

ADDIS COLLEGE

SCHOOL OF GRADUATE STUDIES

**DEPARTMENT OF CONSTRUCTION TECHNOLOGY AND
MANAGEMENT**

**ASSESSMENT OF BUILDING CONSTRUCTION PROJECT
PERFORMANCE USING EARNED VALUE ANALYSIS: A CASE
OF SELECTED PUBLIC BUILDINGS IN ADDIS ABABA.**

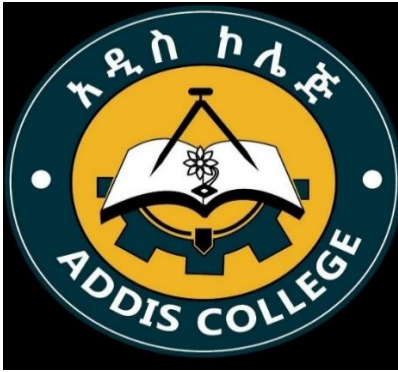
By

YETSEDAW MEKONNEN

*A thesis submitted to school of graduate studies in partial fulfillment of the requirement for the
Degree of Master of Science in Construction Technology and Management.*

SEPTEMBER, 2024

Addis Ababa, Ethiopia



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Advisor

BAHIRU BEWKET (PhD)

SEPTEMBER, 2024

ADDIS ABABA, ETHIOPIA

DECLARATION

I, Yetsedaw Mekonnen, hereby declare that this thesis titled "Assessing Building Construction Project Performance with Earned Value Analysis (EVA): A Case of Selected Public Buildings in Addis Ababa" is my original work. This thesis has been composed by me and has not been submitted, in whole or in part, for any degree or diploma at any other institution.

The research work presented in this thesis has been conducted by me under the guidance and supervision of Doctor Bahiru Bewket, according to the requirements of Addis College. All sources of information and data used in this thesis have been acknowledged and referenced.

I confirm that the information herein is accurate and reflects my understanding and analysis of the subject matter. Any assistance received during the research and preparation of this thesis has been acknowledged.

Yetsedaw Mekonnen

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ANAGEMENT**

Approval of Thesis for defense

I have supervised, read, and evaluated this thesis titled “Assessment of Building Construction Project Performance using Earned Value Analysis (EVA): A Case of Selected Public Buildings in Addis Ababa prepared by Yetsedaw Mekonnen under my guidance. I recommended the thesis be submitted for oral defense. MMM

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Sep 15/2024

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THESIS APPROVAL FORM

This is to certify that the thesis entitled “**Assessment of Building Construction Project Performance using Earned Value Analysis (EVA): A Case of Selected Public Buildings in Addis Ababa**”, is carried out by Yetsedaw Mekonnen MSc student at Addis College.

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DEDICATION

This thesis is dedicated to my beloved family, whose unwavering support and encouragement have been my guiding light, to my parents who instilled in me the value of education and hard work, and for their constant motivation and love.

I also dedicate this work to my advisor, whose invaluable guidance and expertise have been instrumental in completing this research. Your dedication to excellence has inspired me to strive for the same.

Finally, I dedicate this thesis to the construction industry professionals in Addis Ababa city, whose contributions and efforts were the foundation of my study. This may serve as a resource to further enhance the performance and success of future projects.

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ABSTRACT

Construction projects encompass the stages of organizing, designing, funding, building, and overseeing physical infrastructure facilities. However, the implementation and challenges of EVA in Ethiopian construction projects have not been thoroughly studied. The study aimed to assess time and cost performance of construction projects and to forecast costs using earned value analysis, identified variations, and provided suggestions for improving efficiency in the construction industry. Using primary and secondary data, both exploratory and descriptive research types were applied to this study. Three public building projects were selected and Participating experts from the contractors, consultants, and clients participated in the case study using non-probability purposive sampling. A total of 52 survey questions were distributed to client, contractor, and consultant professionals who were working on the selected projects. Using the RII formula, SPSS26, and MS Excel, data from three public building projects was examined. Two of the projects demonstrated poor cost and each of the three public building projects showed poor schedule performance. The outcome showed that the Kolfe Keranyo General Hospital, FHC mixed apartment, and Cinema Complex projects were running at a maximum of 31%, 29%, and 22% behind schedule, respectively, in terms of schedule variance. Concurrently, the projects for the FHC mixed apartment project scored the highest cost variance of 32% under budget from the original budget and the Cinema complex project demonstrated the lowest cost variance, scoring 21% percent over budget from the original budget. With scores of 0.93 Cinema complex project had the lowest Cost performance index values while the FHC mixed apartment building project had the highest cost performance index of 2.47. Out of the three projects, the forecasted completion cost for the cinema complex building project had the EAC more than the final budget. Design modification, Price escalation for materials, and Lack of available building materials in the market, with RII scores of 0.882, 0.836 with a Std of 0.811, and 0.836 with a Std of 0.816, respectively, the top three major responsible causes for time and cost variations. The owner should set the project's budget, and timeline by reality, as indicated. Design modification and Variations order cost problems also should be prioritized by the consultant. Once more, the consultants ought to deliver clear drawings on time. Financial problems should be taken into account by the contractor to enhance the performance of such building projects.

Keywords: *Construction project performance, Building performance assessment, Project management, Relative Importance Index, Earned Value Analysis.*

TABLE OF CONTENTS

DECLARATION	<i>i</i>
DEDICATION	<i>iv</i>
ACKNOWLEDGEMENTS	<i>v</i>
ABSTRACT	<i>vi</i>
TABLE OF CONTENTS	<i>vii</i>
LIST OF FIGURES	<i>xi</i>
LIST OF TABLES	<i>xii</i>
ACRONYMS	<i>xiv</i>
CHAPTER ONE	<i>1</i>
1. INTRODUCTION	<i>1</i>
1.1 Background of the study	<i>1</i>
1.2 Problem Statement	<i>2</i>
1.3 Objectives of the study.....	<i>4</i>
1.3.1 General Objective	<i>4</i>
1.3.2 Specific Objectives	<i>4</i>
1.4 Basic research question.....	<i>5</i>
1.5 Scope of the study.....	<i>5</i>
1.5.1 Thematic scope of the study	<i>5</i>
1.5.2 Spatial scope of the study	<i>5</i>
1.5.3 Temporal scope of the study	<i>6</i>
1.6 Limitations of the Study.....	<i>6</i>
1.7 Significances of the study	<i>7</i>
1.8 Organization of the Study	<i>7</i>
CHAPTER TWO	<i>9</i>
2. LITERATURE REVIEW	<i>9</i>
2.1 Introduction.....	<i>9</i>
2.2 Overview of Project Performance.....	<i>9</i>
2.2.1 Performance problems in construction	<i>10</i>
2.2.2 Project performance and Project success.....	<i>11</i>

2.2.3 Factors Influencing Construction Project Performance	11
2.2.4 Factors affecting cost and time performance.	13
2.2.5 Key Performance indicators in construction projects.	13
2.2.6 Project Performance and Benchmarking	14
2.3 Assessment and Measuring Performance	16
2.3.1 Why take performance measurements?	17
2.4 Importance of Project Performance Assessment.	18
2.6 The history of earned value management (EVM).....	19
2.7 EVA as a tool for performance assessment.	20
2.7.1 Terminology of EVA.	22
2.7.2 Applications of Earned Value Analysis (EVA).....	24
2.7.3 Earned Value Analysis Method	25
2.7.3.1 Basic EVA metrics.....	26
2.7.3.2 Performance indicators and variances in the EVA technique.....	26
2.7.3 Forecast indicators in the EVA technique	28
2.8 Major causes of cost and time variances.....	32
2.9 Conceptual Framework.....	34
2.10 Cases where EVA used for building construction	34
3.11 Research Summary	36
2.12 Research Gaps.....	37
CHAPTER THREE	38
3. RESEARCH METHODOLOGY	38
3.1 Introduction.....	38
3.2 Study Area	38
3.3 Research design	39
3.4 Research approach	40
3.5 Target Population.....	40
3.6 Sampling Technique	41
3.7 Sample Size.....	42
3.8 Source of data.	42
3.9 Data Collection Techniques.....	42
3.9.1 Questionnaires:	43
3.9.2 Discussion:.....	43
3.9.3 Desk study:.....	43

3.11 Data Analysis Tools	44
3.12 Reliability and Validity Analysis Methods.....	44
3.12.1 Reliability.....	44
3.12.2 Validity	46
3.13 Ethical issues.....	47
CHAPTER FOUR.....	48
4. RESULTS AND DISCUSSIONS	48
4.1 Introduction.....	48
4.2 Assessment of Project Performance.....	48
4.3 Response rate	48
4.4 Description of the case study projects	50
4.5 Cost and Schedule Performance Assessment with EVA	51
Kolfe Keranyo General Hospital Building Project.	51
4.5.1 Cost and schedule Performance Assessment.	52
4.5.2 Cost variance (CV) and cost variance percentage (CV %).	55
4.5.3 Cost performance index (CPI)	56
4. 5.4 Schedule Variance (SV) and SV Percentage (SV %).	58
4.5.5 Schedule performance index (SPI)	59
4.5.6 Cost Forecasting.....	61
FHC Mixed Apartment Building Project.....	63
4.5.7 Cost performance assessment.	63
4.5.8 Cost variance (CV) and cost variance percentage (CV %).	66
4.5.9 Cost performance index (CPI)	67
4.5.10 Schedule Variance (SV) and SV Percentage (SV %)	69
4.5.11 Schedule performance index (SPI)	70
4.5.12 Cost Forecasting.....	72
Cinema Complex Building Project.	74
4.5.13 Cost performance assessment.	74
4.5.14 Cost variance (CV) and cost variance percentage (CV %).	76
4.5.15 Cost Performance Index (CPI).	78
4.5.16 Schedule Variance (SV) and SV Percentage (SV %)	80
4.5.17 Schedule Performance Index (SPI).....	81
4.5.18 Cost Forecasting.....	83
4.6 Major factors which are causes of cost and time variations of a project	84

4.7 Correlation analyses between several responders.....	97
CHAPTER FIVE	101
5. CONCLUSIONS AND RECOMMENDATIONS	101
5.1 Conclusions.....	101
5.2 Recommendations.....	103
REFERENCE	105
APPENDIX:	111

LIST OF FIGURES

Figure 2.1. The problem definition of the end product.....	10
Figure 2.2 Categorizing KPIs in selected articles.	14
Figure 2.3 EVA Illustrative Graph.....	21
Figure 2.4.EVM Basic Concepts:	24
Figure 2.5. Earned Value Analysis Showing Schedule and Cost Variance.....	26
Figure 2.6.EVM Metrics Chart	30
Figure 2.7. Conceptual Framework Model-independent and dependent variable	34
Figure 4.1: Kolfe Keranyo General Hospital Building S-curve with EV	53
Figure 4.2: Kolfe Keranyo General Hospital Building progress evaluation in different phases. ...	54
Figure 4.3: Kolfe Keranyo General Hospital Building Projects CPI.....	57
Figure 4.4: Kolfe Keranyo General Hospital Building Project SPI.....	60
Figure 4.5: General Hospital Building Projects Forecasted Cost by Phases.	62
Figure 4.6: FHC Mixed Apartment Building S-curve with EV	64
Figure 4.7: FHC Mixed Apartment Building progress evaluation in different phases.	65
Figure 4.8: FHC Mixed Apartment Building Project CPI.	68
Figure 4.9: FHC Mixed Apartment Building Project SPI.....	71
Figure 4.10: FHC, mixed building Projects Forecasted Cost in phases.....	73
Figure 4.11: Cinema Complex Building S-curve with EV	75
Figure 4.12: Monthly Cinema Complex Building progress evaluation.	76
Figure 4.13: Cinema complex Building Project CPI.	79
Table 4.18: Schedule variance (SV) for the Cinema Complex Building Project	80
Figure 4.14: Cinema complex Project SPI.....	82
Figure 4.15: Monthly Forecasted Cost for Cinema Complex Project.	84

LIST OF TABLES

Table 2.1: Elements influencing building project performance.....	12
Table 2.2. Major factors that cause cost and schedule variance of construction projects	33
Table 3.1: Projects Description.....	39
Table 3.2.: Summary of Research Strategy.	40
Table 3.3 Selected Ongoing building projects in Addis Ababa.....	41
Table 3.4 Cronbach’s alpha interpretation.....	45
Table 3.5 Reliability test of data	45
Table 4.1: Questionnaire circulation summary.....	49
Table 4.2 Description of projects.....	51
Table 4.3 Kolfe Keranyo General Hospital Building Project	52
Table 4.4 Kolfe Keranyo General Hospital Building Project cost variance.	55
Table 4.5: Kolfe Keranyo General Hospital Building Project CPI.....	57
Table 4.6: Schedule variance for the Kolfe Keranyo General Hospital Building Project.	58
Table 4.7: Kolfe Keranyo General Hospital Building Project SPI	60
Table 4.8: General Hospital Building Projects Forecasted Cost by Phases.....	61
Table 4.9 FHC Mixed Apartment Building Project.....	63
Table 4.10 FHC Mixed Apartment Building Project cost variance.....	66
Table 4.11: FHC Mixed Apartment Building Project CPI	67
Table 4.12: Schedule variance for FHC Mixed Apartment Building Project.....	69
Table 4.13: FHC Mixed Apartment Building Project SPI.....	70
Table 4.14: FHC Mixed Apartment Building Project Forecasted Cost in phases	72
Table 4.15 Cinema Complex Building Project.	74
Table 4.16 Cinema complex building Project cost variance.....	77
Table 4.17: Cinema complex building Project CPI	78

Table 4.19: Cinema Complex Project SPI	81
Table 4.20: Monthly Cinema Complex Public Building Project Forecasted Cost	83
Table 4.21 Client-related causes	85
Table 4.22 Contractor-related causes.....	86
Table 4.23 Consultant-related causes	87
Table 4.24 Design-related causes	88
Table 4.25 Material-related causes	88
Table 4.26 Labor and Equipment Delays	89
Table 4.27 external delays	90
Table 4.29 Correlation among the respondents in client-related causes.....	98
Table 4.30 Correlation among the respondents in contractor-related causes	98
Table 4.31 Correlation among the respondents in consultant-related causes	98
Table 4.32 Correlation among the respondents in design-related causes	99
Table 4.33 Correlation among the respondents in material-related causes	99
Table 4.34 Correlation among the respondents in labor &equipment related causes.....	99
Table 4.35 Correlation among the respondents in external related causes	99

ACRONYMS

AC	Actual cost
ACWP	Actual cost of work completed
BAC	Budget At Completion
BCWP	budgeted the cost for work performed
SPSS	Statistical Package for Social Sciences
CBB	contract budget basis
CPI	Cost Performance Index
CPM	Critical Path Method
CV	Cost variance
EAC	Estimate at Completion
ECDSWC	Ethiopian Construction Design and Supervision Works Corporation
ERA	Ethiopian Roads Authority
ETC	estimated the cost of to complete
EV	earned value
EVA	Earned value analysis
EVM	Earned Value Management
EVMS	Earned Value Management System
FHC	Federal Housing Corporation
GBC	Gantt Bar Chart
MR	Management Reserve
PBB	project budget basis
PERT	Program Evaluation and Review Technique
PMB	Performance Measurement Baseline
PMI	Project Management Institute
PV	planned value
RII	Relative Importance Index
SPI	Schedule performance index
SV	Schedule Variance
TCPI	To Complete Performance Index
UN-Habitat	United Nations Human Settlements Programmed
WBS	work breakdown structure

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the study

Construction projects involve the process of planning, designing, financing, constructing, and managing physical infrastructure facilities, requiring the coordination of numerous activities and stakeholders to achieve project goals (Olanrewaju, A. L., & Anahve, G. (2018). According to Liu, A. M. M. and Chan, I. Y. S. (2019). A construction project is a structured endeavor to deliver a constructed asset, which involves significant design and engineering efforts, coordination among various trades, and management of diverse project constraints.

Nguyen et al. (2016) emphasized the importance of effective project management in achieving successful construction project outcomes. They discussed the critical role of project managers in coordinating resources, managing risks, and ensuring timely project delivery. Their study highlighted that projects with experienced managers tend to perform better in terms of cost and schedule adherence.

According to Avlijas (2015) Implementing projects within the allotted time frame while taking the project's scope and available money into account is the goal of project management. According to Hasseb (2011), the extent to which a project accomplishes its objectives is critical to its success, and achieving these objectives requires a high level of management commitment. One of the most important steps in this process is creating an effective performance monitoring system (Avlijas, 2015). Project teams in the construction industry strive to control three key performance indicators (KPIs): scope, time, and cost. For construction projects to be successfully finished, staying within the allotted scope, budget, and schedule is crucial (Dhanashree, 2015).

Project performance is still an issue, according to Padalkar and Gopinath (2015), despite decades of focus and practice in project management. Empirical evidence suggests that initiatives often fall short of the planned scope, budget, and schedule. Klynveld Peat and Marwick Goerdeler (2015) assert that as building projects get larger, they get more complex. These projects are difficult; thus, to execute and develop them effectively, additional tools and methods are required. Candido *et al.* (2014) contend that the necessity for additional tools and methods is justified by the uncertainties and challenges that come with building projects. This suggests that the particular issues presented by construction projects may be beyond the scope of typical project management techniques.

When it comes to construction project monitoring, it can be extremely difficult to choose an appropriate methodology. Earned value analysis (EVA) which is one of the key tools in EVM has emerged as a robust methodology for project performance evaluation in various industries, including construction. Originally developed in the realm of aerospace and defense, earned value analysis integrates schedule performance, cost efficiency, and project scope to offer a holistic view of project progress (Fleming & Koppelman, 2010). Its applicability and effectiveness in construction projects have been demonstrated globally, with significant improvements in project control, risk management, and decision-making (Lehrfeld, 2013).

According to Humpherey (2014), the principles of the EVA process in the construction sector are as follows, in order of precedence: Above all, the process consists of defining the project's goals, which include a general description of the technical specifications, a schedule for completion, and a budgetary allocation (Humpherey, 2014). Second, the project's scope is established. One of the finest methods for breaking down the work into manageable components is the work breakdown structure (WBS). EVA is a project performance measure that utilizes scope, cost, and time data (Jainendrakumar B, 2015). According to Lukas (2008), earned value analysis makes it simple for organizational staff to use EVA.

Aklog Shiferaw Mihrete (2022) States that the implementation techniques and challenges of the earned value analysis in Ethiopian construction projects, however, have not been thoroughly studied or have not been studied at all in Ethiopia. For megaprojects in Ethiopia, this also holds true when evaluating the contribution of EVM to project success.

Therefore, this paper is intended to assess building construction project performance using earned value analysis in the case of selected public building construction projects in Addis Ababa and pinpoint and rank the main causes of the observed variances.

1.2 Problem Statement

Any construction project's success is mostly determined by three key factors: quality, timeliness, and cost. In other words, a project is considered successful if it is finished on schedule, within the specified budget, and with acceptable quality. This procedure is an essential instrument for guaranteeing any project's success. (Adey Tadesse, 2020)

Heseb (2011) observes that delays are prevalent in construction projects worldwide. Jrade and Lessard (2015) further note that building projects often encounter cost overruns alongside these

delays. Warhol (2013) also identifies that overseeing multiple projects concurrently poses a persistent challenge, impacting both the cost and schedule of building projects.

To address such challenges, effective project management requires continuous monitoring and assessment of project performance, facilitated by specialized control mechanisms like Earned Value Analysis (EVA). This approach involves ongoing surveillance of all project aspects affecting cost, time, and quality. EVA, recognized as an advanced project control method, provides a quantitative measure of work performance by seamlessly integrating schedule and cost considerations (A. Naderpour & M. Mofid, 2011).

According to Gebreegziabher's (2019) summary of the empirical literature assessment, schedule management strategies for construction projects are impacted by a variety of causes. Most construction projects in Ethiopia suffer from delays, have poor scope management, run out of budget, and face serious quality defects. Lack of knowledge and awareness of the importance of project schedule management tools and techniques found to be the major obstacles towards the efficient utilization of such tools, identified the effective time management technique and software package used based on their specific study, construction projects continue to face the challenge of delays even in this current phase of knowledge.

According to Adey Tadesse, (2020) Earned Value Analysis (EVA) is widely recognized in project management and has been used in diverse projects globally, but its adoption remains limited in our country. This is attributed to factors such as the complexity of available software, insufficient project data, and overall ineffective project cost control. While many studies have explored reasons for cost overruns and proposed improvements, demonstrative analyses are scarce on local projects utilizing EVA systems.

Koshe and Jha (2016) also discovered that, in Ethiopia, only 8.25% of projects were completed within the originally planned timeframe; the rest 91.75% took longer than 352% of their contracted duration to complete.

Public construction projects, aimed at serving the interests of the community, must ideally be completed within budget and on schedule. However, in Addis Ababa, the majority of such projects fail to meet these expectations (UN-Habitat, 2017).

This study aims to assess the schedule and cost performance of three public building projects in Addis Ababa city. A mixed-use apartment building for the Federal Housing Corporation at the Somali Tera site in Addis Ababa was signed in January 2021 with Revised completion deadline in

August 31, 2024 completion. However only 66.68% of the project's total work had been finished after the preceding month's data collection period, despite the project's scheduled completion of 90.7% i.e. So that, the project is now behind schedule due to several causes such as shortage of material in the market, late approval of documents from client and consultant side, mistake in design document, poor planning of the contractor and weather condition. Similarly, the Kolfe Keranyo sub-city General Hospital building construction project was signed in July 02/2021 G.C with the revised Completion Date of May 11/2024. But due to market fluctuation (ready-mix, cement, rebar & fuel), change of scope, shortage of construction materials such as, rebar shortage and shortage of cement, the project was not completed on the planned time. The cinema complex building project was signed in June 6/2023 and the revised Project completion Date was July 15/2024. But the project is now behind schedule and over budget due to failure to pay payments on time for Subcontractors working with the contractor, inadequate material delivery and design modification.

Therefore, this study is designed to assess the schedule and cost performance of three public building projects in Addis Ababa city using earned value analysis (EVA) and to identify major factors influencing schedule and cost variations and providing recommendations.

1.3 Objectives of the study

1.3.1 General Objective

The main aim of this research was to assess building construction project performance with earned value analysis (EVA) in the case of selected public buildings in Addis Ababa.

1.3.2 Specific Objectives

Specifically, the study aimed to achieve the following specific objectives:

- ✓ To assess the current cost performance of selected public building construction Projects using EVA focusing on cost aspects.
- ✓ To assess the current schedule performance of selected public building construction Projects using EVA focusing on time aspects.
- ✓ To identify and major factors that cause variations in cost and schedule performance of selected public building projects in Addis Ababa.
- ✓ To develop set of recommendations to enhance cost and schedule performance in public building construction projects, based on the identified causes of variations.

1.4 Basic research question.

- ✓ How can the current cost performance of selected public building construction projects be assessed using EVA?
- ✓ How can the current schedule performance of selected public building construction projects be assessed using EVA?
- ✓ What are the factors that influence variations in the cost and schedule performance of selected public building projects in Addis Ababa?
- ✓ What set of recommendations can be developed to enhance cost and schedule performance in public building construction projects, based on the identified causes of variations?

1.5 Scope of the study

1.5.1 Thematic scope of the study

Assessment of building construction project performance using earned value analysis in Addis Ababa research includes assessing the performance of the three public building construction projects which were randomly selected and identify factors that contribute to cost and schedule variances of the projects as well as to give recommendation. This study includes the use of desk study, discussions, questionnaires, statistical measure (RII) and SPSS26 to collect and analyze data, as well as papers and interdisciplinary collaboration among specialists in those projects. The study aimed to assess the performance of building construction projects using the Earned Value Analysis (EVA). The research focused on identifying key performance indicators (KPIs) that are critical in evaluating the cost and time performance of construction projects. By analyzing these KPIs, the study provided insights into the effectiveness of EVA in managing and controlling construction project performance. It also explored the causes of time and cost variations and their impact on project success. The findings were expected to contribute to the body of knowledge in construction project management, particularly in the application of EVA in the context of public buildings.

