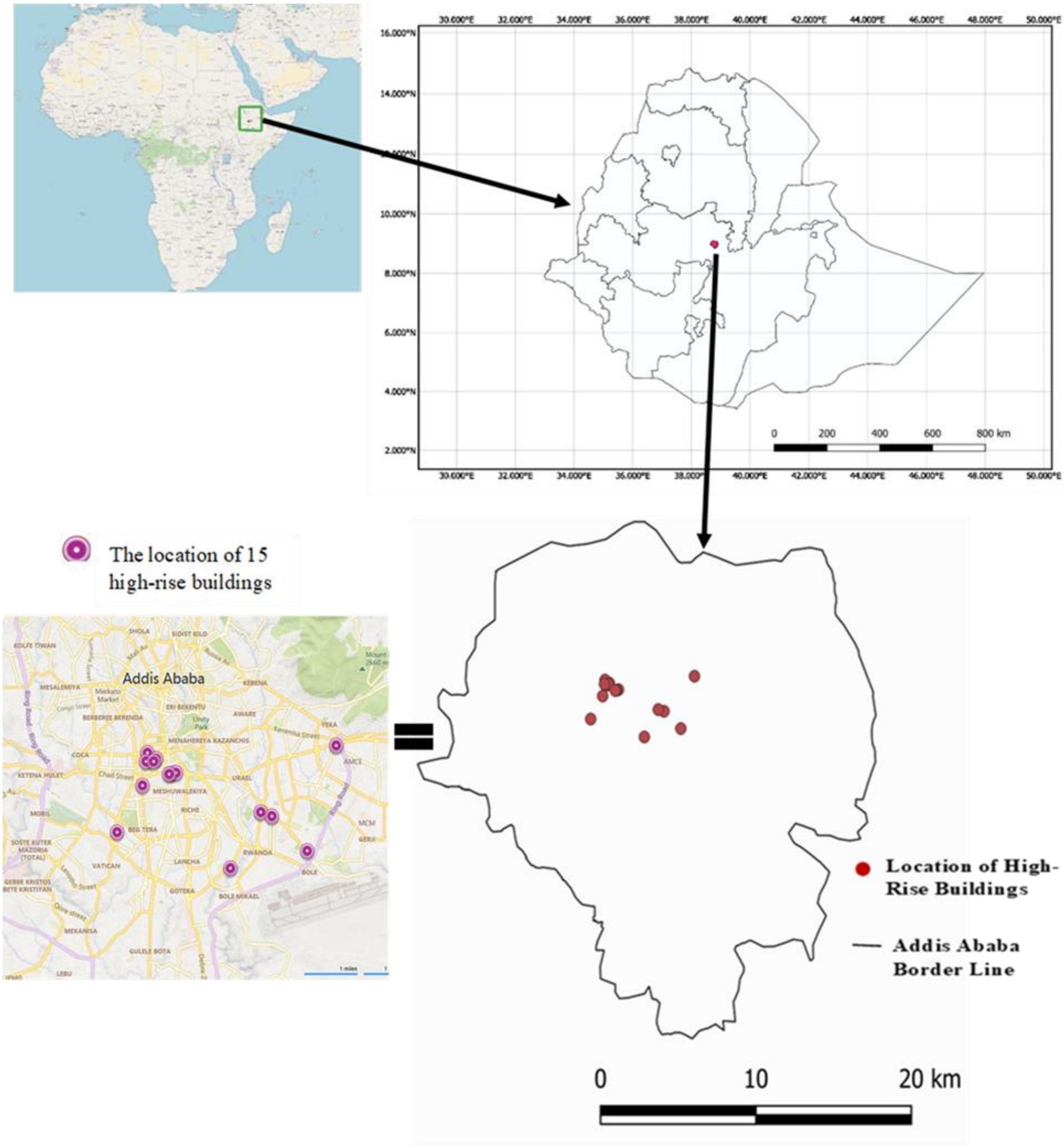

Figure 3. 2 *Distribution of High-Rise Buildings*

3.3. Methods of Data Collection

Different data collection techniques are employed, which enables gathering a sufficient size of data (Alaghbari, 2014; By et al., 2011; Kadiri, 2016). According to Saunders et al. (2009) the type of research and data required to define the method of data collection.

Additionally, the choice of data-gathering methods has been constrained by factors like confidentiality, sensitivity, simplicity of collection, cost, and time (Kumar, 2011). As a result, the following techniques for gathering data were used:

- A literature review related to construction cost estimate of high-rise buildings is conducted. Which provides the basis to design the questionnaire, interview questions, and data collection forms which are used to collect the data needed for the study.
- Questionnaires are distributed to professionals to collect the quantitative, and qualitative data to answer the first objective of the study, which is identifying the cost-significant factors to the construction cost of high-rise buildings in Addis Ababa.
- Factual data collection with personal observation of the selected high-rise buildings is made to assess the percentage of identified cost-significant items to the total construction cost of high-rise buildings in Addis Ababa, which is the second objective of the study.
- Key informant interviews with professionals who have been working in the high-rise building projects are conducted to acquire further insights and recommendations about the study subject.

All the primary data are collected using structured questionnaires, semi-structured interviews, and factual data collection forms. These have happened to be fresh for the first time and, consequently, original in character. The study has applied more than one type of data collection tools have been used to increase the precision through the interpretation of qualitative and quantitative data discussed as follows:

3.3.1. Survey Questionnaire

The questionnaire was used because it enables the study process a bit fast and relatively easy method of collecting data. It has two parts in which the first part was general background information about the respondents including the questions like years of experience, academic qualification, job classification, and organization work experience. This type of information helped the researcher to validate the outcome of the survey. The second part was structured questions that help to identify the cost-significant factors of constructing high-rise buildings developed as follows:

Initially, the survey questionnaire was drafted and shared with five experts for their opinion of its content with the study objective. Then the draft questionnaire was revised and structured based on the feedback of the experts to have a developed questionnaire. The developed survey questionnaires were distributed online in Google Forms (https://forms.gle/V779nJ1wAwzaMcXk9) or shared with fillable PDFs (attached as an appendix) to respondents involved in the construction of high-rise buildings in Addis Ababa. The questionnaires were specifically structured with five groups of cost-significant factors related to the site, design, structural work, finishing work, and other factors.

The questionnaire was used as a quantitative approach to identify the significant factors affecting the construction costs of high-rise buildings.

3.3.2. Interview

A semi-structured interview was used to collect qualitative data. It was preferred its advantage of filling the variety between the structured and unstructured (two extremes) interview questions. It was prepared by incorporating a list of questions and topics that need to be explained during the conversation. However, topical routes in the conversation may move from the guide when further explanation is required. In addition, the interview questions were designed to encourage open responses and opinion expressions.

Purposively selected samples of interviewees having a long year of experience in high-rise building projects or having an educational background based on the recent positions in the respective projects were selected from contractor, consultant and client side. The purposive sampling approach gives far less emphasis on generalizing from a sample to a population, rather, greater attention is paid to its potential to yield insight from its enlightening and rich information sources (Sakyi, 2015). The number of respondents for the interview questions were 15 from different parties as indicated under table 4.20.

3.3.3. Personal Inspection (Factual Data Collection Forms)

A data collection form was prepared and factual data of 11 high-rise buildings has been collected through physical observation. In line with the collection of such data, the summary of the bill of quantities was enquired to the respective departments of the owner of high-rise buildings.

3.4. Population and Sampling

3.4.1. Population

The first step of developing any sample design is to define the set of objects technically called the universe (population) to be studied (Kothari, 2004). According to Burns and Grove (2003), the population is the total number of study units of individuals, artefacts, events or organizations from which data is to be collected. The researcher has observed and assessed the number, type, and age of high-rise buildings in Addis Ababa which meet the defined scope of the study. Accordingly, 15 high-rise buildings were identified as the population of the study (Source; observation, interviews, and online sources).

3.4.2. Sample size

The population size is small in number, and hence all 15 high-rise buildings which fulfil the following selection criteria are considered as the sample size:

- The high-rise buildings must be located in Addis Ababa and have 20 or more storeys, but not exceeding 40 storeys above ground floor level. The upper boundary of the storeys height is set since there is a sole building with a storeys height of 48 floors, which is headquarter building of the Commercial Bank of Ethiopia.

- The beginning date of construction should be within ten years, which means from 2012 to date, and completion shall be within five years, or if it is in progress the skeleton work completed and finishing works contracted.

The selection criteria of study scope are used for the following main reasons;

The initial criterion for selecting data was to choose sizes that were manageable from a budget and time standpoint. The second criterion is to select buildings with complete information about all construction costs. And the third one is to minimize the impact of time change on the construction cost. The actual construction cost of high-rise buildings obtained was subjected to price adjustment for time differences between the project execution period (starting and finishing) of the high-rise buildings with the cost estimation date in the study. Narrowing the development period helps to minimize the errors of the inflation adjustment. Therefore, with the defined scope of the study, 15 high-rise buildings that fulfil the stated boundaries have been included, which are equivalent to the sample size of the study.

3.5.Questionnaire Respondents

For the questionnaire survey, the respondents were professionals that are experienced and experts on the topic of the study. They had been working on completed or ongoing high-rise building projects from the owners, contractors, or consultants' sides. The Likert scale questionnaire was distributed among these professionals. The type of scales used to measure the cost-significant factors is continuous five scales ranging no impact to a huge impact of parameters to the construction cost of high-rise buildings.

The number of questionnaire respondents were 71 from which 61 questionnaires were filled and returned which indicates a response rate of 86%. Following cleaning, 57 of the questionnaires had correctly completed responses, representing an accuracy rate of 80%. The respondents were asked to rate, on a five-point Likert scale cost-significant factors affecting the construction cost of high-rise buildings. The mean score (MS) and standard deviation (SD) were calculated for the responses.

With the discussion made in the previous sections, the list of high-rise buildings included in the study are shown in Table 3.1. From the 15 high-rise buildings assessed by the study a complete cost data was obtained for 11 high-rise buildings only.

Table 3. 1 *List of high-Rise buildings in Addis Ababa*

No	High-Rise Building Name	Height (m)	Storeys including Basement	Year of Cons.		Remarks
				Start	Finish	
1	United Bank HQ	131	35	2016	2022	Data Avail
2	NIB Bank HQ	137	35	2016	2021	"
3	Amhara Credit & Saving Ins. HQ	121	31	2018	2024	"
4	Zemen Bank HQ	112	31	2017	2022	"
5	Century Mall (Bole Brass)	85	25	2019	2023	"
6	Century Mall-Atlas	85	25	2019	2023	"
7	Wegagen Bank HQ	90	23	2012	2018	"
8	Elilta RE Building	86	23	2015	2023	"
9	Yadot Center	98	27	2015	2023	"
10	Bekelle Legesse	109	27	2019	2022	"
11	Senga Tera Trade Union	85	27	2013	2022	"
12	Noah RE Tower	135	36			No Data
13	ARDO (Ameld) HQ	101	27	2015	2022	"
14	Legacy Real Estate Tower	86	22		2019	"
15	KKR Center	86	22		2020	"

3.6. Data Analysis

A quantitative analysis of the five-point Likert scale survey questionnaires with a qualitative interpretation of interview responses was made to identify the cost-significant factors of high-rise buildings. Furthermore, a quantitative analysis was conducted on work items from the bills of quantities, and factual data of the selected high-rise buildings to answer the second and third objectives. Computer applications of

SPSS used for the statistical interpretation of the survey questions, and Microsoft Excel for the analysis of the bill of quantities and factual data of high-rise buildings.

3.6.1. Processing of data

Data processing involves editing, coding, classification, and tabulation of collected data. Editing of data is a process of examining the raw data (especially in surveys) to detect errors and omissions and to correct these when possible (Kothari, 2004a). The data has been edited by removing incomplete questionnaires and those that it is believed are not usable for analysis. After such data cleaning, a few of the questionnaires were found as substantially incomplete. This was done to have accurate data, consistent with other facts gathered, uniformly entered and have been well arranged to facilitate coding and tabulation.

Classification of data is made to arrange data in groups or classes based on common characteristics (Kothari, 2004a). The data classification is made with data collection questionnaires. For example, cost-significant factors of high-rise buildings are grouped into site-related, structural work-related, finishing works, electro-mechanical and other factors.