1.5.2 Spatial scope of the study

This study was confined to selected public building construction projects within Addis Ababa, Ethiopia. The second was the Kolfe General Hospital construction project being built in the Kolfe Keranyo sub-city, district 7, Bethel Mendida area where as the FHC Mixed Apartment Building project which is located at Somali Tera, Arada sub city. The function of this project is (FHC) Mixed Apartment, with 3 floors underground and 23 floors above ground. The last project was the

Cinema Complex construction project. It is constructed in the Lideta sub-city at Sengatera and its project built-up area is 2040m². These projects represented a diverse range of construction activities and provided a comprehensive view of the performance management practices employed in the region. By focusing on public buildings, the study aimed to address the unique challenges and requirements faced in the public building construction project sectors. The selection of Addis Ababa as the study area was due to its significance as the capital city and its concentration of major public construction projects.

1.5.3 Temporal scope of the study

The study also covered the period from March 1, 2021, to July 15, 2024. This timeframe was chosen to capture the most recent and relevant data on the performance of public construction projects in Addis Ababa. It allowed for an analysis of ongoing and recently completed projects, providing a current perspective on the application of EVA. The chosen period also aligns with the availability of project records and data necessary for a thorough evaluation of project performance. Based on the findings, the study would provide practical recommendations for improving the application of EVA in public building construction projects.

1.6 Limitations of the Study

Three public building construction projects in Addis Ababa were selected as case studies for this research. However, the way these projects were chosen was a non-probabilistic sampling strategy rather than a random sampling method. Due to time and budget constraints, the study did not extend to other regions, which may limit the generalizability of the findings to other areas or countries with different economic, environmental, and regulatory conditions. The study's population consisted of contractors, consultants, and clients involved in the selected projects. Although the sample size was determined based on the available resources and practical considerations, it wouldn't comprehensively represent all stakeholders involved in public building projects across the city. The limited number of projects (three) further restricted the ability to generalize the findings to all public building construction projects in Addis Ababa. Data collection faced challenges due to the phase-by-phase creation of payments and progress reports, which made it difficult to obtain consistent monthly payments and progress information. Additionally, obtaining accurate and complete data from all project stakeholders was a challenge, which could impact the reliability of the findings. The study primarily focused on cost and time performance using EVA. Other critical aspects of project performance, such as quality, safety, and environmental impacts, were not covered in depth. This narrow focus may overlook other

significant factors that influence overall project success. The research relied on questionnaires and interviews to gather data, which were subject to respondent bias. The accuracy and honesty of the responses could not be fully verified, and some respondents might have provided socially desirable answers rather than reflecting their true opinions or experiences. The study covered a specific period, and the findings are based on data collected during that time frame. Despite these limitations, the study provided valuable insights into the performance of building construction projects using EVA in Addis Ababa and offers recommendations for improving project management practices in similar contexts.

1.7 Significances of the study

The following findings should emerge from the research: Assess the performance of selected public projects in Addis Ababa by implementing earned value analysis, provide recommendations on how to make selected public projects in Addis Ababa building projects perform better, and identify factors that influence variations in the cost and schedule performance of selected public building projects in Addis Ababa.

The research intended to enhance cost and schedule performance in three selected public building projects in Addis Ababa by using EVA, providing insights for project managers and stakeholders.

1.8 Organization of the Study

This thesis is organized into several chapters, each detailing a specific aspect of the research study on assessing building construction project performance using the Earned Value Analysis (EVA) in selected public buildings in Addis Ababa.

The first chapter in this thesis is the introduction which constitutes introduces the background of the study, the research problem, objectives, and research questions, the significance of the study, and the scope and limitations.

The second chapter, which is the literature review, provides an overview of existing research related to construction project performance, Earned Value Analysis (EVA), and factors affecting cost and time variations in construction projects.

The third Chapter is about research Methodology: This chapter describes the research design, data collection methods, sampling techniques, and data analysis procedures. It also discusses the reliability and validity of the research instruments used.

Chapter Four presents results and Discussions: The results obtained from the data analysis are presented in this chapter. It includes an assessment of project performance using Earned Value Analysis (EVA) and a discussion of the key findings.

The final chapter, chapter five is the Conclusions and Recommendations: This chapter presents the conclusions drawn from the study and provides recommendations for improving project performance in public building construction projects.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of pertinent previous research on the suitability of the EVA system for gauging a construction project's performance. The chapter will also address how project management has incorporated the idea of the EVA approach. This chapter is structured as follows, an overview of the knowledge gaps this study addresses, a theoretical review, a conceptual review and empirical review, an EVA performance analysis and forecast, and lastly, a synthesis of the literature.

2.2 Overview of Project Performance

A project is a brief endeavor that is undertaken to produce a special good or service or to ensure ongoing business operations (PMI, 2013), Project management, on the other hand, is the application of knowledge, skills, tools, and techniques to project activities to achieve project requirements. A project may also involve one person or hundreds of people, depending on its size, and it has a predetermined budget and timetable. Though they can take many different forms, scope, time, and money constraints are the most prevalent ones. In project management, these three elements are referred to as the "triple constraint." One way to conceptualize project management is as the process of overseeing a project from the outset to its conclusion (PMI, 2013).

Completing the project is the main objective of construction project development, which involves several stakeholders, procedures, stages, and phases of work in addition to substantial input from the public and private sectors (Takim & Akintoye, 2002). The construction project implementation process consists of two distinct phases that must be completed to produce the necessary good or service: the preconstruction phase, which is work that is usually completed between the project's initial conception and the signing of the contract, and the construction phase, which is work that the contractor must complete under the terms of the agreement (Sweis, 2013). Yrjölä (2017) stated that good communication between the company and the customer is one effective way to minimize this gap. Can this gap also be minimized by implementing EVM?

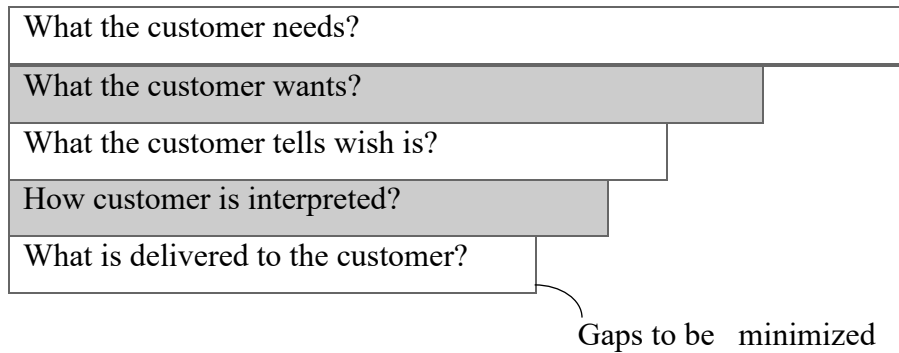


Figure 2.1. The problem definition of the end product. (Adapted from (Yrjölä, 2017/14))

2.2.1 Performance problems in construction

Time or cost issues, or both, challenge the majority of construction projects in terms of performance. Among other performance-related needs, Ong’ondo *et al.* (2015) said that all construction projects must be completed on schedule, within budget, and with the intended quality. Unfortunately, delays, overspending on the budget, subpar work, safety issues, and other issues plague a lot of projects nowadays. Analogously, Abushaban *et al.* (2008) argued that issues and poor performance are the primary causes of any construction project's failure. Furthermore, there are other contributing elements and causes to this issue.

The majority of construction projects experience time overruns and subsequently escalated costs due to the inability to achieve optimal performance. The project completion date may be impacted by time and expense overruns (Salunkhe & Pantil, 2014). Project performance is finally determined by the inability to finish a construction project within the initial budget, schedule, or both (Abd El-Razek *et al.*, 2008).

According to Asmah's (2014) research, underfunding, work stoppage by the owner or contractor, cash flow issues during construction, poor project planning before the start, client delays in obtaining certificates of completion, and a non-compliant attitude amongst parties are the main causes of underperforming projects. Under Navon's (2005) research, there are two primary sources of performance issues: either unrealistic objective settings or the actual building itself. Once more, Navon (2005) noted that traditional project performance control is typically general. Because it is dependent on manual data collection, it is carried out infrequently and sometimes after the controlled event. Manual data gathering typically yields low-quality data in addition to low frequency.

2.2.2 Project performance and Project success.

Several factors contribute to a project's success, such as reaching goals, staying within budget and timeline, satisfying stakeholders, and long-term viability. Shenhar *et al.* (2018) stress the significance of striking a balance between project effectiveness (fulfilling customer expectations and strategic goals) and efficiency (keeping budget and schedule).

Project management techniques, leadership, stakeholder engagement, corporate culture, and the external environment are just a few of the many variables that affect a project's success. According to Turner and Cochrane (2019), a leader's approach is critical to encouraging team spirit and creativity, which in turn affects the outcome of a project.

The construction sector is dynamic, which leads to a lack of clarity in defining the concept of project success. In other words, Arazi *et al.* (2011) concurred that success is the ultimate goal of any project, and that success is a byproduct of project performance. According to Ali and Rahmat (2009), a project's success is measured by the desirable and intended outcome it achieves for both clients and contractors. This success is attributed to the identification of performance measurement criteria and the understanding of the relative relevance of each criterion. In a similar vein, Abushaban *et al.* (2009) made it clear that every project has certain goals that are driven by the needs of the customer. The project is deemed successful if these goals are accomplished. These goals can be assessed by looking at how well the project performs in terms of cost, schedule, and quality. Thus, the success of construction projects depends mainly on the success of performance.

Metrics like cost performance, schedule adherence, quality, and stakeholder satisfaction are evaluated as part of the project performance review process. Pinto and Slevin (2019) make the case for a methodical approach to measuring project performance that takes into account both quantitative measures and qualitative elements like team morale and client satisfaction.

2.2.3 Factors Influencing Construction Project Performance

According to Addis Alemayehu (2023), the two categories of factors affecting the performance of construction projects are procurement and non-procurement-related elements; however, there is likely to be tight interaction between the two. This might be illustrated with a thorough description of the procurement choices flowing from five subsystems in a hierarchy. Some research divided the components into internal and external causes. Comparatively speaking, factors can be widely classified as controllable or uncontrollable. In general, the performance of building projects is

influenced by several aspects throughout various research studies. Table 2.1 outlines the general groupings into which these elements are divided.

Table 2.1: Elements influencing building project performance

Performance factor group	Factors
Project performance-related factors [Dissanayaka S.M., and Kumaraswamy, M.M. (199)]	
Procurement	Work package determined by the package size; functional grouping according to the distribution of design, construction, and management duties; mode of payment; mode of selection; and terms of contracts
No procurement	Project-related, client-related, designer-contractor-related, team-performance-related, and outside circumstances factors
Project performance-related factors [Belassi, W. and Tukel, O.I. (1996),]	
External causes	Weather, unforeseen site conditions, market swings, and regular adjustments are outside the project teams' control.
Internal causes	Caused by suppliers, contractors, designers, consultants, and customers
Factors affecting the performance of projects [Assaf S.A., and Al-Hejji, S.J. (2006)]	
Factors relating to the project team member	Technical expertise, aptitude for troubleshooting, commitment, and communication
Factors relating to the project manager	Proficiency, dedication, awareness of his job and obligations, capacity to assign power, ability to compromise, ability to organize
Factors relating to the project	Dimensions and worth, distinctiveness of project operations, project density, vitality, and urgency
Factors relating to the organization	Project champion, functional managers' support, top management backing, and project organizational structure
Factors relating to the external environment	The client, rivals, subcontractors, the political, economic, social, and technical environments, and the environment
Project performance-related factors [Ankrah, N. and Proverbs D. (2005)]	
Uncontrollable	Industry factors and external limitations
Controllable	Project complexity, project duration, modifications, contracts, and procurement routes

However, the study also demonstrated that several independent and dependent variables impact how well building projects operate. Cost, time, and leadership aspects are included in the

dependent variables, while the performance of building projects is the only independent variable (Edger D, 2007).

2.2.4 Factors affecting cost and time performance.

The project's nature, the type of work to be done, and the preparation of personnel, equipment, and advanced construction methodologies are all crucial to completing the project on schedule, within budget, and with the necessary quality (David, 2013). If not, there would be project underperformance, which could lead to conflicts of interest and eventually force the case into court arbitration (Muthoka, 2014).

The costs of a project never stay the same once implementation gets underway. However, several reasons can cause a cost to increase even after it has solidified. Delays are the main contributing factor. Delays, for whatever reason, nearly always result in higher budget expenses. The delay might have been caused by several things, some of which could have been predicted and unpredicted (DG XVI, 1998).

Time and expense overruns in the framework of EU program funding have clear consequences for the number of initiatives that can be sponsored during the program, as well as the size of the effects and outputs produced. In the process of preparing this handbook, research has revealed that numerous pre-construction and execution phases of projects encounter a variety of issues. These cause projects to go over budget or take longer than expected. As previously mentioned, delays typically result in increased project costs (DG XVI, 1998).

According to Auma (2014), financial issues with contractors, poor planning, poor site management, and delays in site delivery are the main reasons for time overruns. Additionally, changes in design, variations in material costs, and insufficient examination of contract documents and drawings are the most frequent reasons for cost overruns. Once more, Sweis (2013) concluded that the main factors influencing the project's time performance were the owner's change orders, the contractor's poor planning and scheduling, the ambiguities and errors in the specifications and drawings, the owner's slow decision-making, the quality of the materials, and the low qualification of the consultant engineers' staff assigned to the project.

2.2.5 Key Performance indicators in construction projects.

Determining the key performance indicators (KPIs) aids decision-makers in assessing project performance levels (Chan &Hiap, 2012). According to Elshakour (2012) and colleagues, Key Performance Indicators (KPIs) serve as standards for ‘the continuous process of measuring works,

services, and practices." Key performance indicators (KPIs) for the construction industry at the project level are cost, time, scope, and quality, according to numerous studies carried out by the Construction Industry Institute in the United States of America (USA).

According to Asli *et al.*, (2022) indicates that cost performance and schedule/time performance were most commonly used and quality/high-quality performance and client satisfaction came next. The research determined primary categories for classifying various KPIs to evaluate the chosen articles about building projects (Figure 2.2). Since the created KPIs are mostly based on quality, cost, and time indicators (Tuffaha *et al.* 2020), they can be considered the primary performance indicators for projects. Yet another crucial indicator to be taken into consideration is the satisfaction of the project's stakeholders, particularly the client, who is one of the most vital success elements (He *et al.*, 2021).

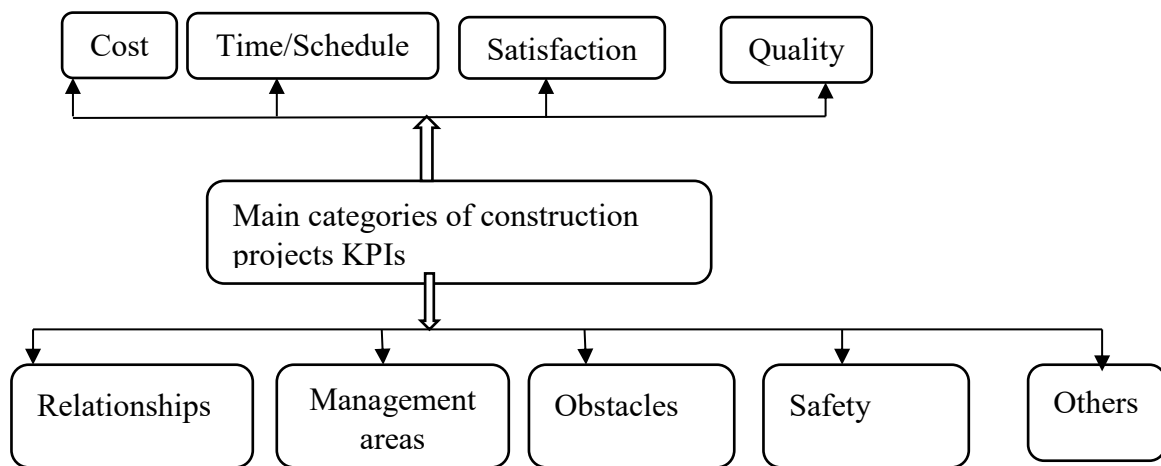


Figure 2.2 *Categorizing KPIs in selected articles. (Source: Asli et al, (2022). KPIs for assessing the selected articles related to construction projects.)*

2.2.6 Project Performance and Benchmarking

Benchmarking is a management technique that can assist businesses in understanding how their performance compares to that of their peers and in driving improvement up to "world-class" levels (OGC, 2007). Additionally, it is a valuable tool for clients, enabling them to assess areas for improvement by contrasting their internal procedures with those of comparable companies. Used to assess how well a client company performs about other comparable organizations or how well various suppliers perform within the same industry (OGC, 2007). It can be applied to the following building projects (OGC, 2007): Evaluate performance in an unbiased and factual manner, highlight areas that require enhancement or development, recognize organizations that demonstrate superior performance through their processes, consider the possibility of integrating similar approaches,

and determine the effectiveness of improvement initiatives through testing and evaluation. The planning, analysis, action, and review phases are the four fundamental building blocks when benchmarking can be implemented (OGC, 2007).

According to El-Mashaleh et al., (2010), there are typically four benchmark implementation stages. Firstly, the benchmarking models that are currently in use are project-specific. This constrained perspective conveys a single project's performance statistic and does not, by any means, represent the firm's entire performance. Secondly, due to their project-specific nature, the current benchmarking methods hinder the assessment of the influence of certain managerial and technological characteristics on the overall performance of the company. Third, knowledge of the trade-offs between the various performances measurements is not supported by the benchmarking models in use today. Fourth, there is no correlation between the indicators' success and the amount spent on them—essentially, a return on investment. The four main construction steps of planning, analysis, action, and review were outlined in OGC's (2007) guidelines for the implementation of benchmarking.

Planning: includes, Choosing the general business procedure or role to be compared, Determining the activity to be benchmarked inside that process, verifying the key performance indicators or metrics to gauge performance in completing the task, recording the current method of completion, creating a preliminary list of possible benchmarking partners to share information with, finding potential information sources and gathering techniques to verify the suitability of proposed partners.

Analysis: includes, gathering data to determine which potential benchmarking partner is most likely to be contacted, verifying which potential benchmarking partner is the best fit, and performing a preliminary analysis of the performance gap, if necessary, getting in touch with them and going to see them to confirm and corroborate the information, identifying innovations and differences by contrasting the current process with the benchmarking partner's, Setting goals for projected gains resulting from implementing the benchmarking partner's methodology.

Action: includes, sharing the study's findings with the benchmarking partner and other pertinent departments within the company, preparing a strategy for implementing the changes, Putting the improvement plan into action, tracking developments, and conducting any required reviews.

Review: includes, Examining the performance once the modifications have been "bedded in", determining and fixing any issues that might have contributed to the organization's failure to reach

its goal, thinking about benchmarking once more to carry on the improvement process, reporting the outcomes of the adjustments made to the organization and the benchmarking partner.

2.3 Assessment and Measuring Performance

Measuring performance is closely tied to performance (Mengesha & Eshetu, 2005). Throughout the project, both during construction and the operational life of the finished facility, performance measurement is the process of comparing actual performance to targets, and project evaluation is the continuous assessment of the project's performance (OGC, 2007). Formal reviews are conducted at significant decision points and gateways, such as project assessments and gateway reviews. Informal checks are routinely performed as part of standard project and contract management practices. In these reviews, the effectiveness of the integrated project team members is evaluated, as is the facility's performance in achieving the benefits that have been identified; progress is measured with quality, cost, and time; the client's capability is evaluated; and opportunities for continuous improvement are sought after (OGC, 2007).

Verzuh (2005) defines progress measures as "the tools we use to identify problems when they are small—when there is still time to catch up." This is how gender measurement is defined. The main focus of progress measurement is cost and schedule progress since they make up two-thirds of the cost-schedule-quality equilibrium. Performance measurement was also described by Navon (2005) as a comparison of the intended and actual performances. For instance, construction management examines the causes of deviations when they are found. The causes of deviation can be broadly categorized into two groups: (a) causes arising from the actual construction; and (b) causes coming from unrealistic target setting or planning (in many cases, the causes of deviation stem from both sources).

The OGC (2007) report states that the following are included in the performance measurement process:

- a. External benchmarking involves comparing a client's performance to that of other significant construction buyers by taking part in a variety of benchmarking programs. These EU programs include the Building Best Practice Program, the European Construction Institute, the Clients' Charter, and the Business Excellence Model.
- b. a performance assessment framework comprising the following: primary performance metrics, which include time predictability, cost predictability, defect count, accident frequency, and client satisfaction (both service and product), and compare the success of the client's projects

with the industry's overall metrics, Secondary metrics that assess various projects inside the client organization, such as the number of requirement modifications made, the final cost with the original estimate, and end-user satisfaction, tertiary metrics, such as decreased construction, maintenance, and operating costs, are project-specific and indicate whether or not the project's performance targets have been met.

Reliable data on quality, cost (design, construction, and in-use costs), delivery time, sustainability, design quality, and health and safety must be gathered by the client to assess the efficacy of the construction process (OGC, 2007).

Achieving the most advantageous and desired result for customers and contractors requires understanding the performance assessment criteria in addition to the relative value of each criterion. According to Arazi et al. (2011), the three most significant factors that respondents deemed essential for assessing project performance from existing practice were the finished project's quality, construction cost, and construction time.

Consequently, project performances have evolved in terms of measurement and assessment over time, and two main strategies have been established thus far regarding completion time and cost performances. These are earned value analyses or variance or deviation analyses based on actual and intended conditions rather than direct differences. Simple deviation analysis and earned value deviation analysis are the names given to these two project performance analysis techniques in this study (Mengesha & Eshetu, 2005.). The most widely used managerial methodology that supports project monitoring and control in practice is earned value analysis. It uses monetary units as a common basis to measure and communicate the progress of a project and to compare the actual and budgeted values of the work performed, the time taken, and the costs incurred (Sabry, 2014).

2.3.1 Why take performance measurements?

According to Chen et al. (2015), measuring project performance is necessary to prevent cost overruns and resource limitations. Furthermore, project time is tracked by performance measurement. Time monitoring is done to evaluate how effectively the project follows the schedule over a given length of time and to demonstrate how well the project stays within the budget that has been agreed upon.

Contractors and government organizations are held responsible for the effective use of public funds through performance measurement. Stakeholders can evaluate whether resources are being used efficiently and openly by monitoring performance indicators like budget adherence and project

milestones. Flyvbjerg, B., et al. (2016). The assessment of construction quality and regulatory compliance is made possible by performance indicators. Authorities can make sure that public infrastructure fulfills predetermined quality norms by keeping an eye on factors like safety records, adherence to building codes, and consumer happiness (Hasan, A. H. M., 2017).

Additionally, Mengesha and Eshetu (2005) explained why the project's performance needed to be assessed and measured. They listed the following as their justifications: It enhances performance, helps with accountability and education in all company administrations, and fulfills numerous project management roles. These include setting likely goals, monitoring performance, and providing management with feedback. Performance metrics can also be used to estimate and forecast project performances, as well as to reward and punish behavior. According to Navon (2005), performance measurement is necessary not only to monitor the projects' present progress but also to update the historical database. These improvements make it possible to more effectively plan future projects in terms of budgets, timetables, staffing, etc.

2.4 Importance of Project Performance Assessment.

Numerous questions come up while assessing how well building projects are performing. Because it is beneficial to measure performance. However, how can we tell if it's good? All businesses track their performance, and the public sector is known to be poorly managed, let alone the private sector. Unfortunately, the financial ratios that are used in the corporate sector to assess a company's success are inappropriate for use in the public sector. What therefore should be measured by governmental agencies? But how should they assess performance, what kind of performance should they measure, and what should they do with the results of these measurements? (Mengesha W.J., Eshetu A., 2005). The goal was to gauge how well the construction was going, and they held the opinion that planning was useless if the project's plan was not well executed. As a result, the accountable parties must continuously monitor the project's budget and timeline. To guarantee that the plan and reality coincide as much as feasible, gather and evaluate data regularly. One decides whether to take corrective action if a variation is found. Of course, there is room for variation in quality just as there is in cost and schedule. The study's findings indicated that project status should be assessed consecutively to locate or reduce this variance.