3.7. Validity and Reliability

The validity test determines how well an instrument measures what it is supposed to measure (Felix et al., 2017). The study has utilized a content validity test to evaluate instrument validity which is the extent to which a measuring instrument provides adequate coverage of the topic. Content validity involved the evaluation of the questionnaire to ensure that it included all essential items and eliminated undesirable ones to construct a domain (Sakyi, 2015).

A literature review has been used to select essential factors affecting the cost of high-rise buildings. Five specialists were consulted to evaluate the questionnaire's content, and some of the initial questions were modified as a result of their input.

Before final data from the entire sample was gathered, a pilot study for the questionnaire was carried out. It serves as a test run for the questionnaire, allowing for the testing of question wording, the identification of problematic questions, and the evaluation of the efficiency of conventional invitations to responders (Naoum, 1998). All questionnaires should initially be piloted; completed by small sample of respondents (Fellows & Liu, 1997). The respondents received an explanation of the study's goals, the substance of the questionnaire, and the inclusion of the data. The approach produced a few explanation-related questions and changed the phrasing of the questionnaire. Minor adjustments and additions were made at the end of the procedure, and the questionnaire's final version was created.

Another crucial test for accurate measurement is the reliability test, which determines if an instrument is trustworthy based on its capacity to produce repeatable results (Kothari, 2004b). The consistency, stability, or dependability of the data is referred to as reliability. Repeating a measurement that produced the same results the first time is considered trustworthy. The measurement is unreliable if the outcomes differ (Sakyi, 2015). For determining the dependability of measurement instruments, many reliability coefficients have been suggested. The most popular metric for evaluating the dependability of data in advance is Cronbach's Alpha (α). A score of more than 0.60 indicates that the data is reliable, while a value of less than 0.5 indicates that the data is unreliable and cannot be accepted (Jugessur, 2022).

The consistency with which an instrument measures the attribute is intended to measure is said to be its reliability (Saunders et al., 2009). The more consistently an instrument measures the same quality, the less variance it generates. The Cronbach's Alpha values for the study data fell between 0.925 and 0.931. This range is regarded as being high and acceptable; the outcome guarantees the validity of questionnaire data. Table 3.2 displays Cronbach's Alpha for all 27 questionnaires, which is 0.930, demonstrating the high reliability of the entire sample. The result shows that the questionnaire is reliable to achieve its purposes.

Table 3. 2 *Reliability statistics*

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.930	0.932	27

Table 3. 3 *CSF-Total Statistics*

Variables	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Access	81.46	210.61	0.65		0.93
Topography	81.28	215.03	0.35		0.93
Location	81.39	205.71	0.64		0.93
SoilType	81.26	213.70	0.47		0.93
Function	79.02	212.62	0.59		0.93
Height	78.81	215.62	0.57		0.93
BUA (Built Up Area)	80.61	201.92	0.71		0.92
No of Basement Floor	80.63	218.92	0.51		0.93
No of Columns	80.74	214.88	0.62		0.93
No Stair-Cases	80.60	215.35	0.52		0.93
No of Elevators	80.18	209.08	0.67		0.93
Foundation Type	80.14	216.80	0.41		0.93
Structure Types	79.98	211.23	0.64		0.93
Slab Type	80.93	214.32	0.46		0.93
Roof Type	81.02	208.91	0.67		0.93
Wall Type (External)	79.42	212.71	0.52		0.93
Wall Type (Internal)	80.33	206.40	0.65		0.93
Wall Finish (External)	79.89	215.67	0.42		0.93
Wall Finish (Internal)	80.44	210.89	0.64		0.93
Floor Finish	79.40	213.35	0.44		0.93
Carpentary & Metal work	80.05	207.52	0.65		0.93
Ceiling	79.05	212.62	0.51		0.93
Electro-Mechanical	79.05	208.27	0.56		0.93
BMS, IT (Building Management System, Information Technology)	79.11	211.38	0.48		0.93
Contractor Type	80.02	203.02	0.68		0.93
Currency	81.14	214.09	0.45		0.93
Contract Type	81.18	201.25	0.64		0.93

3.8. Statistical Analysis

The procedure of recording the data was crucial to the investigation. The researcher created a data summary sheet for the data before beginning the analysis. A "recording scheme" or "producing coding" is the actual procedure of converting the data from the questionnaire onto a data summary sheet (Naoum, 1998). After the data was gathered, the field of statistics was applied to the raw data in order to analyze and discuss the findings.

Descriptive statistics have been used for the analysis of the data's obtained from the questionnaire respondents. Quantitative data analysis was conducted for the data obtained by data collection form and observation. The interview responses were subjected to content analysis to form meaningful results. SPSS program was used to define and code variables, summarize the results on the raw data sheet, and encode and clean the data for the statistical analysis of questionnaires. The results of the SPSS analysis have been translated using the descriptive statistic. For the data's obtained by the data collection form Microsoft Excel have been used.

CHAPTER FOUR

RESULTS AND DISCUSSION

The results and discussion of the data collection process are sorted and interpreted in a way that meets the specific objectives. The analysis of survey questionnaires, bill of quantities, factual data forms, and semi-structured interviews with the application of different methods have been conducted. The results and discussions of the study process are discussed as follows;

4.1. Data with Questionnaires

The data's collected from the questionnaires are designed to answer the first objective of the research, to identify the cost significant factors of high-rise buildings and a statistical analysis have been used for data interpretation.

4.1.1. Quality of the questionnaire Respondents

The questionnaires each has 27 questions were distributed to 71 respondents involved in the construction of high-rise buildings. 61 questionnaires were filled and returned which indicates a response rate of 86%. Following cleaning, 57 of the questionnaires had correctly completed responses, representing an accuracy percentage of 80%. The socio-demographic characteristics, which indicate the quality of the study respondents from the perspective of educational status, type of company involved, job title, years of experience, and experience in building projects are discussed hereunder.

Educational characteristics

Table 4.1 shows that 57.89% of respondents have an educational background of Bachelor of Science-BSc, 26.32% of them have a Master of Science-MSc, 7.02% have a Doctorate of Philosophy-PHD, and the remaining 8.77% possess Diploma. It indicates that above 90% of the respondents have BSc or above. Having such an educational level of respondents improves the cognitive abilities to get knowledge-based responses and increases the consistency of the research result (Olson et al., 2019).

Table 4. 1 *Educational characteristics of the respondents*

	Frequency	Percent	Cumulative Percent
Diploma	5	8.8	8.8
BSc	33	57.9	66.7
MSc	15	26.3	93.0
PhD	4	7.0	100.0
Total	57	100.0	

Organizational Characteristics

As shown in Figure 4.2, 45.6% of the respondents were working in consultant offices, while 28.1% in contractors' side, 17.5% in Client side and 8.8% on other type of offices. This indicates that all type of experience are included and the highest percentage is working in consultant who design and estimate the initial cost of projects, and the second high percentage of the respondents are working for contractor companies which implement and deemed the real cost of projects. Therefore the responses from such related professionals to the study issue would contribute to find a consistent result from the analysis.

Table 4. 2 *Organizational characteristics*

	Frequency	Percent	Cumulative Percent
Client	10	17.5	17.5
Contractor	16	28.1	45.6
Consultant	26	45.6	91.2
Other	5	8.8	100.0
Total	57	100.0	

Level of Experience

As shown under table 4.3, 35.09% of the respondents rated their experience as team lead level, 15.8% rated themselves at the expert level, 7.02% managerial level, and 5.26% of the respondents are CEO level. The remaining 36.84% of the respondents rated themselves as junior-level professionals (others).

Table 4. 3 *Level of Experience*

	Frequency	Percent	Cumulative Percent
CEO	3	5.3	5.3
Managerial	4	7.0	12.3
Team Lead	20	35.1	47.4
Expert	9	15.8	63.2
Others	21	36.8	100.0
Total	57	100.0	

Years of Experience in Building Construction Projects

3.55% of the respondents have above 20 years of experience in building projects, 24.6% of the respondents have 10-20 years, 29.8% are between 5-10 years, 26.3% have 2-5 years, and the remaining 15.8% have below two years of experience (Table 4.4). The result indicates that most of the respondents have direct experience in the subject issue of the study. It enables them to determine the critical factors that affect the cost of building projects.

Table 4. 4 *The Respondents Experience on Building Projects*

	Frequency	Percent	Cumulative Percent
Below 5 Years	9	15.8	15.8
2-5 years	15	26.3	42.1
5-10 years	17	29.8	71.9
10-20 Years	14	24.6	96.5
above 20 Years	2	3.5	100.0
Total	57	100.0	

Conclusion on respondents' characteristics

As discussed above, the majority of the respondents to the questionnaire are well-experienced, educated, and able to give reasonable responses. The outcomes from the analysis will indicate good-quality of results.

4.1.2. Questionnaire Data & Analysis Results

The respondents were asked with a five-point Likert scale to rate the CSF in constructing high-rise buildings. The responses were analyzed to determine the CSF of developing high-rise buildings in Addis Ababa. Then the mean score (MS), and standard deviation (SD) were computed.

The CSF was divided into five categories based on the review of literature and the opinions of key-informant interviews which are site-related, design, structural work, finishing work, and other factors. Each has a set of sub-factors with a Likert scale rating of 1 to 5. Rating 1 indicates that the change in the parameter has no significant effect on cost. Rating 5 indicates that the parameter change significantly affects high-rise building costs. Accordingly, table 4.5 shows the range of limits that determines how each of the CSF impacts the cost of building high-rises.

The limiting values are calculated by dividing the difference between the maximum and minimum length to the maximum length of Likert Type Scale, which is (5 – 1)/5 = 0.8.

Table 4. 5 *Mean Interval Limit*

Mean		
Lower Limit	**Upper Limit**	**Cost Influence Level**
1	1.8	Very Low-Significant
1.81	2.6	Low-Significant
2.61	3.4	Significant
3.41	4.2	High-Significant
4.2	5	Very High-Significant

4.1.3. Cost-Significant Factors of High-Rise Buildings

The first objective of the research is to identify the cost-significant factors (CSF) that affect high-rise development costs. These factors are then categorized into five major groups and the responses from the questionnaire respondents interpreted based on the results of statistics. The statistical analysis showed that multiple CSFs has the same median and mode, which creates difficulty of ranking the factors. Therefore, the CSF under each group are ranked by their mean discussed in the following sections.

1. **Site-related factors**

The sub-categories under this factor are access to the construction site, topography, site location, and soil type which ranked 4th, 2nd, 3rd, and 1st with the average rating score of 1.89, 2.07, 1.96 and 2.09. The site-related factors have an average significant rate of 2.00 which indicates a low significance to influence the construction costs as shown in the following descriptive statics table 4.6.

Table 4. 6 *Site-related factors*

		Cost Significance Level		
	N	Mean	Std. Deviation	Rank by Mean
Soil Type	57	2.09	.912	1
Topography	57	2.07	1.067	2
Location	57	1.96	1.101	3
Access	57	1.89	.838	4
Total		2.00	0.98	

2. **Design-related factors**

The sub-categories under this factor are the function of the building, number of storeys, built-up area, number of basement floors, number of columns, number of staircases, and number of elevators (Table 4.7). The function of the building and number of storeys have ranked second and first with significance scores of 4.33 and 4.54, respectively, which indicates the two parameters are very-high significant to the construction cost of high-rise buildings. Other sub-factors are in significant ranges, starting from 2.61 to 3.18.

In general, the site-related factors have an average significance rate of 3.27, which indicates the design-related issues are high-significant factors for costs, as shown below in Table 4.7.

Table 4. 7 *Design-related factors*

		Cost Significance Level		
	N	Mean	Std. Deviation	Rank by Mean
Height	57	4.54	.657	1
Function	57	4.33	.809	2
No of Elevators	57	3.18	.889	3
No of Staircases	57	2.75	.739	4
BUA (m2)	57	2.74	1.173	5
No of Basements	57	2.72	.526	6
No of Columns	57	2.61	.648	7
Total		**3.27**	**0.78**	

3. Structural work-related factors

The sub-categories under this cost-significant group are type of foundation, structure type, type of slab, and type of roof, which ranked 2nd, 1st, 3rd, and 4th with influence ratings of 3.37, 3.21, 2.42, and 2.33, respectively. The average response rate for the four sub-category items indicates structural differences have a significant influence on the overall cost of high-rise buildings, with a rated influence level of 2.83, as shown in the following descriptive statistics table 4.8.