Measurement of project performance is also necessary because of budget constraints and to prevent overspending. Furthermore, project time is monitored through the use of performance assessment.

Time monitoring serves as a tool to demonstrate how well the project stays within the agreed budget and to evaluate how effectively the project follows the intended schedule over time. The reasons they listed were that it helps with project management in several ways, enhances performance, and helps with responsibility and learning in all business administrations. For the following reasons: setting realistic goals, monitoring progress, and providing management with feedback. Performance metrics can also be utilized to estimate and forecast project performances, as well as to reward and punish conduct (Mengesha W.J., Eshetu A., 2005).

Performance measurement is necessary to update the historical database in addition to managing the projects' present state. Better scheduling of upcoming projects, expenses, and labor allocation is made possible by these modifications (Navon R., 2005). In reality, managers plan, decide, and alter plans to reallocate resources or enhance performance in the future. Likewise, managers set performance goals to inspire and, ultimately, enhance performance. It is indirectly but unquestionably true to evaluate jurisdictions by comparing their respective performances. The goal of rewarding excellence is to spur further development. Notifying relevant parties encourages them to assess and gain knowledge (Behn R.D., 2013).

2.6 The history of earned value management (EVM).

Earned value management (USAF EVMS) was introduced as a basic method of program management (EVM project management) in 1966 when the US Air Force enforced it along with other planning and controlling mandates on air force programs. The required document was called the Cost/Schedule Planning Control Specification (C/SPCS). Over the years, the notion and its prerequisites have not changed all that much. Cost/schedule control system criteria (C/SCSC), earned value management systems criteria (EVMSC), and the current 32 guidelines in the EIA-748 standard for earned value management systems (EVMS) are some of the titles that have undergone periodic changes.

When incorporated into any program, be it R&D, engineering, production, etc., the EVM idea outlined in these criteria is a sensible management strategy that gives management at all levels early warning of potential schedule and cost problems. Nowadays, programs all across the world employ earned value management. The main markets for EVM are China, Japan, Europe, England, Canada, Australia, and the United States. The Department of Defense (DoD), the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), the Intelligence Community, the Department of Homeland Security (DHS), the Federal Aviation

Administration (FAA), the Department of Transportation (DOT), and the Health and Human Services (HHS) are among the numerous U.S. government agencies that require it.

According to Humphreys Associates (2012), the objective of EVM is: To link time-phased budgets to particular contract tasks and work statements, determine the foundation for documenting job progress evaluations with relation to the baseline, provide accurate, timely, and reliable data or information for project management activities and proactive analysis, provide managers with a concise overview to facilitate efficient decision-making, Refer to technical, time, and cost performance.

EVM compares the amount we spent and what we had budgeted for the tasks we completed. A comparison between the work completed and the scheduled amount is made to ascertain time performance. Along with performance indices for project performance management, EVM computes schedule and cost variances to make these comparisons (Medhanit. G, et al, 2020)

2.7 EVA as a tool for performance assessment.

According to Suresh and Ramasamy (2015), "A method of performance measurement used in the evaluation and forecasting of building projects is earned value analysis or EVA," a method of earned value management that shows future job progress using the phrase "work in progress." Nevertheless, the quality of the output depends on the input data and the proper tracking of expenses and modifications.

The most common method of performance measurement, earned value analysis in all of its variations, is also demonstrated by (PMBOK, 1996). To assist the project management team in evaluating project performance, it incorporates scope, cost (or resource), and schedule measures. The most widely used technique for measuring performance is earned value analysis, in all of its variations. The integration of scope, cost, and schedule measures facilitates the assessment of project performance by the project management team.

Many developed nations have made significant advancements in their building procedures over the past ten years by using EVA technology in both privately and publicly sponsored projects. In July 2000, the South Korean Congress approved a bill known as "The Effective Plan of the Public Construction Industry Bill," which required construction companies to use earned value analysis (EVA) for any project valued at more than USD 50 million Eom, S. (2008). Through the use of three data sources, EVA can compare the earned value (EV) of finished physical work, the actual value (AV) of completed work, and the budgeted value of planned work (PV). Therefore,

performance data obtained through EVA serves as an impartial gauge of the real work that has been done.

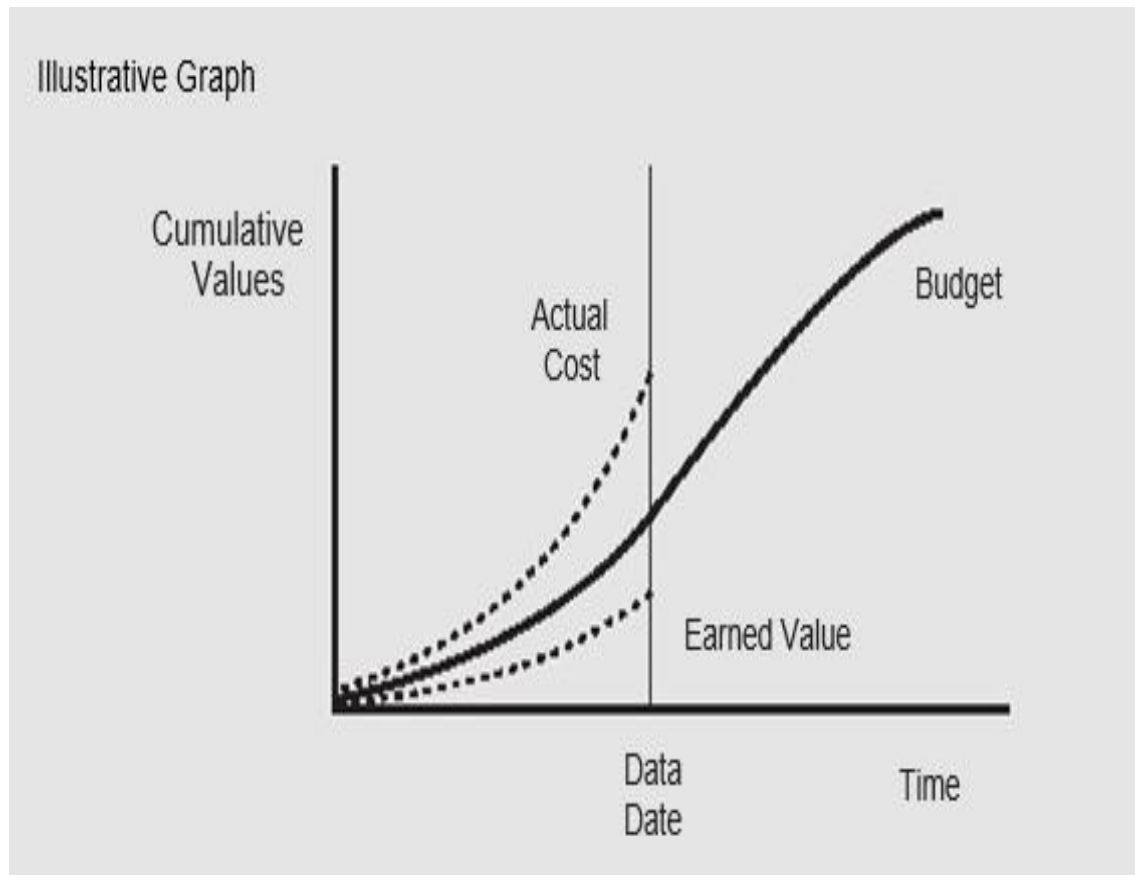


Figure 2.3 EVA Illustrative Graph. (Source: PMBOK (1996)).

Moreover, the approach assists managers in determining whether corrective measures are necessary. It incorporates a project monitoring system's cost and time views. See the following section for a more thorough discussion of the fundamentals of earned value analysis (Sabry, 2014).

The precision of earned value estimations is essential to a meaningful earned value analysis. One must estimate to calculate earned value.

- a. What percentage of the tasks have you finished so far?
- b. What percentage of the task's overall budget is intended to be spent, given the amount of work completed?

Assuming that there is a direct correlation between the percentage of a task that you finish and the amount of money that you should have spent, you should have spent 60% of the task budget if you have completed 60% of the assignment (Stanley, 2007).

Stanley (2007) states that there are three methods to calculate earned value depending on the circumstances.

1. Percent-complete method: The portion that denotes the completion of an activity and the entire activity budget is multiplied to get EV. If you are correct in estimating the portion of the task that you have finished, this approach might be the most accurate. This strategy is most susceptible to mistakes or deliberate manipulation, though, as the estimate is dependent on your subjective assessment.

2. Milestone method: Before you finish the activity, EV is zero; once you do it, it represents 100% of the entire activity budget. In terms of accuracy and conservatism, the milestone technique is the least used. During the task, you anticipate spending some money. On the other hand, until you finish the full task, this approach prevents you from declaring an EV bigger than \$0. As a result, while you're doing the task, you'll always seem to be over budget.

3. 50/50 method: Before the activity begins, EV is zero; once the activity is underway, it represents 50% of the entire activity budget; and once the activity is completed, it represents 100% of the activity budget. Because you can declare an EV larger than \$0 while completing the work, the 50/50 technique approximates reality more closely than the milestone method. However, overspending may be unintentionally concealed by this approximation (Stanley, 2007).

When selecting one of the three approaches for the project, it is important to balance the likelihood of correctness with the potential for erroneous conclusions based on subjective data. The 50/50 and milestone approaches enable the approximation of earned value without calculating the task's completion percentage (Stanley, 2007).

2.7.1 Terminology of EVA.

Many scholars and professionals have critiqued the nomenclature used in EVA. According to the PMI 2005 practice standard, the terms are divided into two groups: EVA measures (variances, indices, and forecasts) and important characteristics of EVA, such as planned value (PV), earned value (EV), and actual cost (AC).

An essential component of EVA is performance indices. In the EV approach, the schedule performance index (SPI) and the cost performance index (CPI) are two often utilized indices.

According to PMI (2011), it refers to the fundamental terms used in EVA that one must fully comprehend before moving on to more general notions. These are:

Planned value (PV). Is the allowed budget that is allocated to the planned work on a particular reporting date. The work that should have been completed at any given moment is defined as the intended value. One might report the planned value for a certain reporting period or the total

amount of work completed thus far. Another name for this could be the planned expense for the planned job. Earned Value (EV). The extent of the work completed, stated in terms of the funds allocated for it. Either the total earned value to date or a particular reporting period may be reported for earned value. The budgeted cost for work performed (BCWP) is another name for it.

Actual Cost (AC). The actual expense paid for the labor spent on a task within a given time frame. This might be reported for a particular reporting period or cumulatively to date. Alternatively, it is referred to as the actual cost of work completed (ACWP). **Budget at Completion (BAC).** The total of all the budgets set aside for the work that needs to be done on a project, work package, control account, or component of the work breakdown structure. The total of all work package BACs is the project BAC.

Estimate at Completion (EAC). The amount of the estimated cost to complete (ETC) plus the actual cost incurred thus far (total expected cost of completion).

Estimate To Complete (ETC). The projected cost of completing all outstanding work. The estimate at completion (EAC) is the outcome of adding the ETC to the actual cost (AC) at any point in the project.

Management Reserve (MR). A portion is withheld for management control from the project budget basis (PBB). These funds are set aside for unanticipated expenses that fall under the project's purview. Management must give specific permission before using management reserves. It is applied in unique situations where the project manager determines that altering the performance measurement baseline is necessary but not altering the project's budget as specified in the project charter or contract.

Performance Measurement Baseline (PMB). A project execution's authorized integrated scope, schedule, and cost plan serves as a benchmark for managing and measuring success. Together with budgets with defined scope that have not yet been allocated to control accounts (undistributed budget), the budgets allotted to control accounts make up the PMB. When the distributed budget is added to the undistributed budget, the PMB is equal. The managerial reserve is not included in it.

Project Budget Base (PBB). This serves as the foundation for initial budgets. This is the project's overall budget, which also includes any management reserves and the expected cost of work that has been approved but isn't yet completely detailed. The contract budget basis (CBB) is the amount that is allocated to the project under the terms of the contract.

PMI (2011) uses Figure 2.4 to create a graphic that shows the link between these terms.

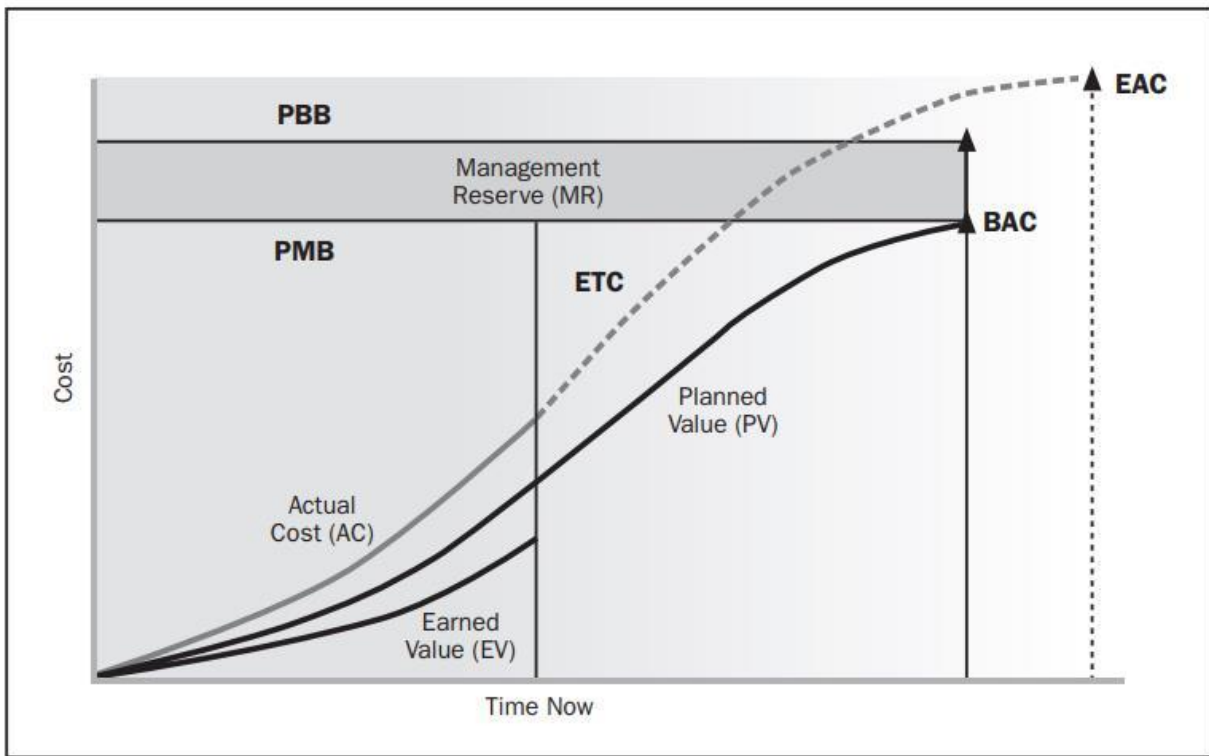


Figure 2.4. EVM Basic Concepts: Chart Form (Adopted from PMI (2011:10))

2.7.2 Applications of Earned Value Analysis (EVA)

The earned value analysis method has become the industry standard in project management and is acknowledged as a valuable tool by numerous government agencies and practitioners. It has shown sufficient versatility to be implemented on any kind of project, from small-scale projects to multi-year military systems costing millions of dollars. According to Czarnigowska (2008), clients and contractors can utilize the analysis, which can be performed at any level of the work breakdown structure.

Earned value analysis is one of the best performance measurement and feedback tools for managing construction projects (Raveesh & Shenoy, 2015). For any initiative to be successful, feedback is essential. Obtaining pertinent feedback ahead of schedule helps project managers spot issues early on and make changes that maintain a project on schedule and within budget. Earned value analysis enables projects to be managed more effectively on schedule and within budget. Once a project has progressed to a level of performance, the regular and continuous flow of information on the true status of the project is crucial (Raveesh & Shenoy, 2015). Earned value analysis also optimizes the project by motivating the management team to focus more intently on cost, time, and progress (Czarnigowska, 2008).

Earned value analysis is used to assess the current state of a project, including whether it is on track or behind schedule. Does the budget go over or under? As well as the extent of the present plan deviations. Additionally, it enables a project manager to extrapolate existing trends to conclude the project's ultimate impact in terms of duration and cost (Przybystok, 2008). A fair and equitable environment that promotes the successful completion of contracted or outsourced project items can be achieved by carefully considering and negotiating the procedures and tools utilized for progress determination (Raveesh & Shenoy, 2015). Earned value analysis is also used to calculate progress payments to contractors based on the outsourced or contracted work's earned value (EV). It is crucial to take into account the prescribed procedure for assessing progress because such contractual agreements impose financial and legal duties.

2.7.3 Earned Value Analysis Method

It is a quantitative way of project management that compares actualized progress and costs to the budget and progress plans to assess project performance and forecast project performance results. (J. A. Lukas, 2008). Three dimensions are used in this method: the amount of work accomplished, the percentage of work finished, and the earned value (Fleming *et.al*, 1994). By estimating the cost and time needed to finish all work based on the performance index at the reported period and knowing how the project has been performing, this method allows one to determine the relationship between the percentage of work completed and the budget spent during the project performance. Therefore, if the prearranged strategy is not followed, corrective action may be taken. By computing indicators, variances, and the performance index, one can examine the Earned Value Concept (EVA). The remaining time and project cost are then estimated using the results. The following approach may be used to finish the analysis phases:

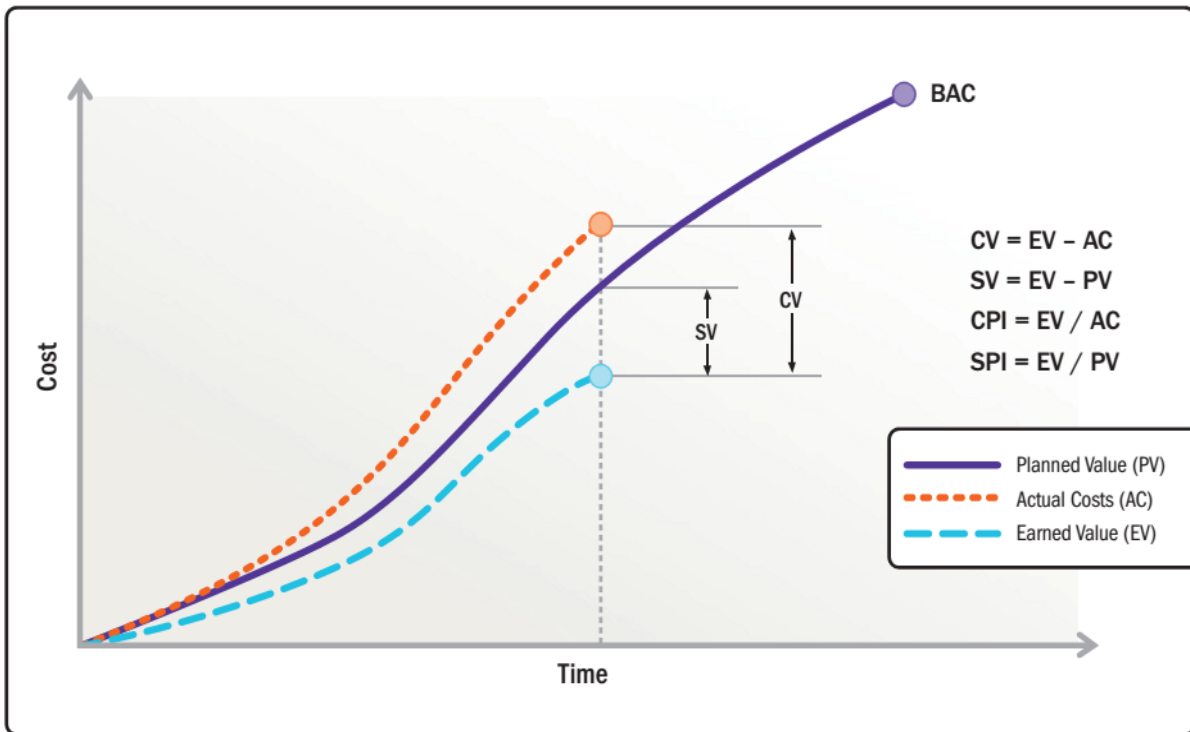


Figure 2.5. Earned Value Analysis Showing Schedule and Cost Variance. (Adapted from PMBOK Seventh Edition July 2021)

According to the Project Management Institute (2005), the following three sets of measurements are identified: forecast indicators, performance indicators and variations, and basic metrics.

2.7.3.1 Basic EVA metrics

Earned Value (EV)-The budgeted cost of work performed (BCWP) for a specific period (BAC x % Complete). To what extent is the task completed?

Planned Value (PV): PV is the estimated cost of the work scheduled (BCWS) that must be finished by a specific date. To what extent is labor to be done?

Actual Cost (AC): This shows the expenses incurred for the task that was finished as of a given date.

2.7.3.2 Performance indicators and variances in the EVA technique

Schedule Variance (SV): SV is an efficiency metric that shows how well the project is progressing according to its timetable. It computes the discrepancy between the actual and anticipated amounts of work completed. When the project is finished, SV will ultimately equal zero since every planned value will have been achieved. It is calculated as follows (PMBOK, 2000).

$$SV = EV - PV \text{----- Equation 1}$$

If there is a negative schedule variance, the project is behind schedule (bad), meaning the job took longer than expected to complete. Likewise, a positive variance signifies that the project is ahead of schedule (excellent), meaning that it took less time to complete than anticipated.

It is important to note that the schedule variance (SV), which quantifies the departure from the schedule using monetary values rather than time units, is reported (Suresh & amasamy, 2015; Verzuh, 2005). A positive SV% indicates that more work has been completed than initially anticipated, which is good. An unfavorable SV% indicates that less work has been done than anticipated (Verzuh, 2005) an equation can be utilized to express the schedule variance (SV) as a percentage.

$$SV\% = (SV/PV) \times 100 \text{----- Equation 2}$$

According to Dwaikat (2016), the schedule variance percentage (SV %) calculates the amount of work completed that deviates from the original project time plan.

Cost Variance (CV): CV The project's cost performance is reflected in the CV, an efficiency metric. The difference between the actual amount spent on the finished task (ACWP or AC) and the budget (BCWP or EV) is measured. As stated by PMBOK (2000), it is computed as follows:

$$CV = EV - AC \text{----- Equation 4}$$

Using Equation (Dwaikat, 2016), the cost variance (CV) can be expressed as a percentage.

$$CV\% = (CV/BCWP) \times 100 \text{----- Equation 5}$$

According to Dwaikat (2016), the cost variation percentage (CV %) expresses how much more or less work was completed on the original project cost plan.

Schedule Performance Index (SPI): SPI the project completion date can be predicted using the SPI in addition to the project schedule status. Occasionally, the SPI is used with the CPI (cost performance index) to forecast the project's estimate at completion (EAC). According to PMBOK (2000), it is computed as follows:

$$SPI = EV/PV \text{----- Equation 6}$$

Cost Performance Index (CPI): The CPI is simply expressed, the CPI is the ratio of EV (BCWP) to AC (ACWP), and it is a widely used cost-efficiency indicator that is used to track project costs and forecast cost overruns. According to PMBOK (2000), it is computed as follows:

$$CPI = EV/AC \text{----- Equation 7}$$

2.7.3 Forecast indicators in the EVA technique

Estimate to Complete (ETC): The estimated cost required to finish all outstanding work for a control account, work package, or project is known as the estimate to complete (ETC). Developing a new, comprehensive, bottom-up estimate based on an examination of the remaining work is the most accurate approach (Raveesh & Shenoy, 2015).

$$ETC = (BAC - EV) / CPI \text{----- Equation 8}$$

Estimate at Completion (EAC): When the specified scope of work is finished, the estimated total cost of a control account, work package, or project is known as the "estimate at completion" (EAC). Usually, the EAC is calculated by adding the estimate to complete (ETC) for the unfinished job to the actual cost incurred for the work done (AC). There exist various methodologies for computing the EAC. Here are a few of them (Vandenbussche & Buyse, 2010):

1. EAC: Current actual plus a revised estimate for all work still to be done. When historical performance demonstrates that the initial estimating assumptions were essentially incorrect or that they are no longer applicable due to a change in circumstances, this strategy is most frequently employed.
2. EAC: Actual up to this point + Budget left over. When present variations are viewed as abnormal and the project management team anticipates that such variances won't happen again, this strategy is most frequently employed.
3. EAC: Actual up to this point plus the remaining budget adjusted by a performance factor (usually the cumulative cost performance index, or CPI). The most common application of this strategy is when existing deviations are thought to be representative of future variances.
4. The budget at completion (BAC), or EAC, is modified by a performance element called the cumulative cost performance index (CPI). This approach is used most of the time when there are no BAC variances.

EAC is a straightforward linear extrapolation of prevailing trends. Because it doesn't account for potential hazards or the results of remedial action, it isn't a reliable forecast. EAC does, however, highlight the possible scope of cost issues. Given that the Earned Value method necessitates regular progress reports from the outset of a project, an early EAC-based construction project whose current trends are likely to double the cost is likely to serve as a useful warning signal and prompt corrective action when there is still time (Czarnigowska, 2008).

The EAC does not always operate under the premise that expenses will continue in the same manner as they do now although there are other possibilities, linear extrapolation is the norm and works well since the approach is based on a simplified project model.

The general EAC formula allows for several simple scenarios (Dhawale & Tuljapurkar, 2015):

$$EAC = ACWP + (BAC - BCWP) / CPI \text{----- Equation 9}$$

According to Vandebussche and Buyse (2010), this model is the most widely used one for cost forecasting. For example, EAC is the total of all committed expenses plus the budgetary remainder multiplied by a coefficient (CPI) that represents the correlation between the project's past and future. Project-specificity may apply here. The most common scenario taken into consideration is that the remaining tasks will be completed at the anticipated cost, meaning that future costs will not affect present expenses and that $CPI=1$ (Czarnigowska, 2008) applies. So

$$EAC = BAC + CV \text{----- Equation 10}$$

In this research, the forecasting performance of the public building construction projects was calculated and the projects were evaluated using the EAC concept using equation 9.

Variance at Completion (VAC): The difference between BAC and EAC is known as Variance at Completion,

$$VAC = BAC - EAC \text{----- Equation 11}$$

It estimates the amount of surplus or deficit in the budget at the conclusion of the project. The project's estimated completion budget is displayed to the team by the VAC. VAC divided by BAC yields the percentage for this (Raveesh & Shenoy, 2015).

To Complete Performance Index (TCPI): The amount needed to do the remaining tasks is compared to the work that has already been performed. A conversation examining whether the needed performance is practically attainable can be based on the TCPI statistics. As stated by Raveesh and Shenoy (2015), it is the ratio of completed work to remaining funds.

$$\begin{aligned} TCPI &= \text{Work Remaining} / \text{Cost Remaining} \\ &= (BAC - BCWP \text{ Cumulative}) / (EAC - ACWP \text{ Cumulative}) \text{----- Equation 12} \end{aligned}$$

The following figure, Figure 2.6, depicts the graphical relationship between the EVA metrics.

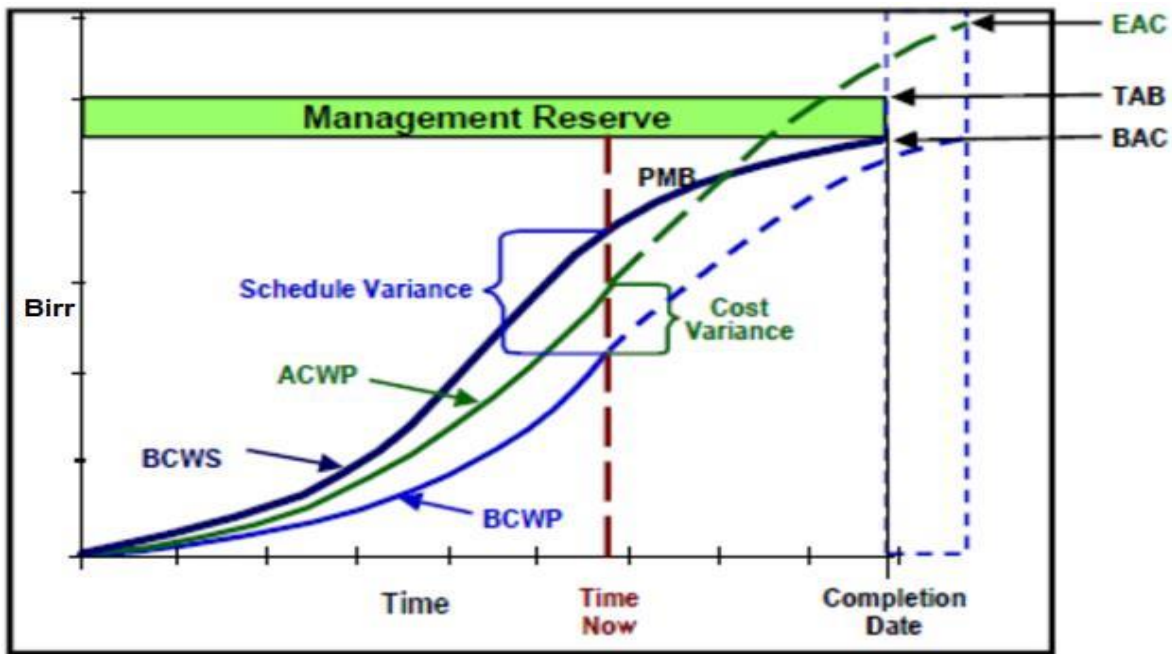


Figure 2.6. EVM Metrics Chart. Source, Dau Program Managers Tool Kit (2011)

The amount of schedule and cost variations from the initial project plan are indicated using the earned-value method. But it doesn't pinpoint the issue's root cause.

A number of additional crucial practices in process planning, execution, and control are also necessary for the successful use of EVM, in addition to incorporating the project management concepts described in the PMBOK Guide into regular project management procedures (PMI, 2005). When introducing the globally accepted EVM method into other nations, it should be structurally modified to fit the current project control methodologies.

Specifically, since the results of EVMs rely on the gathering and handling of integrated cost and schedule data, it is necessary to create a data representation model that is acceptable for the local market. Furthermore, studies should be conducted to determine the proper degree of information detail for different project sizes and types, as this affects how well control is exercised during the information integration process (Kim et al., 2008).

Focusing on three factors—level of knowledge and application of EVM due to the paucity of commercial books and articles on the subject, high costs of data collection for EVM analysis, and estimation of project completion percent—Limilia and Mokaya (2018) found that all three significantly contribute to employee and contractor resistance when trying to put EVM into practice. Additionally, Limilia and Mokaya (2018) proposed two approaches to implementing EVM in the construction sector: (1) introducing and ongoing training on the application of EVM,

and (2) establishing a long-lasting and efficient strategy for resolving issues impacting the quality of building projects.

According to Valle and Soares (2006), the primary advantages of EVM are as follows: (1) integrated cost, progress, and time management; (2) improved project scope and procurement vision; (3) early problem detection; (4) predictability of project deviation trends; (5) shorter time to perceive and comprehend issues and their solutions; (6) support for decision-making and negotiations; and (7) employee motivation to execute the project control process.

According to Kim et al. (2008), the project control methods currently in use in Korea are unable to precisely deliver integrated data on cost and schedule for EVM. Kim et al. (2003) discovered that overall organizational approaches are linked to the successful implementation of EVM. They also developed three major critical success factors (acceptance, use, and performance) that are each comprised of several success subfactors to achieve better successful outcomes for EVM implementation in facilitating project success.

Several factors, including fixed schedules without iterative processes, inadequate change management, weak requirements, high complexity, inaccurate estimation or metrics, inadequate planning, unclear or shifting goals, etc., are identified by empirical research on project management as contributing to project failures. This indicates that the real project environment is anything but deterministic (Kappelman et al., 2006; Nelson 2007; Chua 2009).

According to Terrel et al. (2008), having precisely defined resource information is essential for the Earned Value Analysis to be executed successfully. A performance measurement baseline (PMB) that is erroneous and disconnected from reality is created as a result of the inability to gather these data.

According to Fleming & Koppelman's (2010) research, having a suitable work breakdown structure (WBS) is crucial for successfully implementing EVM. A high control cost and a significant amount of paperwork will result from breaking up the work into smaller pieces. A poorly stratified subdivision, on the other hand, can indicate inaccurate data regarding actual costs and timeframes.

According to research by Vagas (2014), EVM encourages project participants to pay closer attention to expenses and progress, encourages more intense discussion of cost elements, and optimizes costs, all of which contribute to the timely and cost-effective completion of the project.

Project activities and management efforts in any of the project stages could impact a project's success (Aklil Gebreegziabher, 2019). As a result, managing a project becomes a more difficult and complex activity that calls for a more complete perspective. Many project control techniques, including the Gantt Bar Chart (GBC), the Critical Path Method (CPM), and the Program Evaluation and Review Technique (PERT), have been created over the previous few decades (Lester, 2014).

Ethiopian construction projects are accused of performing below expectations, according to Desta (2015), who examined the administration of the construction process at the Ethiopian Roads Authority (ERA). According to Desta (2015), the phases and fundamental procedures that ERA uses for project delivery are similar to "accepted practices," but he also found some significant differences between how ERA executes and manages these procedures and the best practices that have been suggested in the literature. One such example is that: ERA uses an extra-fragmented approach; the Authority's methods and procedures for project delivery are not sufficiently customized to the unique features and circumstances of its projects and surroundings; The Authority's methods for performance monitoring and assessment are self-serving, and, the unstable external environment, the inadequate supply chain, the fragmented knowledge base, and the careless and lax industry practices are important factors that impact the Authority's project delivery.

According to Koshe and Jha (2016), several major factors contribute to construction delays in Ethiopia. These include the inability of a contractor to finance the project, increases in material costs, inadequate project planning, scheduling, or resource management, late payments for completed work, a shortage of qualified professionals in the organization that handles construction management, and seasonal or varying labor availability. Koshe and Jha (2016) also discovered that, in Ethiopia, only 8.25% of projects were completed within the originally planned timeframe; the rest 91.75% took longer than 352% of their contracted duration to complete.

2.8 Major causes of cost and time variances

Numerous previous research on project success about cost and time considerations have been conducted (Pheng and Chuan, 2006).

According to Iyer and Jha (2005), the following factors influence cost performance: the project manager's competence; top management's support; the project manager's coordinating and leadership skills; participant monitoring and feedback; decision-making; coordination among project participants; the owners' competence; and the social, economic, and climatic conditions.

Out of all the aspects that have the greatest impact on a project's cost performance, coordination among participants is the most crucial.

According to Long Le-Hoai*, *et al* (2008), the items in Table 2.2 can cause the cost or schedule to vary from the original project plan.

Table 2.2. Major factors that cause cost and schedule variance of construction projects

Poor site management and supervision
Poor project management assistance
Financial difficulties of the owner
Financial difficulties of contractor
Design changes
Unforeseen site conditions
Slow payment of completed works
Inaccurate estimates
Shortages of materials
Mistakes in design
Poor contract management
Price fluctuations
Obsolete or unsuitable construction method
Incompetent subcontractors
Slow inspection of completed works
Mistakes during construction
Slow information flow between parties
Additional works
Shortages of skilled workers
Bad weather
Obstacles from government

The performance of your project isn't precisely going as you intended, as stated by Stanley (2007), whether the cost or schedule variations have positive or negative values. If a variance is found, you should identify the cause(s) as soon as possible so that you may either ensure that the current

course of action is followed (in the case of a positive variance) or take corrective action if the variance is negative.

2.9 Conceptual Framework

A conceptual framework, according to Miles (1994), is a concrete product—written or visual—that clarifies the essential elements being studied. Within the framework of this research, the conceptual framework functions to specify the main topics to be examined, either visually or by narrative explanation. In particular, the research aims to assess the level of knowledge of Earned Value Analysis (EVA). Additionally, it looks for things that make it easier or harder to apply Earned Value Analysis (EVA) to the management procedures of certain public building projects. The study also seeks to identify obstacles and problems that arise during the EVM implementation process in certain public projects in Addis Ababa.

The conceptual framework positions Earned Value Analysis (EVA) as the independent variable, which is utilized to assess the level of awareness, identify influencing factors, and recognize challenges. Simultaneously Systems, measured through their effectiveness in gauging project progress. This conceptual framework provides a structured foundation for the study, aligning its objectives with a systematic and comprehensive approach to evaluating the application and impact of EVA in the context of public building projects.

Figure 2.7 below depicts the conceptual framework that underpins this investigation. This chapter's literature review is built upon this conceptual framework. The study focused on assessing public building construction projects in Addis Ababa city.

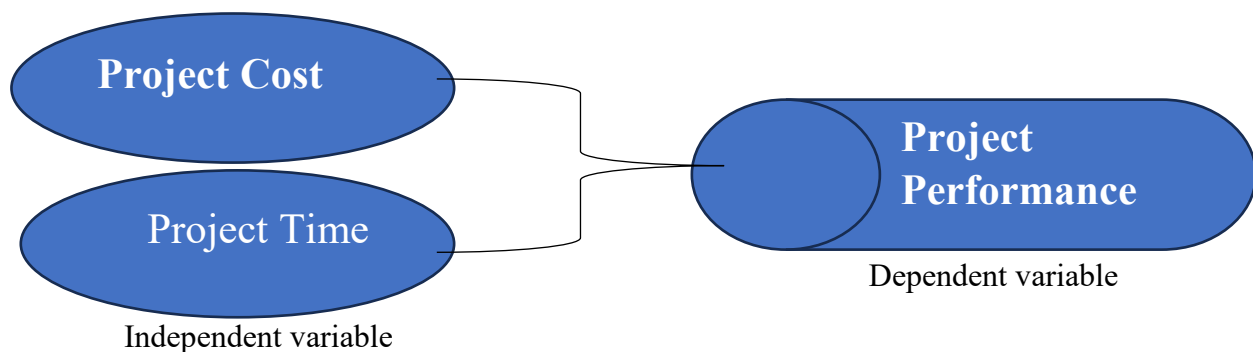


Figure 2.7. Conceptual Framework Model-independent and dependent variable

2.10 Cases where EVA used for building construction

Brazil: EVA was used in the civil construction of Monica Park, a theme park located inside the Citta America Shopping Center in Rio de Janeiro, Brazil. The park, which occupies 10,000 square

meters and contains 30 attractions, was constructed for US\$ 5 million in ten months, from January to October 2000. Reports, graphics, analysis, and comments are included in the case file. An analysis of the use of EVA in amusement parks is presented. It is demonstrated that EVA played a significant part in the integrated management of the project's scope, schedule, progress, cost, risks, and procurement of its primary supply and services.

Dubai, United Arab Emirates: The Burj Khalifa is the tallest building in the world, a landmark project that required precise project management to achieve its ambitious goals. Throughout the construction of the Burj Khalifa, EVA was used to track the performance of various contractors and work packages. The analysis helped maintain control over the project's vast budget and intricate schedule, ensuring the building was completed within its planned time frame and cost parameters.

Singapore: Marina Bay Sands is a large integrated resort with a hotel, convention center, shopping mall, and entertainment venues. The complexity and scale of the Marina Bay Sands project necessitated rigorous project management. EVA provided insights into the progress of various components of the project, helping the management team stay on top of costs and timelines, and ensuring that the project was delivered as planned.

Sydney: The Sydney Opera House underwent significant renovations to update its facilities and improve its infrastructure. The renovation project used EVA to monitor project health and performance, ensuring that all activities were aligned with the project plan. EVA metrics were critical in managing the complex coordination of various renovation tasks. The project achieved its goals within the allocated budget and time frame, with EVA playing a crucial role in maintaining control over project execution.

Ghana: EVA was used to monitor and control the construction of the Kwame Nkrumah University of Science and Technology (KNUST) Library Complex. By comparing the planned value (PV), earned value (EV), and actual cost (AC) of the project, the project team was able to assess the project's performance and take corrective actions to keep it on track.

Ecuador: The finished projects of a construction company in the city of Cuenca, Ecuador, were assessed. EVA was applied to projects from a database developed with information from each one to rebuild past events, existing problems, and critical points and evaluate the performance over time. The results of this analysis are meant to determine the project's success, calculating the cost variance at the end. EVA motivates project stakeholders to pay attention to costs and progress so

that timely actions can be taken to optimize resources, resulting in the completion of a project within budget and on time. In conclusion, EVA played an essential role in the integral management of the project in terms of scope, time, and cost.

ETHIOPIA: EVA was employed to monitor the construction progress and cost performance of the African Union Conference Center and Office Complex high-profile project. By comparing the planned value (PV), earned value (EV), and actual cost (AC), project managers were able to assess project performance and make informed decisions.

Similarly, a research study titled "Performance evaluation of housing construction projects, using earned value analysis: the case study of 20/80 condominium Addis Ababa Bole Arabsa site" was conducted in Ethiopia. The two projects at Yreka and Bole Sub City Projects that are included in the study are G+4 with an anticipated duration of 540 days and G+7 with an estimated time of 720 days. The projects are over budget and delayed for all sample blocks, as the report states. The aforesaid outcome is implied by their CPI and SPI, which are calculated.

3.11 Research Summary

In order to gauge performance, some academics studied earned value analysis methods in building construction projects. However, all they are doing is computing the projects' performance. The earned value analysis method is applied to a housing construction project in a local study by Medhanit G. et al. (2020). However, do not combine time and cost in isolation; instead, compute condominium project performance at month's end. Regarding the earned value analysis conclusion, there is no explanation regarding the reasons for the time and cost variance.

According to Edger D. (2007)'s theory of performance, project causes and external factors are ignored and only cost, time, and leadership are regarded as dependent variables. Conversely, scholars such as Raveesh L. and Shenoy (2015) concentrated on evaluating project performance through the application of earned value analysis, whereas Czarnigowska A. (2008) utilised the earned value approach solely as a project cost control tool. But in order to arrive at their conclusions, researchers looked at cost and time performances without taking into account future performance indicators. They also ignored the main reasons behind project cost and time changes, which prevented them from integrating cost and time performances at the same time. [Alvarado C.M., Silverman R.P. and Wilson D. (2004), Czemplik A. (2014)].

2.12 Research Gaps

Despite the extensive knowledge available on Earned Value Analysis (EVA) from existing literature, there are currently limited studies that specifically assess schedule and cost performance using EVA, according to the researcher. Furthermore, there is a scarcity of research focusing on identifying and comprehensively analyzing factors contributing to performance variations in public building projects using EVA within the context of Addis Ababa. The existing literature lacks a holistic examination of the application of EVA in assessing both schedule and cost performance, as well as in identifying factors influencing performance variances in these projects. These gaps highlight the need for focused and tailored research on the integration and effectiveness of EVA in the specified geographical and project context.

The study identified a research gap in using Earned Value Analysis (EVA) to assess project performance in building projects in Addis Ababa. While existing research has primarily focused on individual projects involving a single contractor, consultant, and owner, there remains a lack of understanding across multiple projects with different stakeholders. Previous research and the researcher's perspective indicate a shortage of studies on evaluating public building construction project performance using EVA in Addis Ababa. This study provides valuable insights into these underexplored areas and the availability of user-friendly application tools.

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter mainly discusses the approaches, procedures, techniques, and analytical methods used in conducting the research. This chapter covers the research design and methodology for gathering the data required to address each of the research's specific objectives, the method for analyzing the data and information, the tool to be used for analysis, and the format for the findings report. Each input data set, study assumptions, and the underlying basis of the original hypothesis are all addressed in depth.

3.2 Study Area

The research was conducted on three selected ongoing public building projects in Addis Ababa. It was a case analysis of three different projects. The first one was the FHC Mixed Apartment Building project which is located at Somali Tera, Arada sub city. The function of this project is (FHC) Mixed Apartment, with 3 floors underground and 23 floors above ground. The project was adjacent to an eight-story building with two basements on the west side, a municipal road on the north side, and simple houses on the east and south sides. It was constructed by China communications construction company (CCCC) grade1 contractor. It was also consulted by Accute Engineering Plc. The second was the Kolfe General Hospital construction project being built in the Kolfe Keranyo sub-city, district 7, Bethel Mendida area with a contract price of more than 3,347,189,374.10 birrs under the contractor of Ethiopia Construction Works Corporation (ECCO). The consultant was Ethiopian Construction Design and Supervision Works Corporation Building Design and Supervision Works Sector (ECDSWC, BUDSWS). The last project was the Cinema Complex construction project. It is constructed in the Lideta sub-city at Sengatera and its project built-up area is 2040m². It was constructed by Bamakon Engineering plc which is grade 1 contractor and consulted with Noble consulting plc. All the three projects had different clients, consultants and contractors

Table 3.1: Projects Description

Projects	Kolfe Keranyo General Hospital Building Project (14 buildings)	Cinema Complex	FHC Mixed Apartment Building at Somali Tera.
Budget (15 %VAT)	3,723,686,380.69	1,127,769,835.77	2,142,613,137.26
Duration	730 days	335 days	1305 days
Construction type	Public Building	Public Building	Public Building

Source, own survey 2024

3.3 Research design

The research design is the overarching strategy for addressing some of the challenges faced during the research process and gaining answers to the questions being posed. From here, which can be characterized as the first set of questions to be answered and conclusions to be drawn, a study design is a plan for getting there [Al-Moghany S.S. (2006)].

This research was practical and focused on addressing specific problems in public construction projects in Addis Ababa. As a result, both exploratory and descriptive research types were applied to this study, because this research will try to answer what are the factors that influence variations in the cost and schedule performance of selected public building projects in Addis Ababa and aimed to familiarize the reader with the Earned Value Analysis as a successful cost and schedule performance measurement strategy. Based on the source of data, both primary and secondary data sources were employed. Although the qualitative research method has also been used, a quantitative research approach was primarily prioritized in this study since the primary goal is to implement EVA for public project performance measurements in Addis Ababa city. The study employed a qualitative approach to investigate the extent of cost and schedule performance measurement practices implemented at the sample project. This was achieved through a review of pertinent literature, on-site observation, professional interviews, and primary access to project documents from the relevant stakeholders.

The study tried to ascertain the effectiveness of the cost and schedule performance measures of the public buildings used by employing a quantitative research method, specifically, the use of EVA techniques like those mentioned in the literature review.

Table 3.2.: Summary of Research Strategy.

Type of Information Needed	Schedule and Cost-related documents, such as payment schedules and plans, etc.
Research Type	Exploratory and descriptive
Technique and Approach of the Research	case studies
Data Collection Method	Questionnaires, Review of the literature (secondary research), direct document review, interviews
Data Analysis Method	RII, SPSS 26
Outputs	Graphs, Tables, Charts

Source, own survey 2024

The parties involved in three public building construction building projects, including the Clients, Consultants, and Contractors, were approached to obtain primary research data. Documents such as the Contract Agreement, Bill of Quantity, approved Master Schedule, updated schedule, payment certificates, and documented actual cost of works were requested to gather the necessary input data for conducting Earned Value Analysis. Following analysis and organization, the collected data was utilized as the appropriate input data for data analysis.

3.4 Research approach

The research is grounded in a review of the literature, quantitative analysis, and qualitative research using an exploratory research approach and case studies. A detailed review of the literature was done at the start of the study on the topics of EVA research. Understanding the shortcomings and limitations in the use of EVA in Addis Ababa public building projects, as well as identifying appropriate study techniques, are made easier with the aid of the literature review.

According to Efe, 2015, exploratory research is useful for defining problems in their early stages. This method is used when a researcher is unsure about a problem and requires further information. The case study helps address knowledge gaps and explore potential solutions to the research topic. This study used a combination of qualitative and quantitative data in a descriptive and exploratory research method, which was preferred in light of the objectives.