Table 4. 8 *Structural works-related factors*

		Cost-Significance Level		
	N	Mean	Std. Deviation	Rank by Mean
Structure Types	57	3.37	.816	1
Foundation Type	57	3.21	.796	2
Slab Type	57	2.42	.885	3
Roof Type	57	2.33	.893	4
Total		**2.83**	**0.85**	

4. **Finishing Work-related Factors**

Under this category, there are nine sub-categories: electro-mechanical, ceiling, BMS, floor finishing type, external wall type, external wall finish, carpentry and metal work, interior wall type, and interior wall finishing, which rank with the cost-significance level from 1 up to 9, respectively.

The responses scored by ceiling, electromechanical, and BMS-IT work indicate that these items are very-high significant. The mean significance rating for all sub-factors is 3.71, which indicates that the finishing work items are highly cost significant. The results of the questionnaire are presented as shown in Table 4.9:

Table 4. 9 *Finishing work related factors*

		Cost-Significance Level		
	N	Mean	Std. Deviation	Rank by Mean
Ceiling	57	4.30	.925	1
Electro-Mechanical	57	4.30	1.101	1
BMS, IT	57	4.25	1.057	3
Floor Finish	57	3.95	.990	4
Wall Type (Exterior)	57	3.93	.904	5
Wall Finish (Exterior)	57	3.46	.867	6
Carpentry & Metal work	57	3.30	.999	7
Wall Type (Interior)	57	3.02	1.044	8
Wall Finish (Interior)	57	2.91	.830	9
Total		**3.71**	**0.97**	

5. Other Factors

Under this category, there are three sub-categories: contractor's locality, the currency of the contract, and contract type, ranked 1, 2, and 2 with a response rate of 3.33, 2.21, and 2.18, respectively. The result indicates that the currency of the contract and contract type have low significance while being local or foreign contractors has a significant influence on the construction cost.

Table 4. 10 *Other Factors*

		Cost-Significance Level		
	N	Mean	Std. Deviation	Rank By Mean
Contractor (local- foreign)	57	3.33	1.170	1
Currency	57	2.21	.921	2
Contract Type	57	2.18	1.325	3
Total		2.57	1.14	

Summary of the identified CSF

Table 4.11 hereunder displays the cost-significance levels of all items in descending order by cost influence level. The first five items are rated as very high-significant; items from numbers six to eight are rated as high-significant; items from nine to nineteen are significant; and all the remaining items are rated below 2.6, which falls into the category of low-significant to the construction cost of high-rise buildings.

Table 4. 11 *All CSI in descending order*

	No	CSI	N	Mean	Std. Deviation	Rank by Mean	Cost Significance Level
I	1	Height	57	4.54	.657	1	Very High Significant
	2	Function	57	4.33	.809	2	
	3	Electro-Mechanical	57	4.30	1.101	3	
	4	Ceiling	57	4.30	.925	4	
	5	BMS, IT	57	4.25	1.057	5	
II	6	Floor Finish	57	3.95	.990	6	High-Significant
	7	Wall Type (Exterior)	57	3.93	.904	7	
	8	Wall Finish (Exterior)	57	3.46	.867	8	
III	9	Structure Types	57	3.37	.816	9	Significant
	10	Contractor Type	57	3.33	1.170	10	
	11	Carpentry & Metal work	57	3.30	.999	11	
	12	Foundation Type	57	3.21	.796	12	
	13	No of Elevators	57	3.18	.889	13	
	14	Wall Type (Interior)	57	3.02	1.044	14	
	15	Wall Finish (Interior)	57	2.91	.830	15	
	16	No Stair Cases	57	2.75	.739	16	
	17	BUA (m2)	57	2.74	1.173	17	
	18	No of Basement Floor	57	2.72	.526	18	
	19	No of Columns	57	2.61	.648	19	
IV	20	Slab Type	57	2.42	.885	20	Low-Significant
	21	Roof Type	57	2.33	.893	21	
	22	Currency	57	2.21	.921	22	
	23	Contract Type	57	2.18	1.325	23	
	24	Soil Type	57	2.09	.912	24	
	25	Topography	57	2.07	1.067	25	
	26	Location	57	1.96	1.101	26	
	27	Access	57	1.89	.838	27	

Summary of Identified CSF by their Group

The total mean under each table from 4.7 to 4.10 indicates the cost significance level of the group factors. Hence, finishing work and design-related parameters have the highest impact on the construction cost of high-rise buildings. The table below summarizes the cost influence level of cost-significant items by their group:

Table 4. 12 *Cost-significant Factors by group*

		Cost-Significance Level		
Group of Factors	**N**	**Total Mean**	**Std. Deviation**	**Rank By Mean**
Finishing Works	57	**3.71**	0.97	1
Design-Related	57	**3.27**	0.78	2
Structural Works	57	**2.83**	0.85	3
Others (contractor's locality, currency of contract, and contract type)	57	**2.57**	1.14	4
Site-Related Factors	57	**2.00**	0.98	5

4.2. Portion of Cost-Significant Items (CSI) to the Construction Cost of High-Rise Buildings

Assessing the percentage of identified CSI in the total construction cost of high-rise buildings is the second objective of the study. The bill of quantities (BOQ) has been collected only for nine out of 15 high-rise buildings within the study scope. The BOQ was not collected for six high-rise buildings. This is due to the fact that some of the owners did not allow to provide the construction cost information and the rest did not have a complete cost record. Therefore, the percentage of CSI in the total construction cost of high-rise buildings would be estimated based on the BOQ of these nine high-rises. The construction work items in the BOQ shall be further confined to make the analysis more reliable and usable (Kadiri, 2016). Therefore, the bill of quantities is summarized and analyzed with CSI categories, as shown in Table 4.13.

Table 4. 13 *Category of CSI*

Category of CSI	CSI of High-Rise Building
Structural Works (Concrete Work)	Earth Work, Concrete Work for Sub & Super Structure, Other Foundation Works (including water proofing)
Architectural Works (Wall, Floor, Ceiling & Elevation)	All finishing works related to the external wall and partition walls, floor, ceiling, carpentry and jewelry, and walls
Sanitary Works	All sanitary installations, and fittings. Which includes the wastage system lines, treatments, Water supply lines and systems. (All with complete accessories)
Electrical Works	All electrical installation, and fittings
Electro-Mechanical Works	It included all electro-mechanical items including the elevator system, plumbing works, power supply, fire-fighting installation, AC system equipment and installation.
Building Management System (BMS)	The BMS, networking, Information Technology Systems, CCTV, gate systems, HVAC controls.

Table 4.14 below shows the estimated percentage of cost portions covered by each CSI category of high-rise buildings. According to the factual data collected in Table 4.14, four of the nine high-rise buildings have advanced BMS, and the other five were constructed without BMS or with less technological advancement. Accordingly, the analysis of the bill of quantities of the nine high-rise buildings is made with two separate groups of buildings having and not having BMS.

The percentages of cost portions are calculated by dividing the CSI's total cost by the project cost of each high-rise building.

Table 4. 14 *Percentage of the total cost covered by each CSI*

CSI of High-Rise Buildings	High-Rise Buildings Having BMS						High-Rise Buildings Without BMS						
	B1	B2	B3	B4	Mean	Rank	B5	B6	B7	B8	B9	Mean	Rank
Structural Works	26.9%	14.8%	28.6%	23.5%	23.5%	2	32.5%	38.8%	36.0%	28.4%	32.4%	33.6%	2
Architectural Works	31.4%	42.8%	36.4%	36.8%	36.9%	1	48.2%	43.0%	42.6%	45.5%	43.3%	44.5%	1
Sanitary Works	6.5%	3.6%	5.1%	5.1%	5.1%	6	7.7%	4.8%	5.9%	4.5%	7.8%	6.1%	5
Electrical Works	12.8%	12.4%	11.2%	12.1%	12.1%	3	6.0%	7.9%	8.3%	10.7%	10.2%	8.6%	3
Electro-Mechanical Works	6.1%	15.2%	10.7%	10.6%	10.7%	5	5.6%	5.5%	7.3%	11.0%	6.3%	7.1%	4
Building Management System (BMS)	16.3%	11.3%	8.0%	11.9%	11.9%	4							

Note: - B1, B2… B9, represents the nine buildings with BOQ for analysis

As shown in Table 4.14, the CSI that dominates the total cost of high-rise buildings is the architectural works, which rank first for both types of high-rise buildings with and without BMS, covering 36.9% and 44.5% of the total cost, respectively. The next dominant CSI is structural work, which covers 23.5% of buildings with BMS and 33.6% of buildings without BMS. Electrical work is the third dominant CSI for buildings with and without BMS, with 12.1% and 8.6% cost coverage, respectively. For high-rise buildings with BMS, the fourth dominant CSI is the BMS with 11.9% cost coverage, while for high-rise buildings without BMS, electro-mechanical works are the fourth dominant CSI with 7.1% of the cost portion. The fifth cost-dominant factor for high-rise buildings with BMS is electro-mechanical with 10.7% cost coverage, and for high-rise buildings without BMS, sanitary work is the fifth dominant CSI with 6.1% of the total cost. For high-rises with BMS, sanitary work is the sixth dominant CSI with 5.1% of cost coverage.

Table 4. 15 *Min, Max, and Average cost portion of CSI in %*

CSI of High-Rise Buildings	Minimum	Maximum	Weigheted Average	Rank
Structural Works	14.8%	38.8%	31%	2
Architectural Works	31.4%	48.2%	43%	1
Sanitary Works	3.6%	7.8%	6%	6
Electrical Works	6.0%	12.8%	11%	4
Electro-Mechanical Works	5.5%	15.2%	9%	5
Building Management System (BMS)	8.0%	16.3%	12%	3

Based on the analysis shown in Table 4.15, the portion of the total cost of high-rise buildings covered by the architectural work ranges between 31.4% and 48.2% with a weighted average of 43%, and it is ranked first among the other CSIs'. The structural works cover the second highest portion of the total cost, with a minimum of 14.8% and a maximum of 38.8% and a weighted average of 31%.

If the high-rise buildings have the BMS, then the highest percentage of the total cost is covered by the BMS, with a minimum of 8% and a maximum of 16.3% and a weighted average of 12%. The next highest percentage of cost is covered by the electrical work, with a weighted average of 11%, a minimum of 6%, and a maximum of 12.8%. Last but not least cost portion of CSI items that covers 9% and 6% with the weighted average are the electro-mechanical and sanitary works, respectively.

4.3. Construction Cost per Square Meter of High-Rise Buildings

Assessing the construction cost per square meter of high-rise buildings in Addis Ababa is the third objective of the study. Based on the analysis of the factual data collected by the data collection form and the researcher's observation, the construction cost per square meter has been estimated. From the 15 high-rise buildings within the study scope, factual data was collected for 11 high-rises only. For the remaining four high-rise buildings, either the construction progress has stopped, or the total construction cost is not yet known. For this reason, the study has excluded these four high-rise buildings. Therefore, the construction cost per square meter was assessed based on the

11 high-rise buildings' data. The collected factual data were interpreted as shown below in Table 4.16.