3.5 Target Population

The study's target population had concentrated on selected public ongoing public building projects. The target population consisted of three grade one contractors, three grade one consultant, and two

clients who had close involvement in one of the three projects that were purposively chosen from public projects which is shown in the table below. The respondents it targets consisted of professionals from clients, consultants and contractors who are directly involved in the three projects in Addis Ababa. Projects are financed, constructed, and supervised under different clients, contractors, and consultants including internal consultants such as the FHC Mixed Apartment Building at Somali Tera project. There are 53 professionals in all three projects and all were chosen as respondents from three parties.

Table 3.3 Selected Ongoing building projects in Addis Ababa.

<i>Project Name.</i>	<i>Scale</i>	<i>Contract type.</i>	<i>Clients</i>
Kolfe Keranyo General Hospital Building Project (14 buildings)	2B+G+3	DB	Addis Ababa City administration Design and Construction bureau
Cinema Complex	4B+G+8	DBB	Addis Ababa City Administration Design & Construction Bureau
FHC Mixed Apartment Building at Somali Tera.	3B+G+23	DBB	Federal Housing Corporation (FHC).

Source, own survey 2024

3.6 Sampling Technique

According to Kothari (2004), sampling technique is the process of choosing the samples from the population. Sampling techniques can be either probability samples or non-probability samples. While the probability every element has a chance of being included in the sample, the non-probability samples do not give every respondent the chance of being selected (Kothari, 2004).

For the case study, a non-random sampling method or non-probability sampling (purposive sampling) was used. The research samples for the case study consisted of participants from all selected ongoing public building projects in Addis Ababa.

3.7 Sample Size

Kothari (2004) defines a sample as a portion of the target population that has been carefully chosen to serve as the study's representative. According to Maggi (2015), the sample size is deemed limited due to factors such as time, cost, and human resources, as well as the need for an in-depth understanding of the phenomenon under study.

For the case study, non-probability sampling also known as purposive sampling was used. The study's sample size consisted of contractors, consultants, and clients who had close involvement in one of the three projects that were purposively chosen from public building projects. Professionals received questionnaires from census surveys of all ongoing public building projects. Participant questionnaires for three ongoing public building construction projects were delivered. From census surveys, a total of 53 professionals were used as a sample from all the three projects.

3.8 Source of data.

In order to set research objectives and questions, assess the practices and challenges of implementing EVA, design and develop a research questionnaire and interview guidelines, and conduct a literature review, the primary sources of data and information were the research outputs and other related publications. Major sources of data and information for most of the research questions and objectives the researcher set were the expert opinions of consultants, clients, and project managers obtained through questionnaires and interviews.

Both primary and secondary sources provided data for this study. A structured questionnaire that was distributed in-person, online via email, and telegram, by self-administered methods was used to gather primary data.

3.9 Data Collection Techniques

To acquire adequate answers to the issues given, the data collection approach takes into account the sort of evidence to be collected, its sources, and the process of interpretation employed, (Easterby Smith M.T.et al, 2002). The many dimensions of the research objective are investigated using a variety of data sources.

Primary and secondary data are thus two categories into which the usable data can be divided. As detailed in the upcoming subsections, these diverse data were gathered at different times and with varied techniques. First, monthly planned cost for three projects was collected for the earned value analysis desk study. Next, the percentage of activities completed was collected, and lastly, actual

cost of the activities was collected. During this process, the client, consultant, and contractor's engineers again discussed the main reasons for time and cost variations. First, the planned cost the actual cost, and the percentage completion of the three projects were collected on a monthly basis from the clients, the contractors, and the consultants. A set of structured questions concerning the research project were included in the questionnaires also distributed and collected, which were intended for respondents who were major participants and stakeholders such as contractors, consultants, and clients. The following techniques were used when the data collected in all the three projects.

3.9.1 Questionnaires:

Questionnaires are employed as an additional technique to further classify and prioritize the reasons for changes. The purpose of this questionnaire was to gather information on the performance of ongoing building projects in Addis Ababa using Earned Value Analysis (EVA). The respondents were participants in selected construction projects, including consultants, clients, and contractors. The data collected would help in understanding the performance metrics and identifying potential issues affecting project execution.

3.9.2 Discussion:

It was one method that aids in identifying the main factors influencing a project's differences in time and cost. According to the researcher, the assessment of building construction project performance using Earned Value Analysis (EVA) in selected public buildings in Addis Ababa provides valuable insights into the current state of project management and execution in this region. The discussion was held with key professionals such as project managers, project coordinators, site Engineers, and Office Engineers. The discussion covered, the findings derived from the data collected through questionnaires, contract documents, master schedules, and progress reports, and identified key themes and issues impacting project performance.

3.9.3 Desk study:

The desk study is a different method involved in reviewing existing literature, reports, and data related to the performance of building construction projects using Earned Value Analysis (EVA). This secondary research helped in understanding the context, identifying common issues, and comparing findings with the primary data collected from ongoing projects in Addis Ababa.

The following data were collected from various sources involved in the selected ongoing building construction projects in Addis Ababa. These data points were crucial for assessing project performance using Earned Value Analysis (EVA). The collected data were: the contract document,

the master schedules, monthly planned (financially), `monthly planned (physical), monthly progress report (financially), monthly progress report (physical), problems encountered during project execution

3.11 Data Analysis Tools

After the data was gathered, it was evaluated using a variety of methods to see if it was sufficient, clear, and comprehensive. After entering the desk study results into Microsoft Excel, the data was changed to make it usable for the investigation. The study used the Relative Importance Index (RII) and SPSS 26 software to rank the primary sources of schedule and cost variations based on questionnaire responses. Kometa et al. (1994) and Sambasivan and Soon (2007) used the RII method to determine the relative importance of the various causes of delays.

$$RII = \frac{\sum W}{A * N} \quad (0 \leq RII \leq 1)$$

Where W= is the weight given to each case by the respondents

A= the highest weight and

N= Total number of respondents

3.12 Reliability and Validity Analysis Methods

3.12.1 Reliability

If the results of a measurement can be consistently reproduced, it is deemed that the measuring instrument is reliable. Reliable scales offer consistent measurements across various times and conditions. The Cronbach's coefficient alpha, which gauges internal consistency and how closely connected a group of items is to one another, was created by Lee Cronbach in 1951 and is used to assess scale reliability. Greater values signify increased agreement among the items. Elevated Cronbach's alpha coefficients suggest that each participant's answers to a series of questions are consistent. As an illustration, individuals are more likely to respond favorably to the other items when they give a high answer on one of the items.

Thus, to determine the reliability of surveys with many Likert scale questions, Cronbach's alpha tests are used. The alpha value of Cronbach's coefficient typically ranges from 0.0 to + 1.0 Mohamad Ali (2017). The paper was taking the following steps to ensure Reliability:

Pilot Testing: It was conducted a pilot study with a small sample of similar projects to test the data collection methods and was done adjustment of the instruments if inconsistencies arise. For example, before full data collection, it was tested the performance data collection process with 3

public buildings in Addis Ababa and 8 questions were distributed and tested to ensure the tools measure consistently.

Repeatability: The researcher tried to collect the same data for more times at different intervals to check for consistency. For example, since the thesis measured the cost performance (Earned Value, Planned Value, etc.) every week, it was checked that the calculations of Earned Value (EV) gave consistent results.

Inter-rater Reliability: multiple professionals were involved in data collection, and told them to follow the same process. This ensured that the data gathered by different individuals was comparable.

Table 3.4 Cronbach's alpha interpretation. (Source, Mohamad Ali, 2017)

Cronbach's alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

The internal coherence of data is evaluated using the Cronbach's alpha coefficient. Internal consistency is assessed by identifying the main causes of time and expense discrepancies before data grouping. The results of this evaluation, which was carried out with SPSS 2026, are described in full below.

Table 3.5 Reliability test of data

Reliability Statistics	
Cronbach's Alpha	N of Items
.884	42

Based on the Pilot Testing, the SPSS 2026 resulted the value of 0.884 which falls within the range of $0.9 > \alpha \geq 0.8$, according to table 3.4, meaning that the internal consistency is considered good.

3.12.2 Validity

Measurement validity is the capacity of a scale or other measuring device to measure what it is supposed to measure. For any researcher, internal and external validity are crucial. Whereas quantitative researchers prioritize a greater level of external validity, qualitative researchers place more emphasis on the study's excellent internal validity (Susan & Chad, 2013).

For the assessment of building construction project performance using Earned Value Analysis (EVA), several strategies were employed to ensure both internal and external validity.

- a. Internal Validity: Multiple sources of data, including contract documents, master schedules, and progress reports, were used to triangulate the findings. This helps to minimize biases and errors in data collection (accurate Data Collection). The questionnaires were carefully designed to cover all relevant aspects of project performance, including financial and physical progress, and were tested in a pilot study to ensure clarity and comprehensiveness. The use of SPSS 26 software for statistical analysis ensures rigorous handling of data. Techniques like the Relative Importance Index (RII) helped to quantitatively rank the sources of schedule and cost variations, providing a clear basis for analysis. Efforts were made to control extraneous variables that might affect the outcomes, such as the size and complexity of the projects, to ensure that variations are attributed to the factors being studied.
- b. External Validity: The study included participants from various roles (clients, consultants, contractors) across multiple ongoing building projects in Addis Ababa. This diversity enhances the generalizability of the findings. By focusing on public building projects in Addis Ababa, the study's findings were directly relevant to the local context. However, similar methodologies can be applied to other regions, making the results potentially applicable to broader contexts. The findings were also compared with existing studies and literature on EVA and construction project performance. This comparison helped to validate the results by placing them within the context of established knowledge. Including data from different phases of the projects allowed for a more comprehensive understanding of performance over time, rather than at a single point, enhancing the robustness of the conclusions.

The paper was taking the following Steps to ensure Validity:

Content Validity: It ensured that the data collected covers all aspects of the three-project performance that it intended to assess. The thesis focused on cost and time performance of the projects, so the data collection was included detailed financial records, schedule data, and project milestones.

Construct Validity: The variables and metrics in this paper actually represent the performance aspects the thesis was trying to measure. In this case, metrics like EV, PV, and AC should accurately reflect the performance of public building projects. For example, the Earned Value (EV) was calculated based on actual work completed, not just budget allocations, to ensure it represents the true progress of the project.

Face Validity: The data collection tools made sense to the participants (engineers, project managers, etc.). It was asked experts in the field to review the data collection tools and ensure that they agreed the tools accurately assess project performance. For example, experienced engineers in the public building projects reviewed EVA calculation templates and confirmed they reflect industry standards.

External Validity: Ensure that the results can be generalized to other public building projects outside of the three public building projects.

3.13 Ethical issues

Ethics are crucial in research, and the study adheres to guidelines such as voluntary involvement, informed consent, anonymity, secrecy, risk of damage, and results communication. The research project ensures no negative effects and avoids personal details.

All participants, including clients, consultants, and contractors, were informed about the purpose of the study, the nature of their involvement, and their right to withdraw at any time without any negative consequences. Informed consent forms were provided, detailing the study's objectives, procedures, potential risks, and benefits. Participants gave their consent voluntarily, ensuring that they were fully aware of what participation entailed. Personal and sensitive information collected during the study was kept confidential. Data were anonymized to protect the identities of the participants.

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1 Introduction

This part of the thesis, serves as the cornerstone of this research, presenting the findings derived from the data collected and providing a thorough analysis of these results. This section aimed to answer the research questions and fulfill the objectives set out at the beginning of the study by examining the performance of building construction projects using Earned Value Analysis (EVA) in selected public buildings in Addis Ababa.

4.2 Assessment of Project Performance

In this study, the performance assessment of public building projects was conducted using data and documents related to cost and time parameters. The primary objective was to evaluate the performance of public building construction projects by considering various project indicators through earned value analysis and relevant parameters.

4.3 Response rate

Key professionals representing three selected public building projects provided the information needed for the study. Professionals from any of the main stakeholders made up the project site responders.

The study's target participants were consultants, contractors, and owners who were involved in the selected public building construction projects. As indicated from table 4.1, a total of 53 Questionnaires were distributed for all 53 professionals who were working on the three selected public projects: 18 went to the consultants, 27 to contractors, and 8 to owners. 8 Questionnaires from owners, 15 from consultants, and 24 from contractors, were among the, 47 that were returned (88 %) response rate. After the data was gathered, critical performance indicators were determined by analysis and discussion. The analysis ranked the main causes of schedule and cost deviations in active building construction projects at Addis Ababa city using the Relative Importance Index (RII) technique and SPSS 2026 and correlation was done using Spearman's rank coefficient.

A questionnaire that was distributed, gathered, and examined in order to reach the target outcome was listed in Table 4.1.

Table 4.1: Questionnaire circulation summary.

a. Client.

Designations	Questionnaire		
	Distributed (No)	Collected (No)	Rate of response (%)
Project Manager	3	3	100%
Counterpart engineer	1	1	100%
Deputy project manager	1	1	100%
Quantity surveyor	3	3	100%
Total	8	8	100%

Source, own survey 2024

b. Contractor.

Designations	Questionnaire		
	Distributed (No)	Collected (No)	Rate of response (%)
Project Manager	3	2	67%
Deputy Project Manager	2	2	100%
Site Engineers	10	8	80%
Architects	3	3	100%
Quantity survey	2	2	100%
Sanitary Engineer	3	3	100%
Safety Engineer	2	2	100%
Electrical Engineer	2	2	100%
Total	27	24	89%

Source, own survey 2024

c. Consultant.

Designations	Questionnaire		
	Distributed (No)	Collected (No)	Rate of response (%)
Project Coordinator	3	2	67%
Structural Engineer	2	2	100%

Resident Engineer	3	2	67%
Architects	3	3	100%
Electrical Engineer	2	2	100%
Quantity surveyor	3	2	67%
Sanitary Engineer	2	2	100%
Total	18	15	83%

Source, own survey 2024

From table 4.1 shown above, participants on the client side were those employed as project managers, counterpart Engineers, deputy project managers, and quantity surveyor. Professionals working as project coordinator, structural, Engineer, resident, Engineer, Architects, Electrical, Engineer, quantity, surveyor, sanitary Engineer contributed from the consultant side at both the office and project levels. At the same time, the contractor was represented at the organizational and project levels by project manager, deputy project manager, site Engineers, Architects, quantity survey, sanitary engineer, safety Engineer, and Electrical engineer

4.4 Description of the case study projects

In this thesis, three currently ongoing public projects were examined to gather data relevant to earned value management systems by using the earned value analysis (EVA) method in public building construction projects. A central focus was placed on comparing this assessment with the specific objectives of each project. The sample construction project budgets are shown in the tables below, with varying ranges and durations. This range of variation enables the researcher to take into account various building construction project sizes.

All projects are delivered using the design-bid-build and Design-build project delivery method, and the contractors are grade 1 general contractors. Every project involves the participation of three grade-one general contractors and three clients for all three projects. This implies that a single contractor works on a single project. For each of the three active public building projects, two grade-one experts for Cinema Complex and

FHC Mixed Apartment Building projects were providing consultation. But for the Kolfe Keranyo General Hospital Building Project, the Ethiopian construction design and supervision works corporation building design and supervision works sector (ECDSWC, BUDSWS), was providing consultation.

Table 4.2 Description of projects

No.	Project	Estimated budget	Contracting date (E.C)	Duration (days)	Building type
1	Kolfe Keranyo General Hospital Building Project (buildings)	3,237,988,157.12	Jul 2/2021	730	DB
2	Cinema Complex	980,669,422.41	June 6/2023	335	DBB
3	FHC Mixed Apartment Building	1,863,141,858.487	Dec 29/2020	1,305	DBB

Source, own survey 2024

4.5 Cost and Schedule Performance Assessment with EVA

During the assessment of project advancement, it's crucial to pinpoint the planned value, actual cost, and earned value or completion percentage of tasks outlined in the collected documents for analysis. Subsequently, the projects' effectiveness was assessed by comparing the real and completed activities in accordance with the schedule. Cost performance assessment using Earned Value Analysis (EVA) provides a comprehensive evaluation of how well a construction project is adhering to its budget. EVA integrates project scope, schedule, and cost variables to offer detailed insights into project performance. This section focused on the application of EVA to assess the cost performance of selected public building construction projects in Addis Ababa.

The difference between the current project and the anticipated project is determined by the schedule variance. When computing schedule variance, numbers enclosed in brackets denote whether they have a positive or negative value. The percentage of schedule variance that is positive indicates the extent to which a project is ahead of schedule, whereas the percentage of schedule variance that is negative indicates the extent to which a project is behind schedule. When a project's worth is zero, everything is proceeding according to plan and on time. This information is used to compute the schedule variance and its percentage for all selected public building projects.

Kolfe Keranyo General Hospital Building Project.

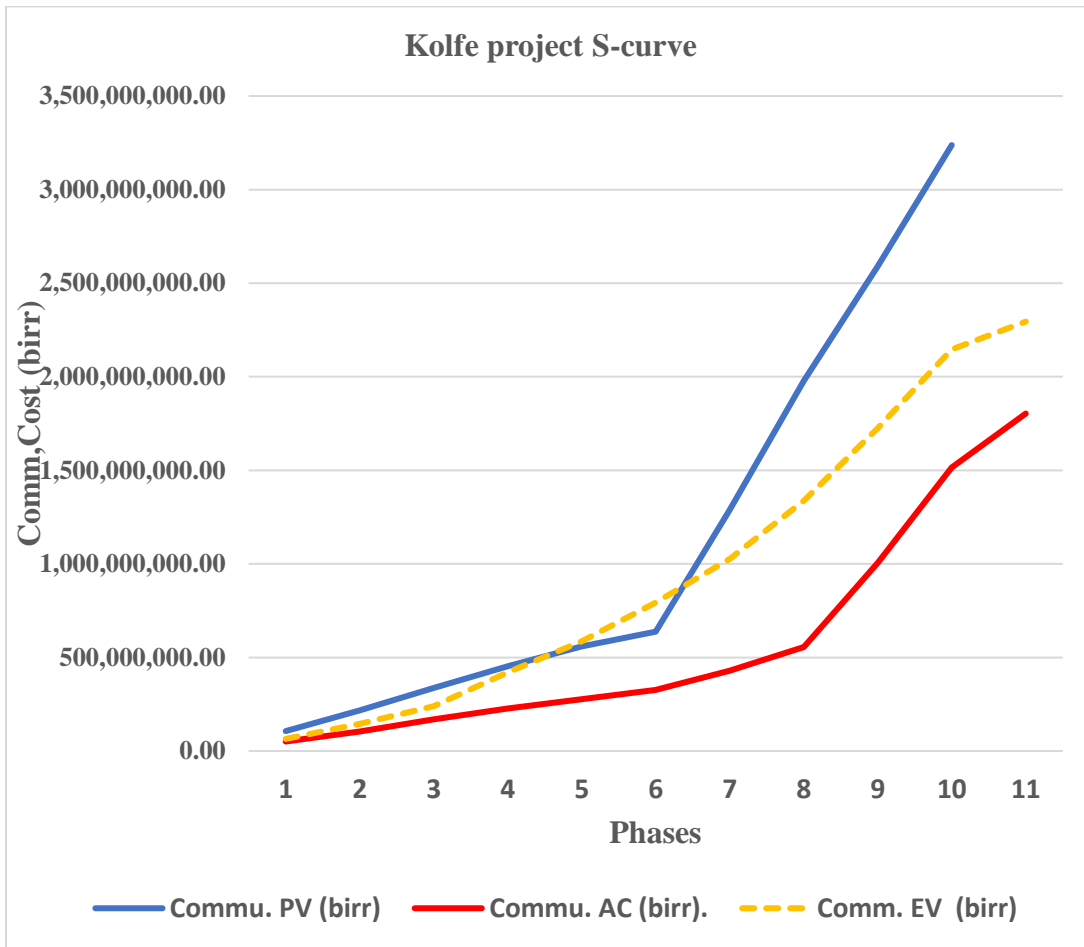
Project Scope: The total area for the project is 33,000 m² and the built-up area is 14,000 m². The general scope of the Project is the construction of general hospital buildings containing 14 Main blocks, Ancillary blocks, Site work, and Fence works. Maximum block size; 2B+G+3. The Project executes civil, electrical, sanitary, and mechanical works.

4.5.1 Cost and schedule Performance Assessment.

Table 4.3 Kolfe Keranyo General Hospital Building Project

Phases	Comm. PV (birr)	Comm. AC (birr).	Comm. EV (birr)
1	106,277,639.19	50,836,896.20	64,759,763.14
2	216,646,889.88	104,704,739.20	145,709,467.07
3	337,337,150.48	169,268,528.86	239,611,123.63
4	452,960,731.14	227,636,424.46	420,938,460.43
5	558,659,096.34	276,612,661.36	586,075,856.44
6	637,665,835.00	326,871,351.69	793,307,098.49
7	1,287,746,415.53	428,490,104.05	1,026,442,245.81
8	1,978,150,770.40	554,843,084.31	1,337,289,108.89
9	2,589,840,920.76	1,005,403,348.2	1,724,876,291.30
10	3,237,988,157.12	1,515,640,328.6	2,145,814,751.72
11	-	1,803,338,980.9	2,294,762,206.95

Source, own survey 2024



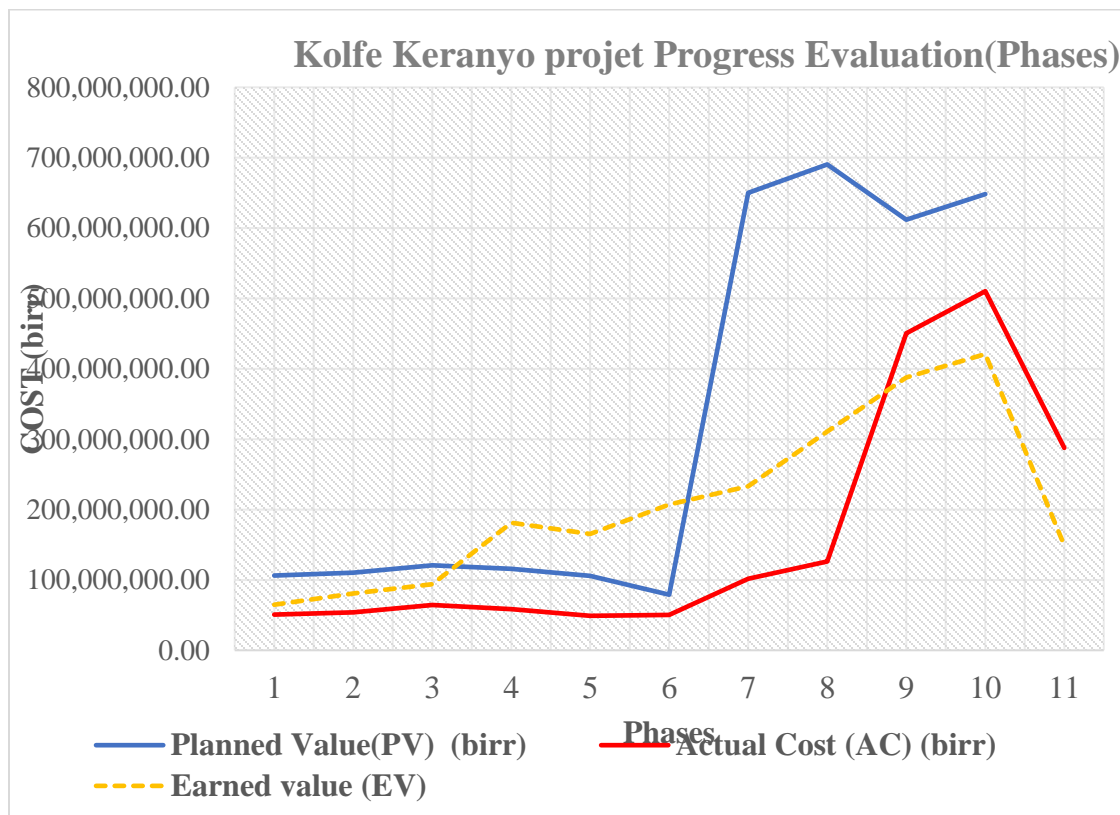
Source, own survey 2024

Figure 4.1: Kolfe Keranyo General Hospital Building S-curve with EV

The project was originally budgeted for 3,237,988,157.12 and was expected to be completed in 730 calendar days. The project's cost was 2,746,564,931.14 birr at the time which indicates that the projects was under budget while data was collected, and there was a 29% delay in the schedule. The above Fig 4.1 clarifies the schedule status of this project. It showed that the project was under budget. But, the status of the project's schedule is also made clear by the above chart. It indicates that the project was not finished on schedule time and the ultimate cumulative completion percentage up to phase 11 was 70.20 % only. Both the earned and actual cost graph lines extended beyond the planned graph line. This shows that the project was not completed according to the planned schedule.