Table 4. 16 *Factual Data of High-Rise Buildings*

No	Buildings	Height m (Storey)	Building's Function	Electro-Mechanical	Ceiling	BMS,IT	Floor Finish	Wall Type Exterior	Wall Finish Exterior	Contractor	Carpentry & Metal Work	No of Elevators	Wall Type Interior	Construction Cost (Birr) Rounded by 10million	BUA (m2)	Construction Period	
																Start	Finish
1	4B+G+31 (NIB)	126 (36)	Mixed-Use	Advanced	Expensive	Moderate	Moderate	AL Curtain	NA	Foreign	Advanced	6	Alframe with glass	1,700,000,000.00	51,420.00	2016	2021
2	4B+G+32 (HibretBank)	131 (37)	Mixed-Use	Advanced	Expensive	Advanced	Expensive	AL Curtain	NA	Foreign	Advanced	13	Alframe with glass	2,400,000,000.00	44,500.00	2016	2022
3	4B+G+M+29 (ACSI)	120 (36)	Mixed-Use	Advanced	Expensive	Advanced	Expensive	AL Curtain	NA	Foreign	Advanced	8	Alframe with glass	4,650,000,000.00	76,750.00	2018	2024
4	3B+G+M+29 (Zemen)	113 (33)	Mixed-Use	Advanced	Expensive	Advanced	Moderate	AL Curtain	NA	Foreign	Advanced	6	Alframe with glass	1,600,000,000.00	41,000.00	2017	2022
5	3B+G+M+19 (CenturyAddis-Brass)	70 (23)	Appartment	Moderate	Moderate	No BMS	Moderate	HCB & Al curtain	Quartz paint	Local	moderate	4	HCB & Alframe with glass	590,000,000.00	24,494.00	2019	2022
6	3B+G+M+19 (CenturyAddis)	68 (24)	Mixed-Use	Moderate	Moderate	No BMS	Expensive	AL Curtain	NA	Local	Moderate	4	No Partitions	660,000,000.00	31,200.00	2019	2022
7	4B+G+M+23 (Wegagen)	100 (29)	Mixed-Use	Advanced	Expensive	No BMS	Moderate	AL Curtain	NA	Foreign	Advanced	8	Alframe with glass	800,000,000.00	32,156.00	2012	2018
8	4B+1SB+G+M+20 (ElilitaRE)	91 (27)	Appartment	Advanced	Expensive	Moderate	Expensive	HCB & Curtain	Quartz	Local	Moderate	6	HCB	2,800,000,000.00	63,550.00	2015	2023
9	Yadot Center (3B+G+23)	98 (27)	Mixed-Use	Moderate	Moderate	Moderate	Moderate	Curtain	NA	Local	Moderate	6	Hcb	1,000,000,000.00	36,558.00	2016	2023
10	2B+G+M+23 (Atlas-Tak…)	89 (27)	Mixed-Use	Advanced	Expensive	Moderate	Expensive	Mixed (Al, block)	Paint & Cladding	Local	Advanced	5	HCB Wall	1,700,000,000.00	42,660.00	2019	2022
11	3B+G+M+22 (SengateraUnion)	85 (27)	Mixed-Use	Poor	Poor	Poor	Moderate	Mixed (Al, block)	Quartz paint	Local	Moderate	6	Mixed (Block+Al)	470,000,000.00	37,050.00	2012	2023

The time it takes for each high-rise structure to complete its construction varies. Each high-rise will have its overall construction cost adjusted to account for cost changes between the first and last years of the development period. The buildings that are part of the data collection were constructed between 2011 and 2022, a period of just over 11 years. The cost of supplies, labor, and machinery is continually fluctuating.

As a result, the construction cost determined by the bill of quantities may not be the cost at either the start or completion year; rather, it should be the midpoint of the development duration that best depicts the entire construction cost of that particular building. Then, it shall be converted to an equivalent cost at the time chosen by the study, which is September 2022.

Cost indices were used to convert the construction cost to its equivalent cost at the chosen time. A consumer price inflation index (CPI) published by the FDRE Ministry of Finance is employed for cost conversion and it is attached as an appendix (Cost Inflation Index, 2022). The following discussion explains how the cost inflation index has been organized and interpreted.

$CCB_{st} = C_o (I_m)$

Where,

CCB_{st} = Adjusted construction cost of each building at selected time.

C_o = Construction cost at the mid-year of construction period.

$I_m = IV_{st}/IV_o$

IV_{st} = Index value at selected estimation time, which is 2022

IV_o = Index value at the mid-year of construction period

The adjustment of cost inflation for non-food items is interpreted as shown under table 4.17.

Table 4. 17 *Cost Inflation Adjustment Factors*

Year (E.C)	Year (G.C)	Price Inflation index for non-food items (CPI)*	Adjustment/Multiplier Index (CI)	Cumulative Cost Inflation Adjustment Factors of year 2022 for historical cosntruction costs from 2014 to 2022 ($CCIAF_{september\ 2022}$)								
		Mid Year of Construction Period		2014	2015	2016	2017	2018	2019	2020	2021	2022
1994	2001	0.003	1.003									
""	""	""	""									
""	""	""	""									
2005	2012	0.146	1.146									
2006	2013	0.106	1.106	**3.510**								
2007	2014	0.080	1.080	1	**3.247**							
2008	2015	0.081	1.081	1.081	1	**3.021**						
2009	2016	0.075	1.075	1.162	1.075	1	**2.609**					
2010	2017	0.158	1.158	1.346	1.245	1.158	1	**2.331**				
2011	2018	0.119	1.119	1.506	1.393	1.296	1.119	1	**2.013**			
2012	2019	0.158	1.158	1.744	1.613	1.501	1.296	1.158	1	**1.730**		
2013	2020	0.164	1.164	2.030	1.878	1.747	1.508	1.348	1.164	1	**1.350**	
2014	2021	0.281	1.281	2.600	2.405	2.238	1.932	1.727	1.491	1.281	1	**1.000**
2015	2022	0.350	1.350	3.510	**3.247**	**3.021**	**2.609**	**2.331**	**2.013**	**1.730**	**1.350**	**1**

Note: Adapted from the FDRE Ministry of Finance

Therefore, the construction cost of each high-rise building is adjusted for inflation between its construction period and the selected study time, which is September 2022. Then the construction cost per square meter is derived by dividing the adjusted construction cost of each high-rise building by its built-up area (BUA), as shown under table 4.18:

Table 4. 18 *Cost per square meter of high-rise buildings as of September 2022*

No	Buildings	Height m (Storey)	Construction Cost (Birr) Rounded by 10million	BUA (m2)	Construction Period		Mid Year*	(I_m)**	Adjusted Cost in ETB (CCB_{2022})	Unit Price (ETB/m2) Rounded by 1000
					Start	Finish				
1	4B+G+31 (NIB)	126 (36)	1,700,000,000.00	51,420.00	2016	2021	2018	2.331	3,963,152,833.37	**77,000.00**
2	4B+G+32 (HibretBank)	131 (37)	2,400,000,000.00	44,500.00	2016	2022	2020	1.730	4,150,893,600.00	**93,000.00**
3	4B+G+M+29 (ACSI)	120 (36)	4,650,000,000.00	76,750.00	2018	2024	2021	1.350	6,277,500,000.00	**82,000.00**
4	3B+G+M+29 (Zemen)	113 (33)	1,600,000,000.00	41,000.00	2017	2022	2019	2.013	3,221,093,433.60	**79,000.00**
5	3B+G+M+19 (CenturyAddis-Brass)	70 (23)	590,000,000.00	24,494.00	2019	2022	2020	1.730	1,020,428,010.00	**42,000.00**
6	3B+G+M+19 (CenturyAddis)	68 (24)	660,000,000.00	31,200.00	2019	2022	2020	1.730	1,141,495,740.00	**37,000.00**
7	4B+G+M+23 (Wegagen)	100 (29)	800,000,000.00	32,156.00	2012	2018	2015	3.247	2,597,939,280.17	**81,000.00**
8	4B+1SB+G+M+20 (ElilitaRE)	91 (27)	2,800,000,000.00	63,550.00	2015	2023	2019	2.013	5,636,913,508.80	**89,000.00**
9	Yadot Center (3B+G+23)	98 (27)	1,000,000,000.00	36,558.00	2016	2023	2020	1.730	1,729,539,000.00	**47,000.00**
10	2B+G+M+23 (Atlas-Tak…)	89 (27)	1,700,000,000.00	42,660.00	2019	2022	2020	1.730	2,940,216,300.00	**69,000.00**
11	3B+G+M+22 (SengateraUnion)	85 (27)	470,000,000.00	37,050.00	2012	2023	2017	2.609	1,226,082,923.32	**33,000.00**

* The mid Year of construction period of high-rise buildings

** A multiplying factor for price inflation adjustment, derived from the inflation index released by Ethiopian Statistical Agency

Maximum Construction Unit Price (Birr/m2)	**93,000.00**
Maximum Construction Unit Price (Birr/m2)	**33,000.00**
Average Construction Unit Price (Birr/m2)	**66,000.00**

Summary of the Construction Cost per Square Meter

According to the results of the analysis of the minimum, maximum and weighted average construction cost per square meter of high-rise buildings is summarized below. The minimum unit cost is 33,000.00 ETB/m2 for 24 storey building above ground floor and its construction period is between 2012 and 2023. The maximum estimated cost is 93,000.00 ETB/m2 for 33 storey building above ground floor and its construction period is between 2016 and 2023. The weighted average unit rate of the buildings studied is 66,000.00 ETB/m2 having storeys ranging from 21 to 33 with construction period between 2012 and 2023.

Table 4. 19 *Summary of Unit Cost per square meter*

Description	Minimum Cost ETB/m2	Maximum Cost ETB/m2	Weighted Average Cost ETB/m2
Unit Cost/m2	33,000.00	93,000.00	66,000.00
Construction Period	2012 -2023	2016 - 2022	2012 - 2023
Storey (No of Floors) including Basement	26	37	23 - 37

The high-rise buildings with the minimum and maximum construction costs per square meter have the characteristics discussed under Table 4.20:

Table 4. 20 *Characteristics of high-rises with minimum and maximum costs*

Cost-Significant Factors	Buildings With Minimum Cost (33,000 ETB/m2)	Buildings With Maximum Cost (93,000 ETB/m2)
Height	85m	131m
Function	Mixed-Use	Mixed-Use
Electro-Mechanical	Poor	Advanced
Ceiling	No suspended Ceiling	Expensive
BMS, IT	Poor	Advanced
Floor Finish	Average	Expensive
Wall Type (Exterior)	Average	Al Curtain (high-quality)
Wall Finish (Exterior)	Quartz paint for HCB walls	Not Applicable
Structure Types	Reinforced Concrete	Reinforced Concrete
Contractor Type	Local	Foreign
Carpentry & Metal work	Average	Expensive
Foundation Type	Mat Foundation	Mat + Pile Foundation
No of Elevators	6	8
Wall Type (Interior)	HCB & AL	Mostly glass wall and Al frame
BUA (m2)	37,050	44,500

Table 4.20 shows that the high-rise building has a minimum unit price of 33,000 birr/m2. It is found to be a mixed-use building with a storey height of 85m above ground level, moderate quality electro-mechanical items, and no building management system (BMS). The builder for this building is a local contractor; the carpentry and metal work are of moderate quality; most of the external wall is HCB block; and the windows are made of aluminum frames with tinted glass.

On the other hand, the building with the maximum construction cost of 93,000 Birr/m2 is found to be a mixed-use building with a storey height of 131m. It has advanced electro-mechanical systems and a BMS. All the floor finishing materials are customized and imported. Most of the partitions are glass walls; some have aluminum frames; and the rest and a small portion have HCB. The external walls have an aluminum curtain. In general, all the electrical, sanitary, and other facilities are well-advanced and of the luxury type.

4.4. Qualitative Data Result

As part of data triangulation, semi-structured interviews were conducted to improve and validate questionnaire answers. 15 professionals who have worked on either side of the contracting parties (client, consultant, or contractor) in the construction of high-rise structures were sought for the interview. The interviewees were chosen on purpose to get information from those who were deemed to be most qualified to do so. After the researcher has explained the data request, the project owner or one of its staff makes a direct reference to the one that concerns the issue the most. The respondents were described their background experience, current role within their company, years of experience, and degree of education. Based on the information replied from each interviewee eight of them work for clients, four work as consultants, and the remaining three are work for contractors. To triangulate the data and gather trustworthy and first-hand information, the interviewees also filled out the survey questionnaire to identify the cost significant factors. The interview with each respondent took 20 to 30 minutes.

All of the interviewees have at least a BSc degree, 8 years of experience in the construction sector, and one year of experience working on high-rise buildings as detailed under Table 4.21 below. Each participant is well-positioned to understand key high-rise building cost principles, and the findings are discussed qualitatively on the next paragraphs.

Table 4. 21 *Interviewee's Characteristics*

No	Contracting Parties	Education Level	Years of Experience		Current Position
			Total	High-Rises	
1	Client	BSc	13	5	Department Head
2	Client	MSc	8	3	Project Engineer
3	Client	BSc	11	4	Engineering Division Director
4	Contractor	MSc	14	3	Project Manager
5	Client	MSc	20	5	Project Manager
6	Contractor	BSc	15	2	Construction Engineer
7	Consultant	MSc	8	3	Resident Engineer
8	Consultant	MSc	23	8	Resident Engineer
9	Client	MSc	11	2	Project Manager
10	Contractor	MSc	9	1	Engineer
11	Consultant	BSc	13	4	Site Supervisor
12	Client	BSc	13	2	Project Manager
13	Client	MSc	17	3	Project Manager
14	Contractor	MSc	12	2	Project Manager
15	Client	BSc	15	5	Team Leader
MSc = Master of Science			BSc = Bachelor of Science		

Experts' Opinion

Interviewees were asked to respond with their opinion to one of the main objectives of the research that is identifying the cost-significant items in the construction of high-rise buildings in Addis Ababa. Accordingly, the findings from the interviewees have been discussed as follows:

Cost-Significant Items:

Interviewees highlighted several items that significantly impact construction costs:

- Aluminum Works: Includes windows, doors, and façade elements.
- Building Management Systems (BMS): Technological systems for monitoring and controlling building functions (e.g., HVAC, lighting).
- Electro-Mechanical Units: Refers to electrical and mechanical systems (e.g., elevators, plumbing, electrical wiring).
- Floor Finishing: Materials and labor for flooring (e.g., tiles, carpets, hardwood).
- Concrete Structures: Foundation, columns, beams, and slabs.
- Partition Materials: Type of walls and partitions within the building.