Fig 4.1 showed that starting from Phase 1 up to Phase 4 and from Phase 7 up to Phase 10 (each phase consists of 3 months), the project's cumulative planned value was more than it was earned from the outset, indicating that the project is behind the schedule in these phases. In Phase 5 and

Phase 6, the planned cost was laid below the earned cost which indicates that the project was ahead of the schedule. In all phases, the actual cost lay below the earned cost showing that the project is under budget. In the first three phases i.e. phase 1, phase 2, and phase 3, the graph is almost linear and there was a little gap between the graphs. The graph showed that the project's cumulative actual and earned value costs are shown in detail, which indicates that the project's actual cost (AC) and earned value costs were far apart starting from phase 4 up to phase 11. According to the chart shown above, Phase 8 and Phase 9 exhibited good cost performance with actual costs much lower than planned. The lowest cost difference was scored at the end of phase 1 i.e. 13,922,866.94 birr and the maximum cost difference was scored at phase 8 i.e. 782,446,024.58 birr.



Source, own survey 2024

Figure 4.2: Kolfe Keranyo General Hospital Building progress evaluation in different phases.

As shown in Fig 4.2 progress evaluation curves showed that each phase preview of planned, actual, and earned value. Excluding phase 4, phase 5, and phase 6 on the graph, the planned value is laid over both actual cost (AC) and earned value (EV). On the chart above phase 1, 2, 3, 4, 5, 6, 7, and phase 8, the actual cost (AC) is laid under earned value (EV). This could indicate that the project has incurred lower costs than anticipated. On the other hand, the actual cost (AC) is laid over the earned value at phases 9, 10, and 11 which indicates that the project has incurred a higher cost than

expected. Over the minimum negative cost difference was scored at phase 9 i.e. 62,973,081.56 birr, which describes the potential cost overruns. The maximum positive cost difference was scored at phase 8 i.e. 184,493,882.82 birr which indicates that the project's actual cost (AC) lay under planned. Generally, it specified that this project was under budget and behind schedule up to the last month the data was collected. As shown above, on the graph the maximum difference between the planned and earned value occurred at phase 7.

The above figure also clarified the schedule status of this project. It indicated that the planned value of the project cost was up to phase 10 i.e. 730 days only. As per EVA analysis results, this project is estimated to be completed beyond the planned timeline and not 18 months as planned before. Both earned and actual costs were stretched further into phases 11, and 12 which means the project to executed away from the scheduled date i.e. the construction project was extended from the scheduled time. Generally, it specified that this project was over budget and behind the schedule up to this data was collected.

4.5.2 Cost variance (CV) and cost variance percentage (CV %)

The cost variance and its corresponding percentages are computed and examined separately for each ongoing building construction project in the case study. Cost variance represents the variance between earned value and actual cost at a specific phase or time. The percentage reflects the ratio of the total cost variance to the total earned value of the project. There exists a direct correlation between the cost variance and its associated percentages. The cost variance and percentages were explicitly outlined in Table 4.5 below for the Kolfe Keranyo General Hospital Building Project.

Table 4.4 Kolfe Keranyo General Hospital Building Project cost variance.

Phases	Cost variance (CV)
1	13,922,866.94
2	27,081,860.93
3	29,337,866.90
4	122,959,441.20
5	116,161,159.11
6	156,972,551.73
7	131,516,394.95

8	184,493,882.82
9	(62,973,081.56)
10	(89,298,519.97)
11	(138,751,197.07)
sum	491,423,225.98
CV%	21%

Source, own survey 2024

Throughout the project, cost variances occurred in each stage. Initially, according to figure 4.4, the conclusion of phases 1, 2, 3, 4,5,6,7, and 8, the project exhibited a positive cost variance in which the maximum cost variance is scored at phase 8 i.e. 184,493,882.82 Birr, which appeared 6% compared to the budgeted construction cost of 3,237,988,157.12 Birr, indicating that actual costs were less than projected at these stages and the work executed was less than the actual planned. However, in phase 9, 10 and phase 11, the project's cost variance turned negative. These cost variances suggest that the project's actual cost (AC) exceeded its budget during those phases. By the end of phase 11, the cost variance amounted to a significant negative figure of 138,751,197.07 Birr, marking the highest negative variance across all phases.

The cost variance did, however, turn negative when phases 9, 10, and 11 got underway, suggesting that the project was going over budget. All cost variations from the project's start to the completion of the designated phases were combined to calculate these discrepancies. Overall, the project's cost variance percentage was 21% less than the project's initial budgeted cost, with a positive variance of 491,423,225.98 birr suggesting that the project is under budget up to phase 11.

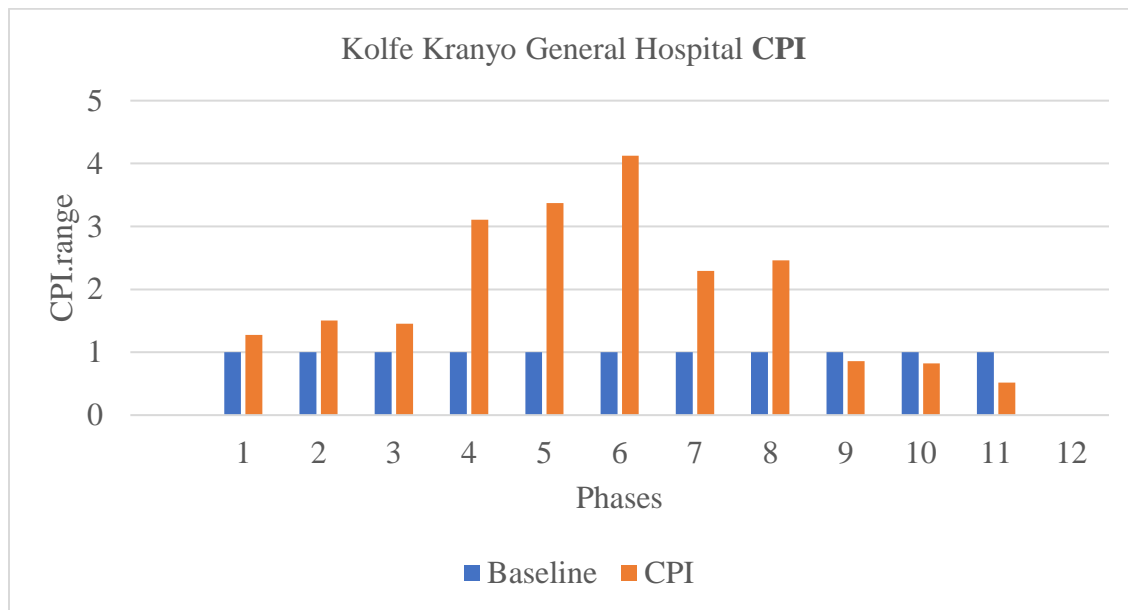
4.5.3 Cost performance index (CPI)

The efficiency of project usage is shown by the cost performance index. It needs to be one or higher in the best-case scenario. Nevertheless, the number of projects that were reviewed was less than one, indicating that the project's cost efficiency was low concerning their spending. The cost performance index is outlined in Table 4.7 below for the Kolfe Keranyo General Hospital Building Project

Table 4.5: Kolfe Keranyo General Hospital Building Project CPI

Phases	Cost performance index (CPI)
1	1.27
2	1.50
3	1.45
4	3.11
5	3.37
6	4.12
7	2.29
8	2.46
9	0.86
10	0.82
11	0.52
Average	1.98

Source, own survey 2024



Source, own survey 2024

Figure 4.3: Kolfe Keranyo General Hospital Building Projects CPI.

As indicated in Figure 4.3 and Table 4.7 starting from Phase 1 up to Phase 8 have a CPI above 1, indicating that the project was under budget in those phases. Phase 6 stands out with a significantly high CPI of 4.12, suggesting that it's highly efficient in managing costs.

Values of the cost performance index less than 1.0 denote poor cost performance, which may be discussed later in section 4.8. Phase 11 had the lowest CPI among all phases, indicating significant cost overruns. This phase had a CPI of 0.52, and it was over budget by 48%, highlighting potential cost management challenges. Similar to Phase 9 and Phase 10 also had a CPI below 1, indicating that it was over budget by 14% and 18% respectively.

The specific factors contributing to the exceptional cost performance observed in these phases and the challenges faced in phases with cost overruns will be discussed in section 4.8. Additionally, exploring the impact of these cost performance variations on project outcomes and stakeholders' perceptions could provide valuable insights for project management practices. The average CPI across all phases is 1.98, indicating the overall efficient cost performance of the project.

4. 5.4 Schedule Variance (SV) and SV Percentage (SV %).

Table 4.6: Schedule variance for the Kolfe Keranyo General Hospital Building Project.

Phase.	SV
1	(41,517,876.05)
2	(29,419,546.76)
3	(26,788,604.04)
4	65,703,756.14
5	59,439,030.81
6	128,224,503.40
7	(416,945,433.22)
8	(379,557,491.79)
9	(224,102,967.95)
10	(227,208,775.93)
11	148,947,455.23
sum	(943,225,950.16)
SV %	(29%)

Source, own survey 2024

The project was ahead of schedule for the four phases, as evidenced by the positive schedule variations at the end of phases 4, 5, 6, and 11, as indicated in table 4.6. It was behind schedule, as evidenced by the negative schedule variance for the other phases. The cost of the works completed in the four phases exceeded the planned budget, especially at phase 11, i.e. 148,947,455.23 birr, when there was a larger positive difference between the project's earned value cost and planned cost than in any previous phase.

However, during the remaining eight phases, the schedule variances were consistently negative. The lowest negative value, indicating the minimum schedule variance, occurred at the end of the third phase, amounting to a numerical negative value of 26,788,604.04 birr. Conversely, the highest schedule variance was observed at the end of phase 7, amounting to a numerical negative value of 416,945,433.22 birr. This variance in the seventh phase exceeded the originally planned project cost by 12.90%. To calculate these variances, the schedule variances from the project's initiation to the end of the specified phases were aggregated. Once again, the sum of the schedule variances resulted in a negative value, indicating an overall project negativity of 943,225,950.16 birr. Furthermore, the project's variance percentage lagged behind the originally planned project duration by 29%. These findings suggest that the project requires corrective actions and adjustments to enhance its performance. Therefore, the project was behind planned time for the first 3 months and the last 4 months.

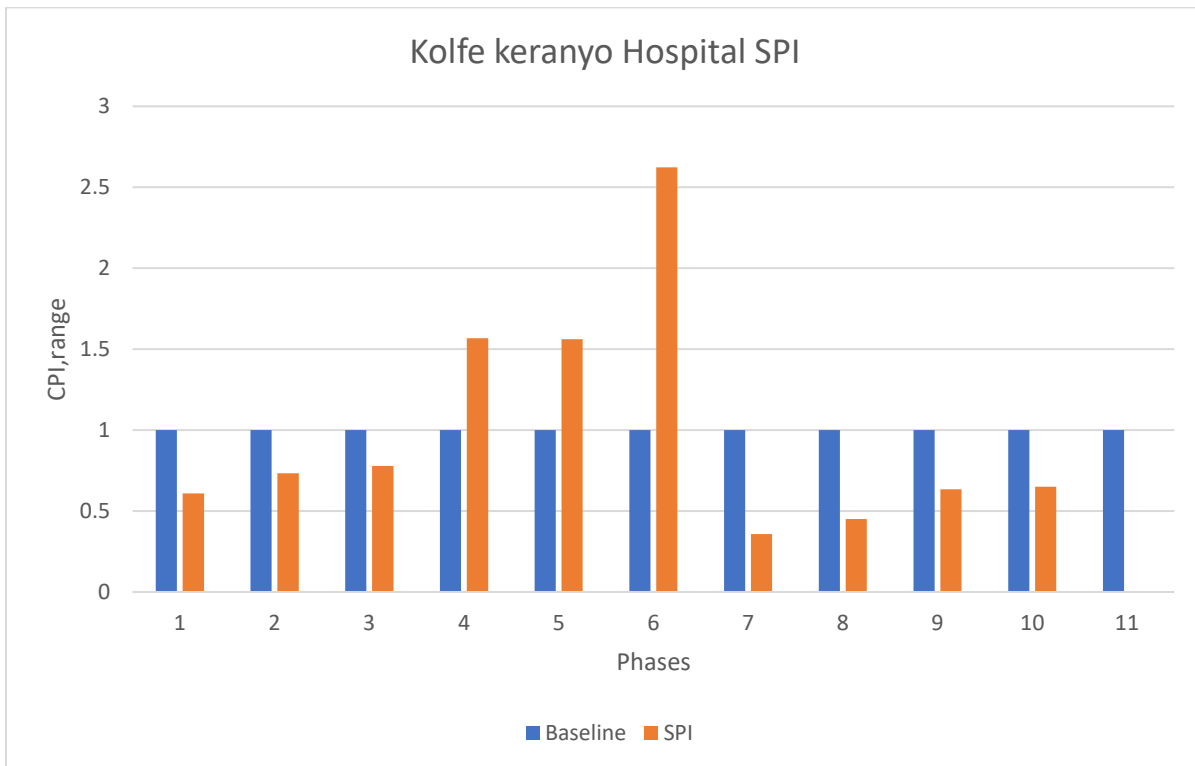
4.5.5 Schedule performance index (SPI)

Projects with SPI ratings greater than 1.0 are running ahead of time. Project progress may exceed expectations if the initial production rates were too low or if the real working conditions exceed expectations. There might be more workers working on the project than anticipated, which would mean that it is finishing earlier than planned. SPI equals 1.0, indicating that the project is on schedule. When the SPI is less than 1.0, it means that the project is running behind schedule. The project schedule may slide due to a variety of reasons, including weather delays, understaffing, messy work, and others. The Schedule performance index outlined in table 4.6 below for Kolfe Keranyo General Hospital Building Project.

Table 4.7: Kolfe Keranyo General Hospital Building Project SPI

Phases	Schedule performance index (SPI)
1	0.61
2	0.73
3	0.78
4	1.57
5	1.56
6	2.62
7	0.36
8	0.45
9	0.63
10	0.65
11	-
Average	0.91

Source, own survey 2024



Source, own survey 2024

Figure 4.4: Kolfe Keranyo General Hospital Building Project SPI.

As can be seen in Figure 4.4 and Table 4.7, the project's timetable performance index ended in all phases except phases 4, 5, and 6, the project's schedule performance index value was behind schedule and below baseline, at the end of each phase. Schedule performance indices below line one indicated that the project was running behind schedule in each of the last seven phases.

The project received an SPI of 1.56, 1.57, and 2.62 at the end of phases 4, 5, and 6 respectively, as shown in the graph and table above, for earning a value that was higher than the estimated cost. The fact that the schedule performance indices for the three phases mentioned above were higher than line one meant that the project was progressing faster than the average CPI of 0.91 % for the planned phases. This shows that 0.91% of the project's planned work was completed for every birr of work that was planned.

In summary, for the project, the figure showed that 2.62 % of the work was completed at phase 6. Showing significant improvement, indicating the project is well ahead of schedule. Even though the average SPI across all phases is 0.91, indicating that, on average, the project is slightly behind schedule.

4.5.6 Cost Forecasting.

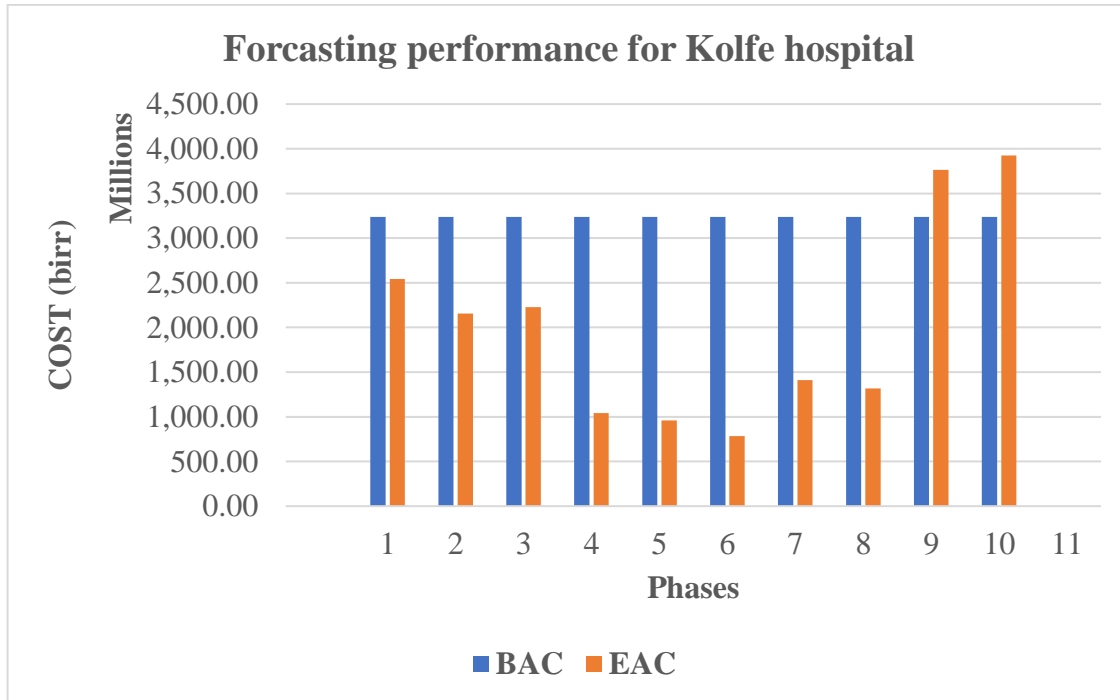
Future cost and schedule performance can be predicted via project performance forecasting throughout the project's development stage.

Table 4.8: General Hospital Building Projects Forecasted Cost by Phases

Phases.	BAC	EAC
1	3,237,988,157.12	2,541,844,810.09
2	3,237,988,157.12	2,154,713,719.95
3	3,237,988,157.12	2,226,337,574.40
4	3,237,988,157.12	1,042,283,849.99
5	3,237,988,157.12	960,318,370.61
6	3,237,988,157.12	785,292,036.39
7	3,237,988,157.12	1,411,371,560.57
8	3,237,988,157.12	1,316,176,877.72
9	3,237,988,157.12	3,764,079,064.05

10	3,237,988,157.12	3,924,899,849.19
11	-	
Average		1,634,594,981.86

Source, own survey 2024



Source, own survey 2024

Figure 4.5: General Hospital Building Projects Forecasted Cost by Phases.

Although the revised budget at completion was approximately 3,237,988,157.12 billion Birr, the projected parameter of Estimate at Completion was roughly 1,634,594,981.86 billion Birr based on the project's average performance index. The EAC was computed using a scale of future cost performance based on actual performance to date. It scales future cost performance based on actual performance to date. At this point, the project will be completed with a total amount increased by the VAC value of 1,603,393,175.26 billion because the VAC, which is the difference between the BAC and the EAC, is positive.

The project's estimated total cost at completion (EAC) was higher than expected for Phase 9, and phase 10 due to lower project completion than anticipated, as shown by the above chart and table. The highest estimate, 3,924,899,849.23 birrs, or a 121% divergence from the initial cost, was made at the end of phase 10 and the lowest forecasting estimate was scored at phase 6 which is 785,292,036.39 birr or 21% from budgeted cost of the project. In Phase 1 up to Phase 8, EAC was

lower than BAC, suggesting that the project continues to be under budget or at least on track financially. Overall, the project is experiencing significant cost underruns in the above-mentioned phases, but there are cost overruns in the later phases, particularly in Phases 9 and 10. The project's cumulative budget was 3,237,988,157.12 birr, while the average projected cost came in at 1,634,594,981.86 birr. This indicates that the project would be completed for the amount allocated budget.

FHC Mixed Apartment Building Project.

The function of this project is Ethiopia (FHC) Mixed Apartment project (3B+G+23), with 3 floors underground and 23 floors above ground. It was owned by the Federal housing corporation and constructed by China Communications Construction Company (LTD).

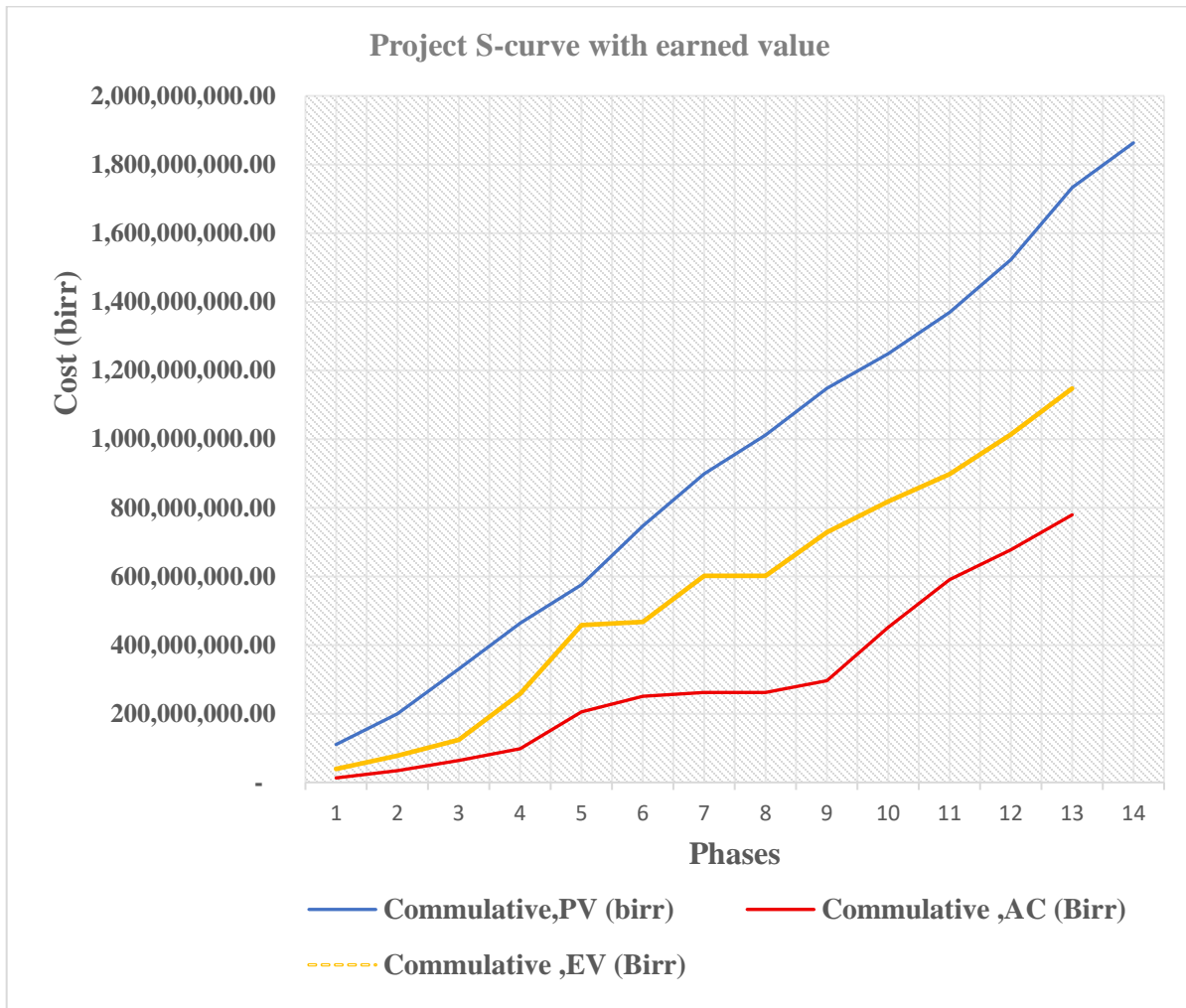
4.5.7 Cost performance assessment.

It's critical to determine the earned value, actual cost, and planned value (or completion %) of the tasks listed in the gathered papers for examination during the project progression evaluation. The cost performance assessment of FHC Mixed Apartment project were discussed by using EVA.

Table 4.9 FHC Mixed Apartment Building Project.

Phases	Commu. PV (birr)	Commu. AC (birr).	Commu.EV (birr)
1	110,360,780.20	13,005,688.47	39,125,979.03
2	200,123,120.89	34,322,976.41	77,506,701.31
3	330,903,357.67	64,012,136.74	123,712,619.40
4	463,574,852.45	97,657,963.59	257,814,234.94
5	575,944,212.57	205,180,527.80	458,288,298.91
6	747,399,895.16	251,310,261.69	467,889,817.13
7	899,236,066.86	262,355,165.27	602,036,030.95
8	1,011,414,936.52	262,355,165.27	602,036,030.95
9	1,148,377,296.88	296,005,659.15	728,729,677.32
10	1,248,746,659.09	451,625,768.35	818,372,637.02
11	1,369,437,020.45	590,186,652.82	897,556,166.00
12	1,522,579,802.58	677,818,788.15	1,013,447,534.37
13	1,732,901,493.18	779,497,648.36	1,147,593,748.18
14	1,863,141,858.49	-	-

Source, own survey 2024

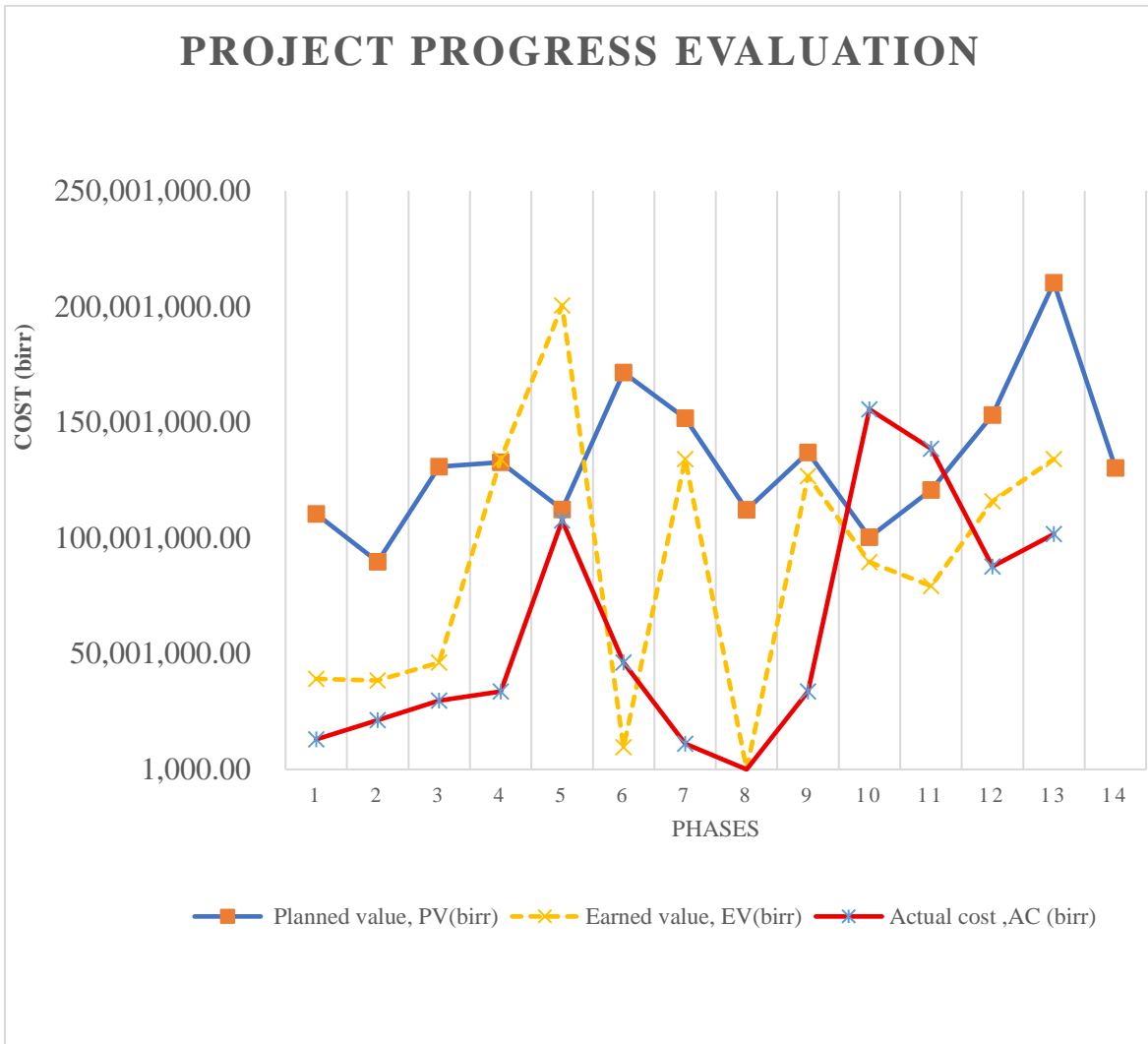


Source, own survey 2024

Figure 4.6: FHC Mixed Apartment Building S-curve with EV

As shown in Figure 4.6, the project in question had a budget of 1,863,141,858.49 Birr and a completion date of 1,305 calendar days according to the revised schedule. The costs versus phases are shown by this S-curve. This building project is underway at the moment. Only 66.68% of the project's total work had been finished after the preceding month's data collection period, despite the project's scheduled completion of 90.7% i.e. it was late about 24.2% from planned completion. As seen in above figure 4.6, the project's budgeted cost was at the very top of both criteria (actual and earned value costs). According to the figure, the project's detailed cumulative actual and earned value cost chart also showed that the project has consistently maintained a higher EV compared to AC in all phases, which is a positive indication that the project is still performing well financially. The s-curve showed that at the end of the 9 phases i.e. 432,724,018.18 birr, the biggest cost difference was recorded and the minimum cost difference was recorded at phase 1 which is 26,120,290.56 birr. As we saw from the above figure, the actual cost of the project remains

constant at Phases 7 and Phase 8 i.e. 602,036,030.95 birr showing that there was no work performed on phase7 in the project.



Source, own survey 2024

Figure 4.7: FHC Mixed Apartment Building progress evaluation in different phases.

As depicted in Figure 4.7, the planned cost of the project surpassed both the actual cost and the earned value from the end of Phase 1 through Phase 4, from Phase 6 through Phase 9, and from Phase 11 through Phase 14. This indicates that during these phases, the project was behind schedule. However, in phase 5, the earned value surpassed both the actual and planned costs, with a cost difference of 253,107,771.11 birr indicating that the project was under budget and ahead of schedule. Additionally, the graphs of the planned cost and actual cost were nearly identical. The graph also showed that the actual cost and earned cost were zero at phase 8 (Dec-22, Jan-23, Feb-23) indicating that the project work was stopped due to the reasons discussed in the next section 4.8. In phases 6, 10, and 11 the actual cost was laid above the earned cost of the project and the

cost the maximum negative cost difference scored at phase 10 i.e. 65,977,149.5 birr, shows the project performance is over budget at the phases. The maximum positive Cost difference was scored at phase 7 i.e. 123,101,310.24 birr and the minimum cost was ranked as zero at phase 8. Generally, it specified that this project was under budget and behind schedule.

4.5.8 Cost variance (CV) and cost variance percentage (CV %).

Table 4.10 FHC Mixed Apartment Building Project cost variance.

Phase	Cost variance (CV)
1	26,120,290.56
2	17,063,434.34
3	16,516,757.76
4	100,455,788.68
5	92,951,499.77
6	-36,528,215.67
7	123,101,310.24
8	-
9	93,043,152.50
10	-65,977,149.51
11	-59,377,355.49
12	28,259,233.04
13	32,467,353.60
14	-
sum	368,096,099.82
CV%	32%

Source, own survey 2024

In this project, cost variances were happened every phase of the project. As table 4.10 illustrated, the project's cost performances at the end of the phase 1 up to 5, and 7, 9, 12, and 13 was numerically positive, indicating that the project was under budget in these phases. However, the cost performances were numerically negative at the conclusion of the phase 6, 10, and 12 phases, indicating that the project actual cost had exceeded its budget cost meaning that the project was over budget in this phase. The maximum negative cost performance received a numerical score of 65,977,149.51 Birr at phase 10 indicates that the project was over budget, while the maximum positive cost performance received a score of 123,101,310.24 Birr at phase 7, showing the project

is significantly under budget. This phase may have been executed very efficiently in terms of project's cost performance. In the first five phases the project was at good performance. The table shows that Phase 8 the project's cost variance was zero, indicating that the project activity was not executed, and there were no actual costs incurred during this phase due to different reasons as discussed in section 4.8.

For this project, the cost variance was generally positive for the 10 phases, indicating that actual costs were lower than earned value costs. Similarly, this positive variance meant that the project was under budget for these phases, but the cost variance turned negative for the 3 phases, indicating that the project was over budget. Overall, the project has a cumulative CV of 368,096,099.82, which is positive, indicating that the project is under budget by this amount. The CV% of 32% indicates that the project is significantly under budget relative to its total budget.

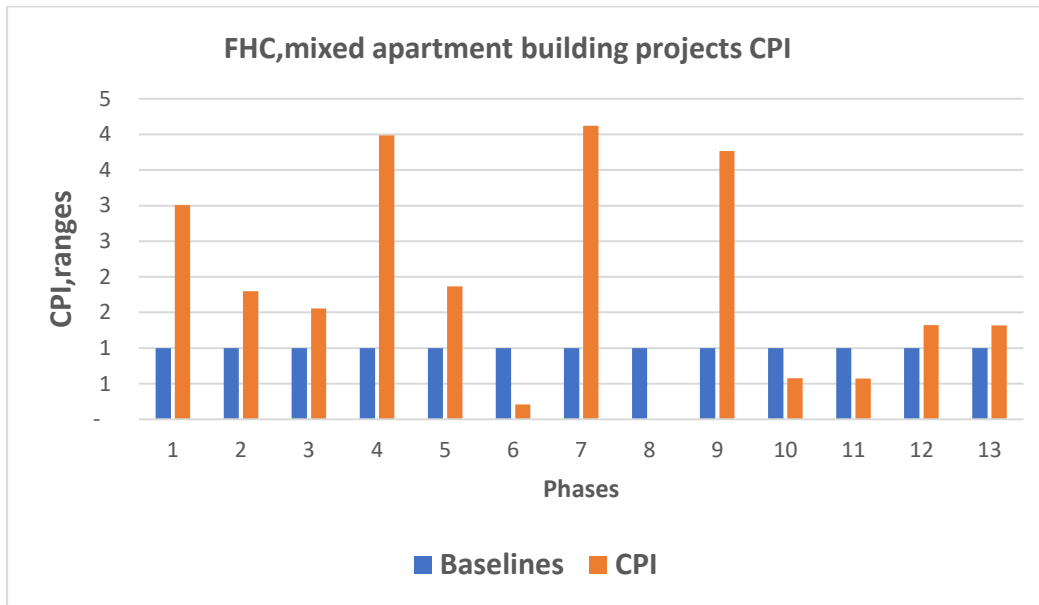
4.5.9 Cost performance index (CPI)

CPI is a measure of the cost efficiency of budgeted resources, expressed as a ratio of earned value to actual cost. It is considered the most critical EVM metric and measures the cost efficiency for the work completed. A CPI value of less than 1.0 indicates a cost overrun for work completed. A CPI value greater than 1.0 indicates a cost underrun of performance to date. A CPI for the FHC Mixed Apartment Building Project will be discussed as shown in Table 4.13

Table 4.11: FHC Mixed Apartment Building Project CPI

Phases	Cost Performance Index (CPI)
1	3.01
2	1.80
3	1.56
4	3.99
5	1.86
6	0.21
7	4.12
8	0
9	3.76
10	0.58
11	0.57
12	1.32
13	1.32
14	-
Average	2.47

Source, own survey 2024



Source, own survey 2024

Figure 4.8: FHC Mixed Apartment Building Project CPI.

According to Figure 4.8 and the table above, there were ups and downs in the project's overall cost performance indices regarding line one. Phases 1 up to phase 5, and phase 7, phase 9, phase 12, and phase 13 phases, the project's cost performance was positioned over the control line. During the remaining four phases, the project failed to achieve cost performance, and overall, it received scores below the control line, ranging from a minimum of 0 to a maximum of 0.58. Phase 1, phase 4, phase 7, and phase 9 have a very high CPI, i.e., 3.01, 3.99, 4.12, and 3.76, respectively, indicating that it is significantly under budget. Phase 8 has a CPI of 0, indicating that there is no progress against the budget, due to no work being performed.

A project's cost performance is considered good when the cost performance index value is higher than 1.0. If real productivity exceeds expectations or if the percentage of work completed is excessively high, good cost performance might be shown. A cost performance index value of less than 1.0 denotes subpar cost performance, which could be the consequence of lower productivity than anticipated or an underestimate of the measured percentage of work accomplished.

In summary, most phases of the project were under budget, with some phases (e.g., Phases 1, 4, 7, and 9) performed significantly better than others. Phases 6, 10, and 11 are over budget, and Phase 8 had no progress against the budget. The average CPI of 2.47 indicates that, on average, the project was under budget. This is because the average is greater than 1.

4.5.10 Schedule Variance (SV) and SV Percentage (SV %)

Table 4.12: Schedule variance for FHC Mixed Apartment Building Project

Phase.	SV
1	(71,234,801.17)
2	(51,381,618.41)
3	(84,574,318.69)
4	1,430,120.75
5	88,104,703.85
6	(161,854,164.36)
7	(17,689,957.89)
8	(112,178,869.67)
9	(10,268,713.98)
10	(10,726,402.52)
11	(41,506,832.37)
12	(37,251,413.76)
13	(76,175,476.79)
14	-
sum	(585,307,745.00)
SV %	(31%)

Source, own survey 2024

The schedule variance (SV) for Phase 4 and phase 5 were positive, indicating that the project was ahead of schedule during these phases, as can be seen by looking at the table 4. 12. In these two phases, earned value cost exceeded the project's planned cost, particularly at the conclusion of the phase 5, when the difference between the project's earned value cost and planned cost had a larger positive value than it had other phases. Comparatively speaking, more than 80M difference has occurred with phase 4. However, except phase 4 and phase 5, the schedule variance turned negative, suggesting that the project was running behind schedule.

The schedule variations were, nevertheless, below the zero line for the other 11 phases. By 10,268,713.98 Birr, the least negative value or schedule variation was scored at the end of the phase 9. Similarly, the largest negative schedule variance was scored by 161,854,164.36 Birr at the end of the phases 6. This phase 6 variation exceeded the project's initial budget by 9%. To determine the variance, all schedule deviations from the start of the project until the completion of the phases under consideration were added together. Once more, the total of the schedule deviations was negative. There was 585,307,745.00 birr negative and the summation percentage of schedule variance was done and scored 31% behind planned time. Therefore, the project was behind planned time for the last 11 phases and the project now needs to be adjusted and corrected.

4.5.11 Schedule performance index (SPI)

Table 4.13: FHC Mixed Apartment Building Project SPI

Phases	Schedule Performance Index (SPI)
1	0.35
2	0.43
3	0.35
4	1.01
5	1.78
6	0.06
7	0.88
8	0
9	0.93
10	0.89
11	0.66
12	0.76
13	0.64
14	
Average	0.67

Source, own survey 2024



Source, own survey 2024

Figure 4.9: FHC Mixed Apartment Building Project SPI.

As seen in the table and chart above, the project was ahead of schedule at the end of the phase 4 and phase 5, but this schedule performance result could not be carried over to other phases. At the end of phase 4 and phase 5, the schedule performance index value was above the control line of 1, which indicates that the project's earned value cost was above the planned cost and Phase 4 has an SPI very close to 1 i.e. 1.01, indicating it is nearly on schedule while Phase 5 is well ahead of schedule, with an SPI 1.78. Following that, the project lagged behind schedule for all 11 phases, with the schedule performance index being less than 1. Phase 9 is slightly behind schedule but with a better SPI compared to some earlier phases. The project's schedule performance index was zero at the end of the 8th phase, indicating that no work has been executed against the planned schedule due to various reasons discussed in section 4.6.

In summary, most phases of the project were behind schedule, with only Phase 4 being on schedule and Phase 5 being ahead of schedule. Phase 8 has an SPI of 0, indicating that there is no progress against the schedule for this phase. Within the planned phases, the average schedule performance index was 67%. This indicates that 0.67 birr of work was completed for every birr that the project was supposed to complete.

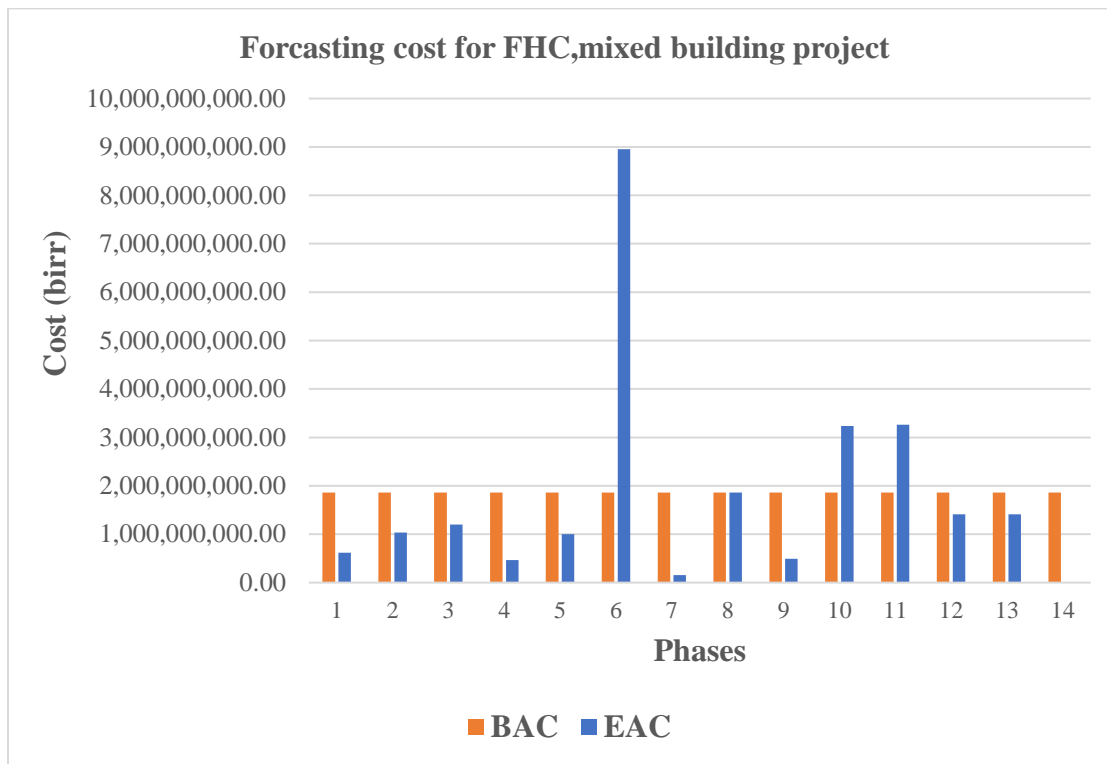
4.5.12 Cost Forecasting

As the project progresses, the project team may develop a forecast for the Estimate at completion (EAC) that may differ from the budget at Completion (BAC) based on the project performance. Forecasting the EAC involves making projections of conditions and events in the project’s future based on current performance information and other knowledge available at the time of the forecast. Forecasts are generated, updated, and reissued based on work performance data that is provided as the project is executed. The work performance information covers the projects past performance and any information that could impact the project in the future.

Table 4.14: FHC Mixed Apartment Building Project Forecasted Cost in phases

Phases.	BAC	EAC
1	1,863,141,858.49	619,318,498.61
2	1,863,141,858.49	1,034,819,802.97
3	1,863,141,858.49	1,197,143,561.60
4	1,863,141,858.49	467,458,562.10
5	1,863,141,858.49	999,280,336.49
6	1,863,141,858.49	8,951,317,502.56
7	1,863,141,858.49	153,401,438.54
8	1,863,141,858.49	1,863,141,858.49
9	1,863,141,858.49	494,860,204.12
10	1,863,141,858.49	3,234,412,835.85
11	1,863,141,858.49	3,260,256,105.34
12	1,863,141,858.49	1,408,828,817.70
13	1,863,141,858.49	1,412,206,391.81
14	1,863,141,858.49	-
Average		753,996,848.68

Source, own survey 2024



Source, own survey 2024

Figure 4.10: FHC, mixed building Projects Forecasted Cost in phases.

The data showed significant variations in the EAC across different phases of the project, with some phases indicating substantial overruns and others demonstrating underruns. These variations were due to different factors as can be discussed in next section 4.6.

The project's cost during the phase 6, phase 10, and phase 11 phases of the EAC was more than the BAC suggesting potential cost overruns in these phases, as shown by the above chart and table. At the end of the 6th phase, the maximum estimation was made, or 8,951,317,502.56 birr, a 380% variation from

Original cost. The project's estimated cost upon completion of the 8th phase matched the project's budget i.e. 1,863,141,858.49 and this phase is projected to be completed exactly as initially budgeted. Phases 4 and 7 showed a considerable difference between BAC and EAC, indicating that these phases were projected to be significantly under budget i.e. 467,458,562.10 and 153,401,438.54 birr respectively. The project's expected completion cost after the 13th phase was 1,412,206,391.81birr, which was (24%) less than what was originally estimated. Except for three phases, every phase's estimated completion costs were under the allocated completion costs. The project's overall estimated cost was 1,863,141,858.49 birr, compared to the project's average

forecasted cost of 753,996,848.68 birr. This indicates that the project would be completed as per the budgeted cost.

Cinema Complex Building Project.

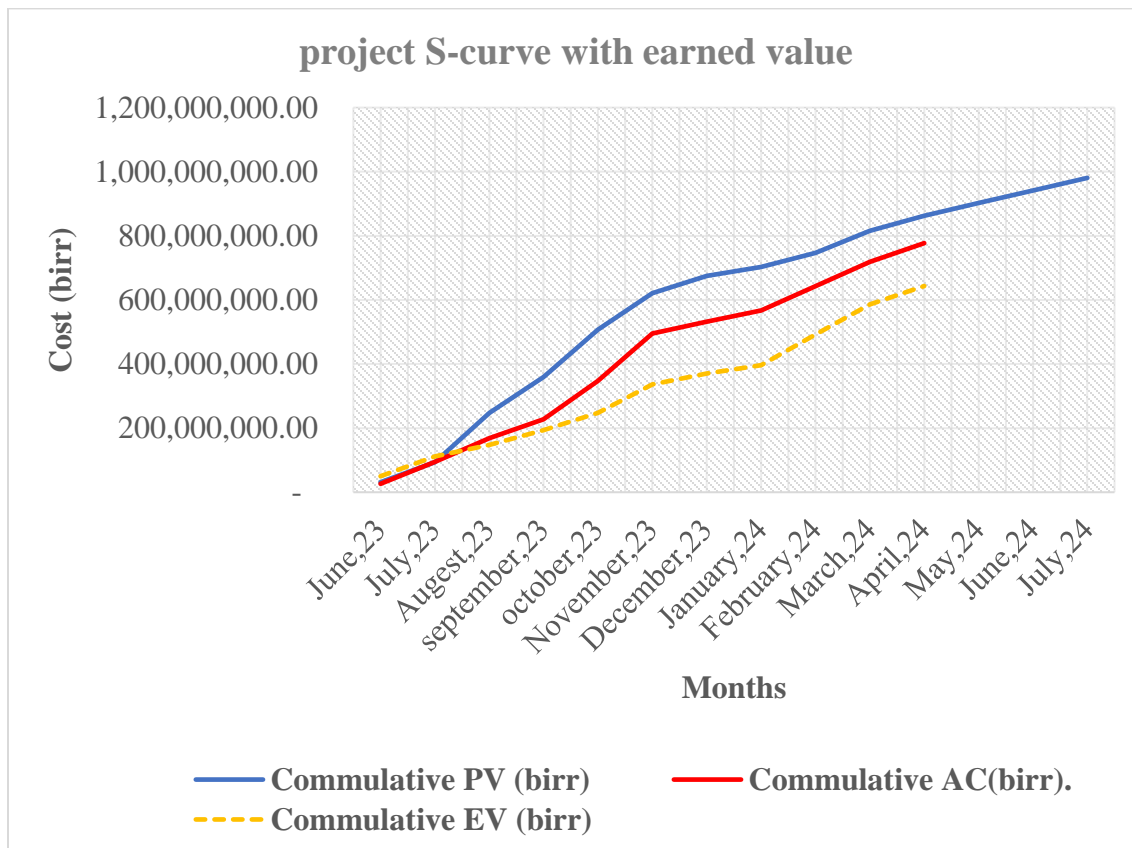
4.5.13 Cost performance assessment.