Factors Influencing Cost per Square Meter:

Interviewees identified various factors affecting construction cost per square meter:

- Contractor Selection: The choice of construction contractor impacts costs.
- Design Simplicity: Complex designs may increase costs.
- Building Function: Purpose (e.g., residential, commercial) influences costs.
- Building Height: Taller structures often incur higher costs.
- Site Conditions: Terrain, soil quality, and accessibility affect costs.
- Built-Up Area: Larger areas correlate with higher costs.
- Number of Columns: Structural complexity matters.
- Number of Staircases: Vertical circulation elements impact costs.
- Currency of the Contract: Exchange rates influence project costs.
- Contract Type: Different contract models (e.g., lump sum, cost-plus) affect pricing.
- Foundation Types: Foundation design and materials play a role.

Less Impactful Factors:

The interviewees also identified the following factors as less-significant to total cost of high-rises:

- The site condition, built-up area, number of columns, structure types, number of staircases, the currency of the contract, contract type, and foundation types are some of the less significant factors.

4.5. Discussion

The data collection process involved the use of survey questionnaires, bill of quantities, factual data forms, and semi-structured interviews. The majority of respondents had a Bachelor's degree or higher, indicating a high level of education and expertise. The respondents were from various types of organizations, with the highest percentage working in consultant offices and contractor companies. The respondents had varying levels of experience, with a significant portion rating themselves as team lead or expert level building construction projects which enhances their ability to provide accurate responses.

The questionnaire data was analyzed using a Likert scale to determine the cost-significant factors (CSF) in constructing high-rise buildings. The CSF were categorized into site-related, design-related, structural work-related, finishing work-related, and other factors. The design-related and finishing work-related factors were found to have the highest significance to the construction cost of high-rise buildings.

The architectural works were identified as the most dominant cost-significant item, followed by structural works and electrical works. - The percentage of cost portions covered by each CSF category was estimated based on the bill of quantities of nine high-rise buildings. If the high-rise building has a building management system (BMS) it had a significant impact on the cost with 16% of the total cost. The findings provide valuable insights into the factors that significantly affect the cost of constructing high-rise buildings.

From the qualitative analysis aluminum works, BMS, electro-mechanical units, floor finishing, and concrete structures are identified as the most cost-significant items in the construction of high-rise buildings. Factors such as the selection of contractors, design simplicity, building function, and building height were mentioned as the highest cost drivers to the construction cost per square meter.

The construction cost per square meter of high-rise buildings in Addis Ababa is assessed based on the data of 11 high-rise buildings. The assessed unit cost was subjected to inflation adjustment between the construction period and estimation date. The cost of supplies, labor, and machinery fluctuates over time. Cost indices were used to convert the construction cost to its equivalent cost at the chosen estimating time, which is September 2022. According to the analysis, the minimum estimated unit cost is 33,000.00 ETB/m2, the maximum is 93,000.00 ETB/m2, and the weighted average unit rate is 66,000.00 ETB/m2. The high-rise buildings with the minimum and maximum construction costs per square meter have different characteristics.

CHAPTER FIVE

SUMMARY OF FINDINGS, AND CONCLUSIONS

This research focused on three specific objectives: Identifying the cost-significant factors, assessing the cost portion of identified cost-significant items, and determining the construction costs per square meter of high-rise buildings in Addis Ababa. Under each of the specific objectives, the following findings and significant conclusions have been deduced and presented based on the discussion from the previous chapters:

5.1. Summary of the Findings

1. **The first objective of this study was to identify the cost-significant factors (CSF) influencing the total cost of high-rise buildings.**

The study has found 27 potential cost-significant factors divided into five main categories related to site work, structural work, finishing work, and others. The study came to the conclusion that not all factors have an equal impact on the price of constructing high-rise buildings in Addis Ababa.

From the 27-potential cost-significant factors, 19 factors that score a rating above the mean are identified as cost-significant, and the remaining eight factors are insignificant. of the 19 cost-significant factors, five are very high cost-significant, three are high-significant, and 11 are significant. The rating and rank of each of the cost-significant factors are listed in descending order of their mean, as shown in the following Table 5.1.

Table 5. 1 *Ranked Cost-Significant Factors*

Identified CSF Rated Above The Average			CSF Rated Below The Average		
Factors	Rating	Rank	Factors	Rating	Rank
Height	4.54	1	Slab Type	2.42	20
Function (Building Use)	4.33	2	Roof Type	2.33	21
Electro-Mechanical	4.30	3	Currency	2.21	22
Ceiling	4.30	4	Contract	2.18	23
BMS, IT	4.25	5	Soil Type	2.09	24
Floor Finish	3.95	6	Topography	2.07	25
Wall Type (Exterior)	3.93	7	Location	1.96	26
Wall Finish (Exterior)	3.46	8	Access	1.89	27
Structure Types	3.37	9			
Contractor Type	3.33	10			
Carpentry & Metal work	3.30	11			
Foundation Type	3.21	12			
No of Elevators	3.18	13			
Wall Type (Interior)	3.02	14			
Wall Finish (Interior)	2.91	15			
No Stair Cases	2.75	16			
BUA (m2)	2.74	17			
No of Basement Floor	2.72	18			
No of Columns	2.61	19			

Table 5.1 shows that the vertical height, its function, and electro-mechanical system types are ranked from first to third, which are the most dominant cost-significant factors in the construction cost per square meter of high-rise buildings. On the contrary, the slab and roof type, currency and contract type, soil and topography, location, and access are the least cost-significant factors.

2. **Assess the percentage of identified cost-significant items to the total construction cost of high-rise buildings in Addis Ababa;**

The results from the analysis of the survey questionnaires, interviews, and factual data on high-rise buildings help identify the cost-significant items. Accordingly, the first three dominant cost factors identified with the analysis of the questionnaires are finishing works, design-related parameters, and structural works.

In Addis Ababa, there are about 16 high-rise buildings with 20 floors above ground level. There is only one building with more than 40 storeys, which is the headquarters of the Commercial Bank of Ethiopia, with 48 storeys above ground level. Due to its unique height, it is excluded from the study.

Of the high-rise buildings under study, foreign contractors constructed about 45.45% of them, while local contractors constructed the remaining 55.55%. The analysis shows that buildings built by foreign contractors are superior in workmanship and have a higher construction cost. The high-rise buildings in the stated range are mostly built for mixed-use, including office and commercial spaces.

Based on the analysis of the bill of quantity of the high-rise buildings, the architectural, structural, building management system (BMS), electrical, electro-mechanical, and sanitary works are the cost components of high-rise buildings, accounting for a portion of the total costs of 43%, 31%, 12%, 11%, 9%, and 6%, respectively. The first three cost-significant items cover 86% of the total cost of construction of high-rise buildings: architectural, structural, and BMS.

The analysis of this study to the bill of quantity for each building shows that when the building materials and technology applications are getting more advanced with quality, the influence of each significant item on total construction cost changes significantly and subsequently to the square unit of building areas.

3. **Assess the construction costs per square meter of high-rise buildings in Addis Ababa**;

The factual data including the bill of quantity, built-up area (BUA), and construction period for each of the study samples of high-rise buildings is collected. Since the construction period of each building is different and the cost analysis date is September 2022, a price inflation index is considered based on the cost index derived by the Ministry of Finance in 2021 to adjust the construction costs to the study date. Then, the adjusted construction unit price per square meter is estimated by dividing the adjusted construction cost of each building by its BUA.
The BUA measured is the gross built-up area including the area covered by the lift shaft, staircase, utility ducts, and other small openings but excluding wide open downs.

Based on this, the estimation of unit price per square meter as of September 2022 shows that;

- ✓ The estimated minimum unit price per square meter to construct a high-rise building in Addis Ababa is **33,000.00 Birr/m^2**.

- ✓ The estimated maximum unit price per square meter to construct a high-rise building in Addis Ababa with advanced technology and high quality is about **93,000.00 Birr/m2.**

- ✓ The average construction cost to build a high-rise building in Addis Ababa with moderate quality and advancement is estimated at **66,000.00 Birr/m2.**

5.2. Conclusions

The research was conducted to evaluate the building costs of high-rise buildings in Addis Ababa with a specified range of building heights. The study made an effort to consider the study samples from the perspectives of height and construction year.

The analysis findings showed that each high-rise building has unique attributes of height, function, floor space, and construction cost units. The price per square meter of high-rise buildings increases with the increase of each storey. The price per square meter rises as building systems and technology become more. The construction cost per square meter is higher for high-rise buildings with premium finishing materials.

Among the categories of cost-significant items, architectural works, concrete skeleton works, BMS, and electromechanical systems are the most cost-dominant items. Accordingly, the costs per square meter greatly vary from building to building due to the variations with the cost-significant items. To strengthen this the quantitative analysis shows a wide range of amounts between the minimum and maximum unit prices of the construction cost of high-rise buildings, which is about 60,000 Birr/m2, twice of the minimum and 68% of the maximum unit price.

The quantitative and qualitative analysis shows that the construction costs are affected by the building height and function, material types and quality, construction methodologies, contract types, and construction duration. And hence, estimating the construction costs of high-rise buildings requires consideration of such cost-significant factors.

5.3.Recommendations

The study makes the following suggestions for further research:

Different cost-significant factors affect the total costs of developing high-rise buildings. However, further research needs to be done to determine how each cost-significant factor impacts the overall price of a high-rise building.

The study has assessed that there is a wide range of construction costs per square meter for high-rise buildings due to minor differences in cost parameters. It's the study's recommendation to conduct further research on why such a wide cost range happens

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Appendix A

Cost Inflation Index for Non-Food Items

በኢትዮጵያ ፌዴራላዊ ዲሞክራሲያዊ ሪፐብሊክ

የገንዘብ ሚኒስቴር

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF FINANCE

ቁጥር / Ref.No [illegible]30/7/5/02

ቀን / Date 8/7/2014

ለገቢዎች ሚኒስቴር

አዲስ አበባ

ጉዳዩ፡ የዋጋ ግሽበት ማስተካከያ መረጃ መላክን ይመለከታል፤

የሚኒስትሮች ምክር ቤት የገቢ ግብር ደንብ ቁጥር 410/2009 (እንደተሻሻለ) አንቀጽ 56(1) በገቢ ግብር አዋጅ የተመለከተው በአክሲዮን ዋጋ እድገት (ምድብ "ሀ") እና በህንጻ ዋጋ እድገት (ምድብ "ለ") ግብር የሚከፈልበት ዋጋ የገንዘብ ሚኒስቴር በሚያወጣው መመሪያ መሰረት የዋጋ ግሽበት ማስተካከያ ሊደረግበት እንደሚገባ ይደነግጋል፡፡

በዚህም መሰረት የገንዘብ ሚኒስቴር በየአመቱ የኢትዮጵያ ብሄራዊ ባንክ የሚያወጣውን የዋጋ ግሽበት መረጃ መሰረት በማድረግ የዋጋ ግሽበት ማስተካከያ የሚደረግበትን መጣኔ መወሰን ይኖርበታል፡፡

ስለዚህ የካፒታል ዋጋ እድገት ጥቅም ግብር በሚሰላበት ጊዜ የዋጋ ግሽበት ማስተካከያ የሚደረግበትን ሰንጠረዥ ከዚህ ደብዳቤ ጋር አባሪ በማድረግ የላክን ስለሆነ ስራ ላይ እንዲውል እንዲደረግ እናሳስባለን፡፡

ከሰላምታ ጋር

ስልክ 251-11-155 24 00, 22 66 98 / 251-11-155 00 81, 83 86 89
የፖ.ሣ.ቁ P.O.BOX 1905,1037
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የዋጋ ግሽበት ማስተካከያ

	የወጪ ግሽበት መረጃ (Cost Inflation Index)	
የግብር አመት	አመታዊ ምግብ ነክ ያልሆኑ እቃዎች የዋጋ ግሽበት መቶኛ % (የኢትዮጵያ ብሄራዊ ባንክ)	የዋጋ ግሽበት ማስተካከያ(CII)
1994	**0.3%**	**መነሻ (Base)100.000**
1995	0.2%	100.2
1996	2.2%	102.4
1997	4.4%	106.8
1998	7.1%	114.5
1999	13.5%	129.9
2000	12.5%	146.2
2001	23.5%	180.5
2002	**18.2%**	**213.4**
2003	21.8%	259.9
2004	22.7%	318.9
2005	14.6%.	365.5
2006	10.6%	404.2
2007	8.0%	436.5
2008	8.1%	471.8
2009	7.5%	507.2
2010	15.8%	761.1
2011	11.9%	657.2
2012	15.8%	761.1
2013	***16.4%***	885.9

28.114% 2014 መስከረም

ምሳሌ

አንድ ግብር ከፋይ የካፒታል ዋጋ እድገት ጥቅም ግብር የሚከፈልበት አንድ ንብረት በ 2004 ኢ.ም በብር አምስት ሚሊዮን ቢገዛ እና ይህንን ንብረት በ2013 ኢ.ም. በብር አስራ አምስት ሚሊዮን ቢሸጥ የካፒታል ዋጋ እድገት ጥቅም ግብር የሚሰላው በሚከተለው አካኋን ይሆናል፡፡

በመጀመሪያ ንብረቱ በተሸጠበት/ በተላለፈበት ጊዜ የሚያወጣውን ዋጋ ለማወቅ ንብረቱ በተገዛበት ዋጋ ላይ ምግብ ነክ ያልሆኑ ሸቀጦችን የዋጋ ግሽበት መሰረት በማድረግ ማስተካከያ ይደረጋል ፡፡

=885.9/318.9-2.8

በዚህ የዋጋ ግሽበት ማስተካከያ መሰረት ንብረቱ በተሸጠበት ጊዜ የሚያወጣው ዋጋ 2.78*ብር 5ሚሊዮን = 13,900,000 ይሆናል፡፡

በመሆኑም የካፒታል ዋጋ እድገት ጥቅም ግብር የሚከፈለው ብር15,000,000-13,900,000= ብር 1,100,000 ሰይ ይሆናል፡፡

Appendix B

Survey Questionnaires

Dear respected Respondent,

I am a graduate student at Addis Ababa University, EiABC. Currently I am conducting a research entitled '**A COMPREHENSIVE ANALYSIS OF HIGH-RISE CONSTRUCTION COSTS IN ADDIS ABABA**. The study aims to generate a cost indicator rate. To this end, your kind and objective response will significantly contribute to find a precise result.

Therefore, your honest responsiveness is strongly required to make the research valuable and reliable. This is purely academic exercise, so any information given would not be disclosed to the 3rd party.

Thank you in advance for your kind cooperation and dedication to your time.
Yitref Derbie (yitrefderbie@gmail.com)

Instructions

No need of writing your name

For 6point Likert scale type questions indicate your answers with a tick/shade in the appropriate block.

For blank spaces (Other Options) please write the correct Information

1. Basic Profile

1.1 Education

- ○ High School
- ○ Diploma
- ○ BSc
- ○ MSc
- ○ PHD

1.2 Total Years of Experience - in construction Industry

- ○ below 2years)
- ○ 2-5years
- ○ 5-10Years
- ○ 10-20Years
- ○ Above 20years

1.3 Years of Experience - in building construction

- ○ below 2years)
- ○ 2-5years
- ○ 5-10Years
- ○ 10-20Years
- ○ Above 20years

1.4 Organizational characteristic you have been working more?

- ○ Client
- ○ Contractor
- ○ Consultant
- ○ Other __________

1.5 What is your level of experience?

- ☐ CEO (Executive)
- ☐ Managerial
- ☐ Team Lead
- ☐ Expert
- ☐ Other __________

2. **Questions to identify the degree of Cost-Significant items in construction of high rise buildings.**

Listed Items in the first column are factors that may/may not affect **construction cost per square** meter of high rise buildings in Addis Ababa (AA).

Numbers between (0-5) in the first raw indicate the impact level of each factor to the change of construction cost per square meter of high-rise buildings.

Number zero refers that the change to this parameter has no effect on the cost, while number five refers that the change in the parameter has a huge influence on cost.

2.1 Site-Related Factors

	0	1	2	3	4	5
1. Access to Construction Site	○	○	○	○	○	○
2. Topography	○	○	○	○	○	○
3. Location (Different parts of AA)	○	○	○	○	○	○
4. Soil Type	○	○	○	○	○	○

2.2 Design Factors

	0	1	2	3	4	5
1. Purpose of Building Uses (Mixed, Commercial, Residential)	○	○	○	○	○	○
2. Height (Storey) of the Building	○	○	○	○	○	○
3. Built Up Area (BUA) of the Building	○	○	○	○	○	○
4. Number of Basement floors	○	○	○	○	○	○
5. Number of Columns	○	○	○	○	○	○
6. Number of Stair Cases	○	○	○	○	○	○
7. Number of Elevators (Shaft Groups)	○	○	○	○	○	○

2.3 Factors Related To Structural Works

	0	1	2	3	4	5
1. Type of Foundation (Mat, Pile..)	○	○	○	○	○	○
2. Structural System (Rigged-Frame, Wall-Frame, Shear-Wall, Frame Solid, Core-Outrigger ...)	○	○	○	○	○	○
3. Type of Slab (Ribbed, Solid, flat)	○	○	○	○	○	○
4. Type of roof	○	○	○	○	○	○

2.4 Factors Related to Material Choices (Finishing Works)

	0	1	2	3	4	5
1. Wall Type (External) HCB, Curtain, Panel)	○	○	○	○	○	○
2. Wall (Partitions) HCB, Al frame, Glass)	○	○	○	○	○	○
3. Wall Finishing (External)	○	○	○	○	○	○
4. Wall Finishing Type (Internal)	○	○	○	○	○	○
5. Floor Finishing Types (Porcelain, Granite, parquet,...)	○	○	○	○	○	○
6. Quality of Carpentry and Metal Works (poor, Moderate, High)	○	○	○	○	○	○
7. Type of False Ceiling (Gypsum, acoustic, AL Frame-Board)	○	○	○	○	○	○
8. Electro-Mechanical Systems including fire fighting, alarm (Poor, moderate, Advanced...	○	○	○	○	○	○
9. Use of Technology (BMS, IT)	○	○	○	○	○	○

2.5 Other Factors

	0	1	2	3	4	5
1. Contractor Selection (Local VS Foreign (Chinese, European...)	○	○	○	○	○	○
2. Currency of Contract (ETB, USD)	○	○	○	○	○	○
3. Contract Type (Unit Price, Turnkey, Lump sum)	○	○	○	○	○	○

Poor = not meeting expectations ; Moderate = Meeting the Expectations Advanced/High = Exceeding Expectations

2.6) If you know other factors,

2.7) If you have any suggestion about merging factors (The effect of one factor considered in other)

Appendix C

Interview Questions

In view of the importance of the construction sector in Addis Ababa, we extend our sincere thanks and gratitude to you for your contribution in answering these questions.

This structured questionnaire, which aims to study the factors affecting the cost of high-rise buildings and we would like to assure you of the following points:

1. This research focuses on the estimating the construction cost of constructing high-rise building by studying the influencing factors
2. All the information obtained from you will be used as input to this research for the purpose of developing cost estimation model

It's my obligation to maintain the confidentiality of your information.

Part One: Introducing

Education

Experience (general & on high-rise building)

Part Two: Cost-significant factors in construction of high-rise building:

1.1. Factors related to site condition.

- Location
- Accessibility
- Topography
- Soil Type
- Other ----------

1.2. Factors related to Design.

- Building Purpose
- Built up area
- Storeys & storeys height
- Shape
- Others ---------------------

1.3. Factors related to Structural Elements.

- Foundation,

- Structural type
- Number of columns
- Slab Types
- Roofing
- Others -------------------------------

1.4. Factors related to the process of finishing works

- Walls
- Flooring tiles
- Ceiling
- Electrical systems
- Electro-Mechanical systems
- Use of Technology (BMS)
- Other -----------------------------

1.5. Other factors like

- Contract type
- Contractor
- Currency

Appendix D.

Factual Data Collection Form for High-Rise Buildings

Data to assess the current construction costs per square meter and to develop a cost prediction tool for construction of high-rise buildings in Addis Ababa

Instructions
No need of writing your name
Fill on hte DATA column (shaded)
If you have any comment you can use the remark column

No.	Input Data to Be Collected	High-Rise Building, Name -------------------------------------- Location ----------------	
		Data	Remark
	I) Contract Data		
1.1	**Total Construction Cost** (actual if completed, and Estimated if it is on progress)		if contract is in USD, please mention the contract date
1.2	Contract Type (Unitprice, DB, Turnkey)		
1.3	Construction Start Date		
1.4	Completion Date (if in progress please indicate the status)		If not completed indicate the sheduled completion date
1.5	Contractor (Local, Foreign)		
			If it has phase contracts please describe the type, date, amount and
	II) Building Type and Size		
2.1	Building Uses (Mixed, Commercial, Residential)		
2.2	Height of the building Above ground level (in Meter)		
2.3	Number of Storeys (floors)		
2.4	Number of Basement floors		
2.5	Built Up Area (BUA) (in m2) including Basement & all upper floors		
2.6	Number of Stari Cases		
2.7	Number of elevators (By Shaft)		
	III) Structural Descriptions		
3.1	Type of Foundation (Shallow (Mat, Raft), Deep, other ?		
3.2	Structure Types (Systems) (Rigged-Frame, Wall-Frame, Shear-Wall, Frame Solid, Core-Outrigger)		
3.3	Type of Slab (Solid, Ribbed, Flat)		
3.4	Type of roof (EGA, Slab)		

No.	Input Data to Be Collected	High-Rise Building, Name ------------------------------------- Location ------ ----------	
		Data	Remark
	IV) Finishing Work Descriptions		
4.1	External Wall (HCB, Curtain, shear wall)		
4.2	Partition Wall (HCB, Al frame, glalss, none)		
4.3	Wall Finishing (External) (Cladding, Paint, none)		if most area is curtain, the finishing is **none**
4.4	Wall Finishing (Internal) (Cladding, Paint, paper)		
4.5	Floor Finishing Types (Porcelain, Granite, parquet)	Common Areas ___________ Wet areas ________________ Other Spaces	
4.6	Qaulity of Carpentry, Metal Works & other finishing (Poor, Moderate, High)		
4.7	Type of Ceiling (Gypsum, acoustic, painted slab)		
4.8	Electro-Mechanical Systems (Poor, Moderate, Advanced)		
4.9	Fire Fighting and Alarm System (Poor, Moderate, Advanced)		
4.10	Use of Technology like BMS (Poor, Moderate, Advanced)		
	Comment on Site Condtion (Topography, Accessebility, …) (Discussion & Observation)		

NB:- Poor, Moderate, Advanced (Three point value rating scale)

Poor: not meeting expectations

Moderate: meeting expectations

Advanced/High: exceeding expectations

RESEARCH ARTICLE

A COMPREHENSIVE ANALYSIS OF HIGH-RISE CONSTRUCTION COSTS IN ADDIS ABABA

Yitref Derbie[1]**,** *Amha Ermias*[2]*

ABSTRACT

There are various occasions when it is important to assess the construction cost of high-rise buildings and related cost drivers. Government offices estimate the costs of high-rises for property tax purposes. Private companies like Insurances estimate costs for the base price, banks and lenders for collateral, project developer for budgeting or related uses. The construction of high-rise buildings in Ethiopia is an emerging sector with technological advancement within a short period of time. In regard, availability of adequate references about the cost and related cost drivers of high-rise buildings rare in Ethiopia in general and in Addis Ababa in particular. The number of high-rises used for analysis are 15 buildings selected with different criterion. Survey questionnaires are distributed to the purposively selected respondents to identify the cost-significant factors. The factual data of 11 high-rise buildings was collected to analyze the unit prices and assess the cost-significant factors of building high-rises. Semi-structured interviews were conducted to strengthen, integrate, and validate the results from the analysis of the factual data and survey questionnaires. Descriptive statistics were employed to analyze the survey data. The first five identified cost-significant factors are the building's height, function, electromechanical systems, ceiling types, and BMS. The study has also estimated the percentage of cost-significant items to the total construction cost and the range of unit prices per square meters. The first three identified cost-significant items that impacts the construction cost of high-rise buildings are architectural, structural, and BMS works having the average percentage of 43%, 31%, and 12% respectively. Furthermore, the study has estimated the unit price to construct high-rise buildings which ranges between 33,000.00 ETB/m2 to 93,0000.00 ETB/m2 with a weighted average of 66,0000.00 ETB/m2.

Keywords: High-rise buildings, Cost, Cost-estimate, Construction-Cost, Estimate

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1.1.Background of the Study

The development of high-rise buildings plays a vital role in defining livable and sustainable cities (Mir M & Aksamija, 2008). As stated (Ali, 2008), high-rise buildings have become important and form a local emblem for cities and symbols of an industrialized and economically prosperous culture. High-rise buildings signify an element of economic power and a sign of advantage to the country,

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and they also consume a large number of people with a piece of land.

Addis Ababa, the capital city of Ethiopia is often called the "African Capital" due to its historical, diplomatic, and political significance for the continent. Due to these and other socio-economic reasons, the number of high-rise buildings in the capital is increasing rapidly (Fisher et al., 2018). In relation to the development of high-rise buildings, accurate cost estimation is very important for budgeting, scheduling, decision-making, valuation, and more. Cost estimates provide a measure against which to control costs (Kadiri, 2016). Studies show that accurate and precise cost estimation enables real estate professionals to get a reliable prediction of replacement costs (Elfahham, 2019).

Despite this, the challenges of cost estimation increase when building heights get higher and higher due to the addition of features and technologies to the construction methodology. To ease this challenge, many countries, especially developed nations, have a detailed construction cost index with revisions for monthly, quarterly, and yearly periods (Sources and Methods, n.d.).

1.2. Statement of the Problem

In the preliminary stage of a construction project in Addis Ababa, there is a lack of appropriate cost estimate indicators, a lack of available forecasting data, and unstable market conditions to make accurate estimates (Negussie, 2017). According to Akintoye (2000), cited by Negussie (2017), the construction industry, in general, is known for having poor cost estimation and forecasting practices. Building contractors, cost estimators, project developers, and property valuers always need precise construction cost estimates (ANDOM, 2008). Studies about the cost indices of high-rises in Addis Ababa are not easily available. In other developed and developing countries written sources, cost indexes, and other forecasting tools are easily accessible. In study papers at the global and continental levels, the high-rise building construction costs of many developing nations have been included, but finding Ethiopia's row in such publications is not yet simple (AECOM SA (Pty), 2021; Gardner & Pienaar, 2019; Statista Research Department, 2022). The estimation of replacement costs for high-rise buildings poses a significant challenge in practice. Despite available literature, there remains a gap in understanding the specific factors influencing these costs, hindering effective decision-making in urban development. Therefore, this study has been conducted with this understanding of the gap.

Objectives

General objective;

The general objective of the study is to evaluate the construction cost and cost-significant items of high-rise buildings in Addis Ababa.

Specific objectives;

The specific objectives of the study are to;

1. Identify the cost-significant factors to the construction cost of high-rise buildings in Addis Ababa.

2. Assess the percentage of identified cost-significant items to the total construction cost of high-rise buildings in Addis Ababa.

3. Assess the construction costs per square meter of high-rise buildings in Addis Ababa.

LITERATURE REVIEW

Different scholars come up with different definitions of high-rise buildings. Some studies defined: buildings with a height higher than the maximum reach of available firefighting equipment (Wisler, 2009). Other writers said high-rise buildings are tall buildings with multi-story structures in which most occupants depend on elevators [lifts] to reach their destinations. According to the Ottawa Council (2003), a "high-rise is a building with ten storeys or more" (Ottawa Council, 2003). The term does not have internationally agreed-upon definitions (Challinger, 2008).

Sometimes, the definition stated in terms of linear height (feet or meters) rather than stories (Hall Jr, 2005). In absolute numbers this has been set variously to have a building height above 75 feet (23 meters) (YÜKSEL, 2019).

The term "high-rise building" is used in this study to refer to buildings that are at least 20 stories above the ground and not more than 40 storeys.

MATERIALS AND METHODS

The research objectives have been answered through a mixed research method. It enabled the study to gather more information and quality data by reducing the disadvantages while gaining the advantages of each approach (Baker, 2010). Both quantitative and qualitative data are collected. The quantitative data collection is conducted through questionnaires and factual data collection forms, while the qualitative data are collected through key informant interviews with the purposively selected professionals of the high-rise building owners, consultants, and contractors. After the collection of quantitative data, checking and sorting of the data have been conducted. The data then analyzed for validity and reliability. Then a thorough discussion has been made to draw a conclusion based on the findings of the study.

RESULTS

Cost-Significant Factors of High-Rises

The study has identified the cost-significant factors (CSF) of high-rise building construction in Addis Ababa through the analysis of questionnaire responses, as shown in Table 1 below. CSFs' with a mean score (MS) greater than 4.2 are considered very high cost-significant; between 3.41 and 4.2 are high cost-significant; between 2.61 and 3.4 are significant; between 1.81 and 2.6 are low-significant; and below 1.8 are insignificant factors. Accordingly, the CSFs identified as very high cost-significant are the building height, the building function, the electro-mechanical system, the ceiling work, and the BMS. While the low CSFs are access, location, topography, soil type, etc.

Table 1 *CSF in descending order of rank*

No	CSI	N	Mean	Std. Deviation	Rank by Mean	Cost Significance Level
1	Height	57	4.54	0.657	1	Very High Significant
2	Function	57	4.33	0.809	2	
3	Electro-Mechanical	57	4.30	1.101	3	
4	Ceiling	57	4.30	0.925	4	
5	BMS, IT	57	4.25	1.057	5	
6	Floor Finish	57	3.95	0.990	6	High-Significant
7	Wall Type (Exterior)	57	3.93	0.904	7	
8	Wall Finish (Exterior)	57	3.46	0.867	8	
9	Structure Types	57	3.37	0.816	9	Significant
10	Contractor Type	57	3.33	1.170	10	
11	Carpentry & Metal work	57	3.30	0.999	11	
12	Foundation Type	57	3.21	0.796	12	
13	No of Elevators	57	3.18	0.889	13	
14	Wall Type (Interior)	57	3.02	1.044	14	
15	Wall Finish (Interior)	57	2.91	0.830	15	
16	No Stair Cases	57	2.75	0.739	16	
17	BUA (m2)	57	2.74	1.173	17	
18	No of Basement Floor	57	2.72	0.526	18	
19	No of Columns	57	2.61	0.648	19	
20	Slab Type	57	2.42	0.885	20	Low-Significant
21	Roof Type	57	2.33	0.893	21	
22	Currency	57	2.21	0.92	22	
23	Contract Type	57	2.18	1.325	23	
24	Soil Type	57	2.09	0.912	24	
25	Topography	57	2.07	1.067	25	
26	Location	57	1.96	1.101	26	
27	Access	57	1.89	0.838	27	

Summary of Identified CSF by their Category

The identified cost-significant factors shown in Table 2 are categorized into five major groups related to **finishing**, design, structural, site, and others. The total MS is calculated for each group as shown in Table 2, which indicates the group factors' cost-influence level. Hence, finishing work and design-related parameters have the highest impact on the construction cost of high-rise buildings.

Table 2 *Cost-significant Factors by group*

		Cost-Significance Level		
Group of Factors	**N**	**Total Mean**	**Std. Deviation**	**Rank By Mean**
Finishing Works	57	**3.71**	0.97	1
Design-Related	57	**3.27**	0.78	2
Structural Works	57	**2.83**	0.85	3
Others (contractor's locality, currency of contract, and contract type)	57	**2.57**	1.14	4
Site-Related	57	**2.00**	0.98	5

Portion of Cost-Significant Items (CSI) to the Construction Cost of High-Rise Buildings

The bill of quantities (BOQ) has been collected only for nine out of 15 high-rise buildings within the study scope. The BOQ of six buildings could not be collected for reasons of either unwillingness to provide the complete cost data or the complete cost data not yet known. Therefore, the percentage of CSI in the total construction cost of high-rise buildings would be estimated based on the BOQ of these nine high-rises. The construction work items in the BOQ shall be further confined to make the analysis more reliable and usable (Kadiri, 2016). Therefore, the bill of quantities is summarized and analyzed with CSI categories, as shown in Table 3.

Table 3 *Category of CSI*

Category of CSI	CSI of High-Rise Building
Structural Works (Concrete Work)	Earth Work, Concrete Work for Sub & Super Structure, Other Foundation Works (including water proofing)
Architectural Works (Wall, Floor, Ceiling & Elevation)	All finishing works related to the external wall and partition walls, floor, ceiling, carpentry and jewelry, and walls
Sanitary Works	All sanitary installations, and fittings. Which includes the wastage system lines, treatments, Water supply lines and systems. (All with complete accessories)
Electrical Works	All electrical installation, and fittings
Electro-Mechanical Works	It included all electro-mechanical items including the elevator system, plumbing works, power supply, fire-fighting installation, AC system equipment and installation.
Building Management System (BMS)	The BMS, networking, Information Technology Systems, CCTV, gate systems, HVAC controls.

Four of the nine high-rise buildings have advanced BMS, and the other five were constructed without BMS or with less technological advancement. Accordingly, the analysis is conducted to the BOQ of the nine high-rise buildings with two separate groups of buildings with and without BMS.

The percentage of costs shared by each CSI category were calculated by dividing the CSI's total cost by the project cost of each high-rise building, as shown in Table 4 below.

Table 4 Percentage of the total cost covered by each CSI

CSI of High-Rise Buildings	High-Rise Buildings Having BMS						High-Rise Buildings Without BMS						
	B1	B2	B3	B4	Mean	Rank	B5	B6	B7	B8	B9	Mean	Rank
Structural Works	26.9%	14.8%	28.6%	23.5%	23.5%	2	32.5%	38.8%	36.0%	28.4%	32.4%	33.6%	2
Architectural Works	31.4%	42.8%	36.4%	36.8%	36.9%	1	48.2%	43.0%	42.6%	45.5%	43.3%	44.5%	1
Sanitary Works	6.5%	3.6%	5.1%	5.1%	5.1%	6	7.7%	4.8%	5.9%	4.5%	7.8%	6.1%	5
Electrical Works	12.8%	12.4%	11.2%	12.1%	12.1%	3	6.0%	7.9%	8.3%	10.7%	10.2%	8.6%	3
Electro-Mechanical Works	6.1%	15.2%	10.7%	10.6%	10.7%	5	5.6%	5.5%	7.3%	11.0%	6.3%	7.1%	4
Building Management System (BMS)	16.3%	11.3%	8.0%	11.9%	11.9%	4							

Note: *B1, B2… B9, represents the nine buildings with BOQ for analysis*

As shown in Table 4 above, the CSI that dominates the total cost of high-rise buildings is the architectural works, which rank first for both types of high-rise buildings with and without BMS by covering 36.9% and 44.5% of the total cost, respectively. The next dominant CSI is structural work, which covers 23.5% of buildings with BMS and 33.6% without BMS. Electrical work is the third dominant CSI for buildings with and without BMS, with 12.1% and 8.6% cost coverage, respectively. For high-rise buildings with BMS, the fourth dominant CSI is the BMS with 11.9% cost coverage, and for high-rise buildings without BMS, electro-mechanical works are the fourth dominant CSI with 7.1% of the cost portion. The fifth cost-dominant factor for high-rise buildings with BMS is electro-mechanical with 10.7% cost coverage, and for high-rise buildings without BMS, sanitary work is the fifth dominant CSI with 6.1% of the total cost. For high-rises with BMS, sanitary work is the sixth dominant CSI with 5.1% of cost coverage.

Table 5 shows the minimum and maximum range of cost portions shared by each CSI of high-rise buildings. The architectural work shared a large percentage of the total cost with a minimum of 31.4% to a maximum of 48.2% with a weighted average of 43%, and it is ranked first among the other CSIs’. The structural works cover the second-highest portion with a minimum of 14.8%, a maximum of 38.8%, and a weighted average of 31%.

Table 5 *Min, Max, and Average cost portion of CSI in %*

CSI of High-Rise Buildings	Minimum	Maximum	Weigheted Average	Rank
Structural Works	14.8%	38.8%	31%	2
Architectural Works	31.4%	48.2%	43%	1
Sanitary Works	3.6%	7.8%	6%	6
Electrical Works	6.0%	12.8%	11%	4
Electro-Mechanical Works	5.5%	15.2%	9%	5
Building Management System (BMS)	8.0%	16.3%	12%	3

High-rise buildings with the BMS, BMS cover a minimum of 8% and a maximum of 16.3%, with a weighted average of 12%. The electrical work covers a minimum of 6% and a maximum of 12.8% with an average of

11%. Last but not least, the cost portion of CSI items that covers 9% and 6% with the weighted average are the electro-mechanical and sanitary works, respectively.

Construction Cost per Square Meter of High-Rise Buildings

Based on the analysis of the factual data collected by the data collection form and the researcher's observation, the construction cost per square meter for high-rise buildings has been estimated. From the 15 high-rise buildings within the study scope, factual data was collected for 11 high-rises.

The remaining four high-rise buildings have either their total construction cost not yet known or their construction progress has stopped. For this reason, the study has excluded these four high-rise buildings. Therefore, the construction cost per square meter was assessed and interpreted based on the data of 11 high-rise buildings shown below in Table 6.

Table 6 *Factual data of high-rise buildings*

No	Buildings	Height m (Storey)	Building's Function	Electro-Mechanical	Ceiling	BMS,IT	Floor Finish	Wall Type Exterior	Wall Finish Exterior	Contractor	Carpentry & Metal Work	No of Elevators	Wall Type Interior	Construction Cost (Birr) Rounded by 10million	BUA (m2)	Construction Period	
																Start	Finish
1	4B+G+31 (NIB)	126 (36)	Mixed-Use	Advanced	Expensive	Moderate	Moderate	AL Curtain	NA	Foreign	Advanced	6	Alframe with glass	1,700,000,000.00	51,420.00	2016	2021
2	4B+G+32 (HibretBank)	131 (37)	Mixed-Use	Advanced	Expensive	Advanced	Expensive	AL Curtain	NA	Foreign	Advanced	13	Alframe with glass	2,400,000,000.00	44,500.00	2016	2022
3	4B+G+M+29 (ACSI)	120 (36)	Mixed-Use	Advanced	Expensive	Advanced	Expensive	AL Curtain	NA	Foreign	Advanced	8	Alframe with glass	4,650,000,000.00	76,750.00	2018	2024
4	3B+G+M+29 (Zemen)	113 (33)	Mixed-Use	Advanced	Expensive	Advanced	Moderate	AL Curtain	NA	Foreign	Advanced	6	Alframe with glass	1,600,000,000.00	41,000.00	2017	2022
5	3B+G+M+19 (CenturyAddis-Brass)	70 (23)	Appartment	Moderate	Moderate	No BMS	Moderate	HCB & Al curtain	Quartz paint	Local	moderate	4	HCB & Alframe with glass	590,000,000.00	24,494.00	2019	2022
6	3B+G+M+19 (CenturyAddis)	68 (24)	Mixed-Use	Moderate	Moderate	No BMS	Expensive	AL Curtain	NA	Local	Moderate	4	No Partitions	660,000,000.00	31,200.00	2019	2022
7	4B+G+M+23 (Wegagen)	100 (29)	Mixed-Use	Advanced	Expensive	No BMS	Moderate	AL Curtain	NA	Foreign	Advanced	8	Alframe with glass	800,000,000.00	32,156.00	2012	2018
8	4B+1SB+G+M+20 (ElilitaRE)	91 (27)	Appartment	Advanced	Expensive	Moderate	Expensive	HCB & Curtain	Quartz	Local	Moderate	6	HCB	2,800,000,000.00	63,550.00	2015	2023
9	Yadot Center (3B+G+23)	98 (27)	Mixed-Use	Moderate	Moderate	Moderate	Moderate	Curtain	NA	Local	Moderate	6	Hcb	1,000,000,000.00	36,558.00	2016	2023
10	2B+G+M+23 (Atlas-Tak…)	89 (27)	Mixed-Use	Advanced	Expensive	Moderate	Expensive	Mixed (Al, block)	Paint & Cladding	Local	Advanced	5	HCB Wall	1,700,000,000.00	42,660.00	2019	2022
11	3B+G+M+22 (SengateraUnion)	85 (27)	Mixed-Use	Poor	Poor	Poor	Moderate	Mixed (Al, block)	Quartz paint	Local	Moderate	6	Mixed (Block+Al)	470,000,000.00	37,050.00	2012	2023

The time it takes for each high-rise structure to complete its construction varies. Each high-rise will have its overall construction cost adjusted to account for cost changes between the first and last years of the development period. The buildings that are part of the data collection were constructed between 2011 and 2022, a period of just over 11 years. The cost of supplies, labor, and machinery is continually fluctuating.

As a result, the construction cost determined by the bill of quantities may not be the cost at either the start or completion year; rather, it should be the midpoint of the development duration that best depicts the entire construction cost of that particular building. Then, it shall be converted to an equivalent cost at the time chosen by the study, which is September 2022.

Cost indices were used to convert the construction cost to its equivalent cost at the chosen time. A consumer price inflation index (CPI) published by the FDRE Ministry of Finance is employed for cost conversion, and it is attached as an appendix (*Cost Inflation Index*, 2022). The following discussion explains how the cost inflation index has been organized and interpreted.

$CCB_{st} = C_o (I_m)$ Where,

CCB_{st} = Adjusted construction cost of each building at selected time.

C_o = Construction cost at the mid-year of construction period.

$I_m = IV_{st}/IV_o$

IV_{st} = Index value at selected estimation time, which is 2022

IV_o = Index value at the mid-year of construction period

The adjustment of cost inflation is interpreted as shown under table 7.

Table 7 *Cost Inflation Adjustment Factors*

Year (E.C)	Year (G.C)	Price Inflation index for non-food items (CPI)*	Adjustment/Multiplier Index (CI)	Cumulative Cost Inflation Adjustment Factors of year 2022 for historical cosntruction costs from 2014 to 2022 ($CCIAF_{september\ 2022}$)								
		Mid Year of Construction Period		2014	2015	2016	2017	2018	2019	2020	2021	2022
1994	2001	0.003	1.003									
""	""	""	""									
""	""	""	""									
2005	2012	0.146	1.146									
2006	2013	0.106	1.106	**3.510**								
2007	2014	0.080	1.080	1	**3.247**							
2008	2015	0.081	1.081	1.081	1	**3.021**						
2009	2016	0.075	1.075	1.162	1.075	1	**2.609**					
2010	2017	0.158	1.158	1.346	1.245	1.158	1	**2.331**				
2011	2018	0.119	1.119	1.506	1.393	1.296	1.119	1	**2.013**			
2012	2019	0.158	1.158	1.744	1.613	1.501	1.296	1.158	1	**1.730**		
2013	2020	0.164	1.164	2.030	1.878	1.747	1.508	1.348	1.164	1	**1.350**	
2014	2021	0.281	1.281	2.600	2.405	2.238	1.932	1.727	1.491	1.281	1	**1.000**
2015	2022	0.350	1.350	3.510	**3.247**	**3.021**	**2.609**	**2.331**	**2.013**	**1.730**	**1.350**	**1**

Note: Adapted from the FDRE Ministry of Finance

Therefore, the construction cost of each high-rise building is adjusted for inflation between its construction period and the selected study time, which is September 2022. Then the construction cost per square meter is derived by dividing the adjusted construction cost of each high-rise building by its built-up area (BUA), as shown under Table 8:

According to the results of the analysis of the construction cost per square meter of high-rise buildings, the minimum estimated unit cost is 33,000.00 ETB/m2, and the maximum is 93,000.00 ETB/m2, with a weighted average unit rate of 66,000.00 ETB/m2. The high-rise buildings with the minimum and maximum construction costs per square meter have the characteristics discussed hereunder in Table 9:

Table 8 *Cost per Square Meter of high-rise buildings as of September 2022*

No	Buildings	Height m (Storey)	Construction Cost (Birr) Rounded by 10million	BUA (m2)	Construction Period		Mid Year*	(I_m)**	Adjusted Cost in ETB (CCB_{2022})	Unit Price (ETB/m2) Rounded by 1000
					Start	Finish				
1	4B+G+31 (NIB)	126 (36)	1,700,000,000.00	51,420.00	2016	2021	2018	2.331	3,963,152,833.37	**77,000.00**
2	4B+G+32 (HibretBank)	131 (37)	2,400,000,000.00	44,500.00	2016	2022	2020	1.730	4,150,893,600.00	**93,000.00**
3	4B+G+M+29 (ACSI)	120 (36)	4,650,000,000.00	76,750.00	2018	2024	2021	1.350	6,277,500,000.00	**82,000.00**
4	3B+G+M+29 (Zemen)	113 (33)	1,600,000,000.00	41,000.00	2017	2022	2019	2.013	3,221,093,433.60	**79,000.00**
5	3B+G+M+19 (CenturyAddis-Brass)	70 (23)	590,000,000.00	24,494.00	2019	2022	2020	1.730	1,020,428,010.00	**42,000.00**
6	3B+G+M+19 (CenturyAddis)	68 (24)	660,000,000.00	31,200.00	2019	2022	2020	1.730	1,141,495,740.00	**37,000.00**
7	4B+G+M+23 (Wegagen)	100 (29)	800,000,000.00	32,156.00	2012	2018	2015	3.247	2,597,939,280.17	**81,000.00**
8	4B+1SB+G+M+20 (ElilitaRE)	91 (27)	2,800,000,000.00	63,550.00	2015	2023	2019	2.013	5,636,913,508.80	**89,000.00**
9	Yadot Center (3B+G+23)	98 (27)	1,000,000,000.00	36,558.00	2016	2023	2020	1.730	1,729,539,000.00	**47,000.00**
10	2B+G+M+23 (Atlas-Tak…)	89 (27)	1,700,000,000.00	42,660.00	2019	2022	2020	1.730	2,940,216,300.00	**69,000.00**
11	3B+G+M+22 (SengateraUnion)	85 (27)	470,000,000.00	37,050.00	2012	2023	2017	2.609	1,226,082,923.32	**33,000.00**

Maximum Construction Unit Price (Birr/m2)	**93,000.00**
Maximum Construction Unit Price (Birr/m2)	**33,000.00**
Average Construction Unit Price (Birr/m2)	**66,000.00**

* The mid Year of construction period of high-rise buildings

** A multiplying factor for price inflation adjustment, derived from the inflation index released by Ethiopian Statistical Agency

Table 9 *Characteristics of high-rises buildings with Min and Max costs*

Cost-Significant Factors	Buildings With Minimum Cost (33,000 ETB/m2)	Buildings With Maximum Cost (93,000 ETB/m2)
Height	85m	131m
Function	Mixed-Use	Mixed-Use
Electro-Mechanical	Poor	Advanced
Ceiling	No suspended Ceiling	Expensive
BMS, IT	Poor	Advanced
Floor Finish	Average	Expensive
Wall Type (Exterior)	Average	Al Curtain (high-quality)
Wall Finish (Exterior)	Quartz paint for HCB walls	Not Applicable
Structure Types	Reinforced Concrete	Reinforced Concrete
Contractor Type	Local	Foreign
Carpentry & Metal work	Average	Expensive
Foundation Type	Mat Foundation	Mat + Pile Foundation
No of Elevators	6	8
Wall Type (Interior)	HCB & AL	Mostly glass wall and Al frame
BUA (m2)	37,050	44,500

5. Conclusion

The building height, function, electromechanical, ceiling type, and BMS technology are the major cost-significant factors in the development of high-rise buildings.

Architectural, structural, sanitary, electrical, electromechanical, and building management systems (BMS) are identified as cost-significant items. Architectural and structural work items account for 43% and 31% of the total cost of a high-rise building, respectively. The BMS, electrical, electro-mechanical, and sanitary works account for 12%, 11%, 9%, and 6% of the total cost, respectively.

High-rise building construction costs in Addis Ababa in September 2022 range from 33,000 Birr/m2 to 93,000 Birr/m2, with an average unit price of 66.000 Birr/m2.

A wide range of unit costs is discovered between the estimated minimum and maximum unit costs. Further research is required to determine why and for which cost-significant factor such a wide disparity occurs. In addition, to produce an accurate cost estimate of high-rise buildings, the impact and relation of each identified cost-significant item with the cost of construction shall be examined further.

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