It's essential to assess the earned value, actual cost, and planned value of the tasks outlined in the collected documents for evaluation during the project's progress assessment. The cost performance assessment of the Cinema Complex Building Project was discussed by using EVA.

Table 4.15 Cinema Complex Building Project.

Months	Commu. PV (Birr)	Commu. AC (Birr).	Comm. EV (Birr)
Jun,23	31,252,978.74	26,301,191.5	50,014,140.54
Jul,23	93,773,878.42	94,435,596.3	111,796,314.15
Aug,23	247,932,816.42	168,391,224.6	148,081,082.78
Sep,23	358,913,780.32	227,583,610.2	193,191,876.21
Oct,23	506,665,575.24	347,796,738.4	247,128,694.45
Nov,23	620,845,258.47	495,177,595.8	336,369,611.89
Dec,23	674,880,370.47	532,468,831.7	370,693,041.67
Janu,24	702,804,370.47	567,119,819.1	396,190,446.65
Feb,24	746,642,143.47	643,422,482.9	492,296,050.05
Mar,24	815,479,916.47	719,140,104.4	586,440,314.60
Apri,24	862,135,504.47	777,133,457.2	643,319,141.10
May,24	902,753,259.15		
June,24	941,073,004.90		
July,24	980,669,422.41		

Source, own survey 2024

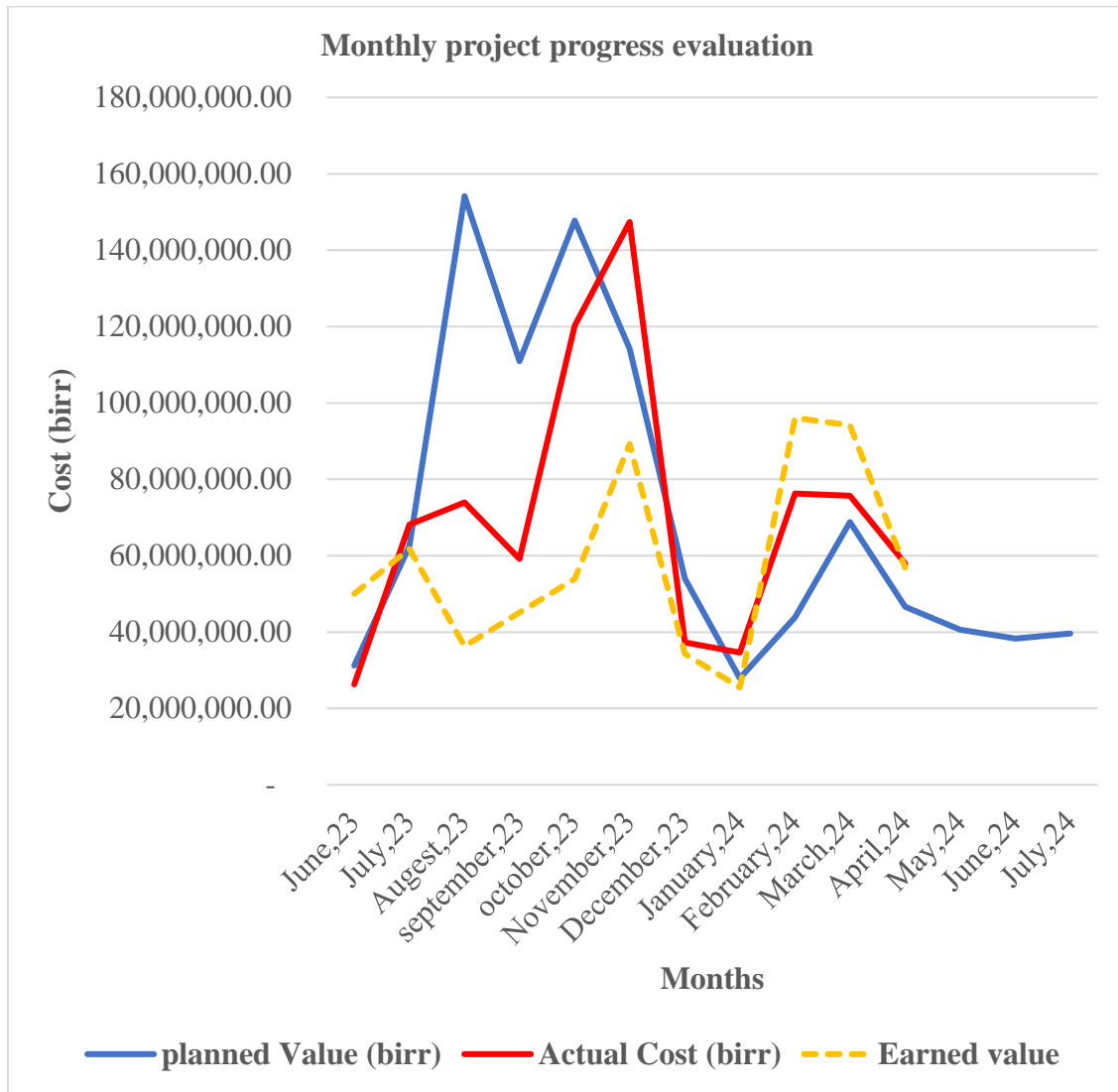


Source, own survey 2024

Figure 4.11: Cinema Complex Building S-curve with EV

According to Table 4.15, the project's cumulative cost was originally estimated to be 980,669,422.41 and took fourteen months to complete. However, for reasons (explained in section 4.6) the project's cost and timeline were increased to 1,114,483,738.60 birr and the duration was delayed by 21%. As shown in Fig 4.11 the actual cost and planned cost were nearly overlapping during for the first and second months, with the earned value exceeding both. This indicates that the project was under budget and ahead of the schedule for these months. The differences between the three curves on the S-curve and the earned value curve were minimal. The project's planned cost was significantly higher than its actual and earned value costs from the end of the third month to the next month. From August 2023 onwards, the project experienced significant budget overruns and schedule delays. The project's actual cost was placed on top of the graphically stated earned value, which had been nearly in the same place until the end of April 2024.

In general, the project initially performed well, being under budget and ahead of schedule in June and July 2023, and From August 2023 onwards, the project faced significant and consistent cost overruns and schedule delays.



Source, own survey 2024

Figure 4.12: Monthly Cinema Complex Building progress evaluation.

Figure 4.12 presents the project's monthly actual and planned costs along with earned value in a transparent manner. The figure illustrated in Jun 2023, Feb 2024, and Mar 2024, earned value laid above both the actual and earned cost. The fact that the actual cost at the end of these months exceeded the earned value showed that the project performance was good. But the project remained over budget in other months. Even though the project planned physical percentage was 75.8 % in April 2024, but it is 65.6% is the total cumulative completion percentage. Overall, the graph indicated that the project was both over budget and behind schedule until the end of April 2024, with work still ongoing.

4.5.14 Cost variance (CV) and cost variance percentage (CV %)

Table 4.16 Cinema complex building Project cost variance.

Months	CV
Jun,23	23,712,949.04
Jul,23	(6,352,231.24)
Aug,23	(37,670,859.67)
Sep,23	(14,081,592.13)
Oct,23	(66,276,309.99)
Nov,23	(58,139,940.01)
Dec,23	(2,967,806.06)
Janu,24	(9,153,582.48)
Feb,24	19,802,939.60
Mar,24	18,426,643.05
April,24	(1,114,526.30)
June,24	-
July,24	-
sum	(133,814,316.19)
CV%	(21%)

Source, own survey 2024

Cost variation occurred throughout the project at every stage. Table 4.16 indicates that, overall, the project's cost variance at the end of Jun23, Feb24, and Mar24 was positive. The maximum positive cost variance was scored as 23,712,949.04 birr on Jun, 23. It shows that the project was moving along as planned at these points. However, the project's cost variance received a numerically minimum negative score of 2,967,806.06 birr at the end of Dec, 23. The maximum cost variance was quantitatively negative at the end of Oct, 23, coming in at 66,276,309.99 Birr, the highest of all the phases.

In June 2023, the project had a positive CV of 23,712,949.04, indicating the project was under budget for that month. However, in the subsequent months, from July 2023 to Jan 2024, the project

incurred over budget as shown by the negative values in the table. The project experienced significant cost overruns during most months, with particularly large negative variances on August 23, October 23, and November 23. Positive variances were recorded in June 2023, February 2024, and March 2024, indicating, periods where the project was under budget.

Generally, the project's cost variance was calculated in birr, and it was found to be 133,814,316.19 birr or 21% of the project's planned duration and it was over the project's budget.

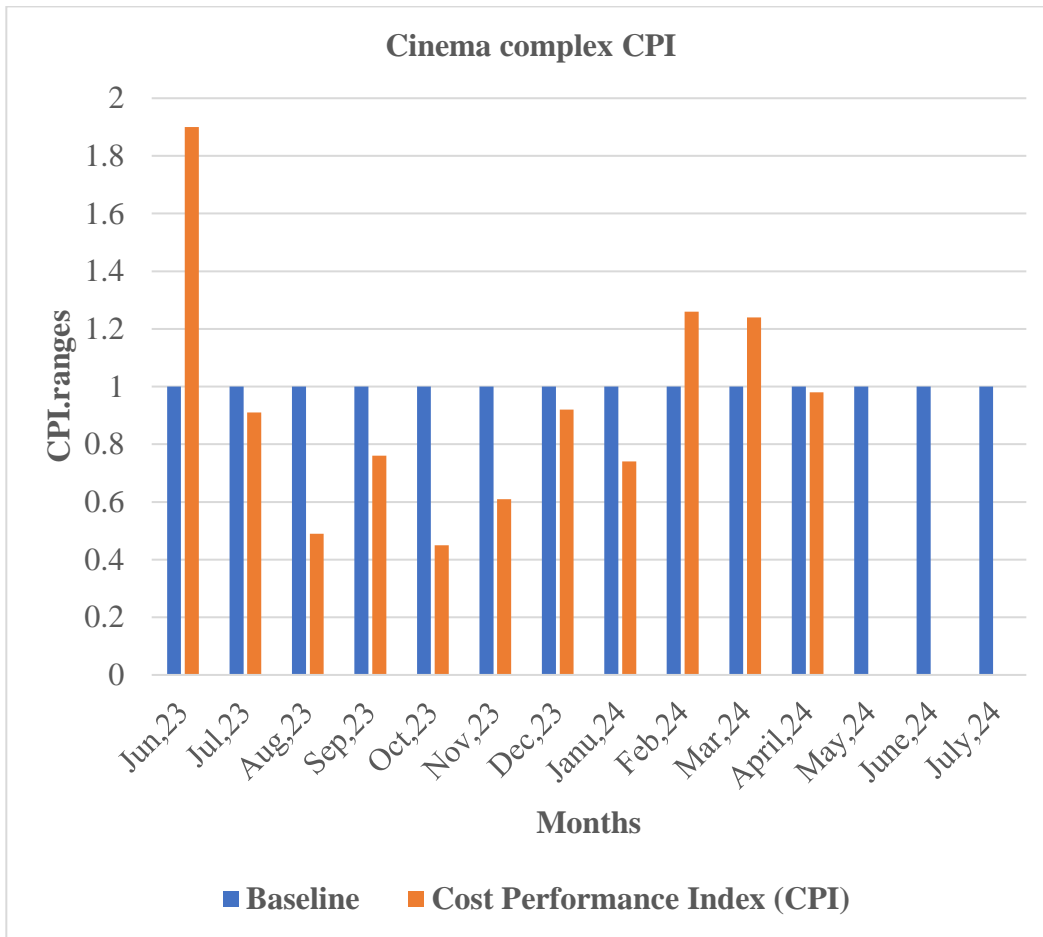
4.5.15 Cost Performance Index (CPI).

Good project cost performance is indicated by cost performance index values greater than 1.0. If the measured percentage of finished work is excessively high or if real productivity is higher than anticipated, good cost performance may be reported. Poor cost performance is indicated by values of the cost performance index less than 1.0, which might be the consequence of either lower productivity than anticipated or an underestimation of the actual percentage of work accomplished.

Table 4.17: Cinema complex building Project CPI

Months	Cost Performance Index (CPI)
Jun,23	1.90
Jul,23	0.91
Aug,23	0.49
Sep,23	0.76
Oct,23	0.45
Nov,23	0.61
Dec,23	0.92
Janu,24	0.74
Feb,24	1.26
Mar,24	1.24
April,24	0.98
July,24	
Average	0.93

Source, own survey 2024



Source, own survey 2024

Figure 4.13: Cinema complex Building Project CPI.

As shown in the figure and table above, the project's cost performance at the end of Jun23, Feb24 and Mar24 months performed over the control line, scoring 1.90, 1.26, and 1.24, respectively i.e. the work completed exceeded the project's actual cost by approximately 90%, 26 %, and 24%, respectively. Additionally, the project's cost performance index had a control line close to it for Apr, 24 and it is 2% less than the controlled line. The project's highest cost performance index capabilities were scored to be 1.90 at the end of Jun, 23, which is 90% more than the project's actual cost. Over the remaining eight months, the project failed to achieve cost performance, and its overall score remained within the control line, ranging from a minimum of 0.45 to a maximum of 0.98.

Generally, In Jun '23, Feb '24, and Mar '24, the CPI values were above 1, indicating good cost performance. In Jul '23, Dec '23, and April '24, the CPI values were close to 1, suggesting the project was on budget. From Aug '23 to Jan '24, the CPI values are below 1, indicating the project

was over budget. The average CPI of 0.93 suggested that, overall, the project is slightly over budget.

4.5.16 Schedule Variance (SV) and SV Percentage (SV %)

Table 4.18: Schedule variance (SV) for the Cinema Complex Building Project

Months	SV
Jun,23	18,761,161.80
Jul,23	(738,726.07)
Aug,23	(117,874,169.37)
Sep,23	(65,870,170.47)
Oct,23	(93,814,976.69)
Nov,23	(24,938,765.79)
Dec,23	(19,711,682.22)
Janu,24	(2,426,595.02)
Feb,24	52,267,830.40
Mar,24	25,306,491.55
April,24	10,223,238.50
July,24	-
sum	(218,816,363.37)
SV %	(22%)

Source, own survey 2024

Table 4.18 indicates that the project's schedule variance at the end of the Jun, 23, Feb, 24, Mar, 24, April, and 24 months had a numerically positive score. In these four months, work costs exceeded the project's planned cost, particularly at the end of the Feb, 24, when the difference between the project's earned value cost and planned cost had a bigger positive value than it had in the previous months figuratively 52,267,830.40-birr. But for the other months, there were scheduling variations below the zero line. The minimum schedule variation, or minimum negative value, was scored at the end of Jul, 23, month and was 738,726.07 birr and the variance took 0.08% from the original project cost indicating that the project was slightly on track. The highest schedule variance, or maximum value, was likewise scored at the end of the Aug, 23 month and was

117,874,169.37 birr and took 12% from the original cost of the project, meaning that it was much behind the schedule. As so, for the last nine months, the project has lagged behind schedule. The project showed a negative variance of 218,816,363.37 birr. Simultaneously, the summation percentage of the schedule variance was calculated, revealing that the project was 22% behind the planned timeline.

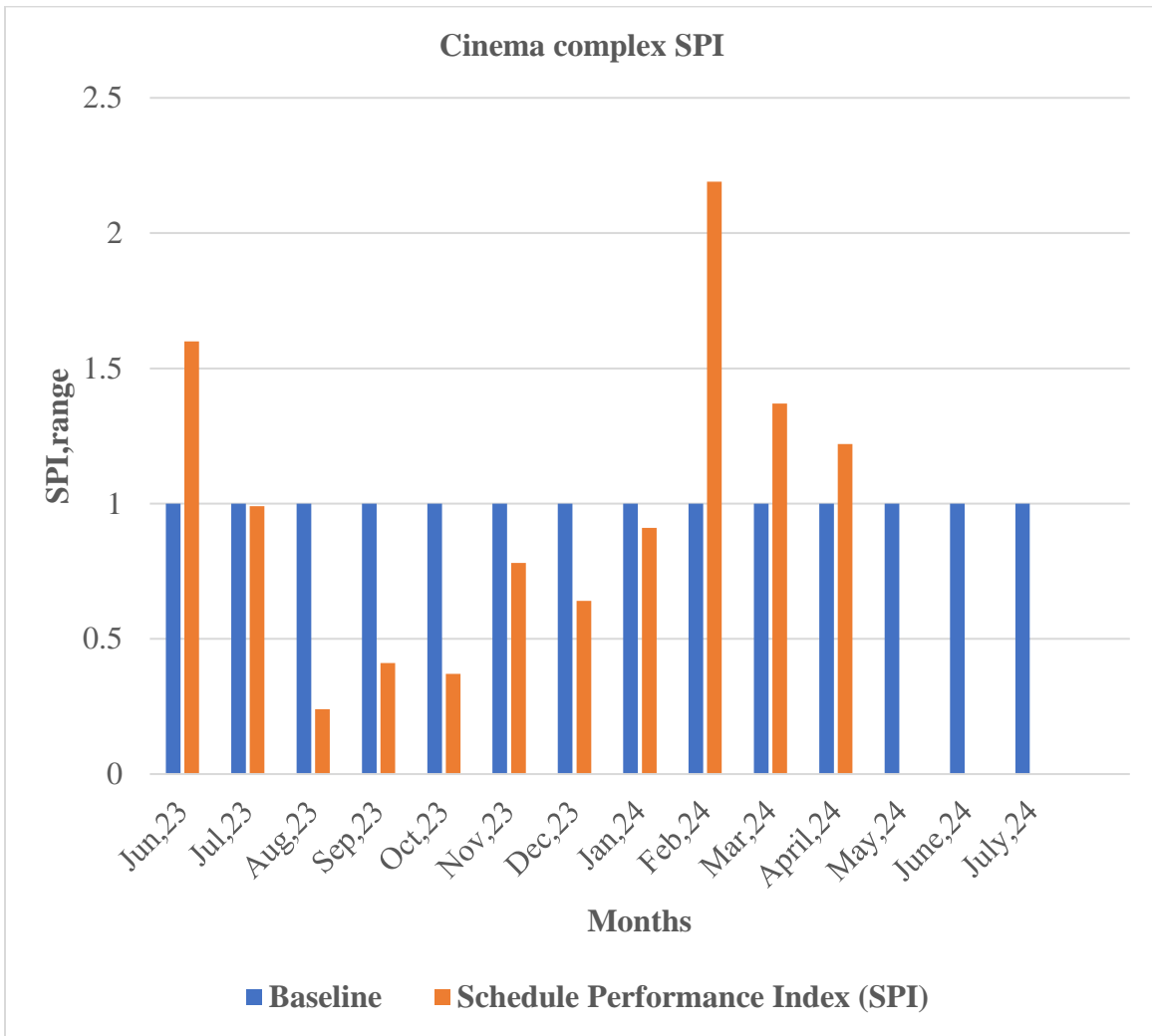
4.5.17 Schedule Performance Index (SPI)

The Cinema Complex Project SPI was discussed below based on Table 4.18.

Table 4.19: Cinema Complex Project SPI

Months	Schedule Performance Index (SPI)
Jun,23	1.60
Jul,23	0.99
Aug,23	0.24
Sep,23	0.41
Oct,23	0.37
Nov,23	0.78
Dec,23	0.64
Jan,24	0.91
Feb,24	2.19
Mar,24	1.37
April,24	1.22
July,24	
Average	0.89

Source, own survey 2024



Source, own survey 2024

Figure 4.14: Cinema complex Project SPI.

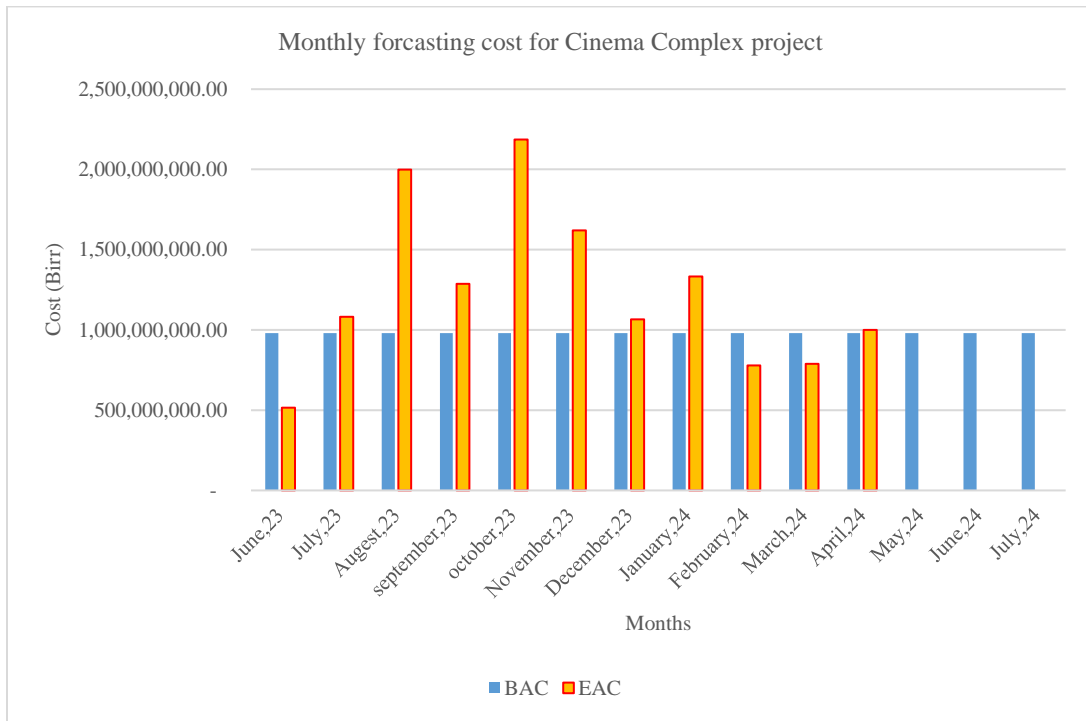
Figure 4.14 showed that the project cost performance was more suspended below baseline, indicating poor cost performance. In contrast, the schedule performance indices were 1.60, 2.19, 1.37, and 1.22 at the end of Jun, 23, Feb, 24, Mar, 24, and April, 24 respectively. In Jun '23 and Feb '24 to Apr '24, the SPI is greater than 1, indicating work was completed faster than planned. In Jul '23, the SPI was close to 1, suggesting the project was on track. From Aug '23 to Jan '24, the SPI was less than 1, showing the project was behind schedule. Aug, 23 (SPI: 0.24) the project is significantly behind schedule, as the work completed is much lower than planned and on Feb, 24 (SPI: 2.19) the project is significantly ahead of schedule. The average SPI of 0.89 implied that across all months, the project was nearly on schedule.

4.5.18 Cost Forecasting.

Table 4.20: Monthly Cinema Complex Public Building Project Forecasted Cost

Months	BAC	EAC
Jun,23	980,669,422.41	515,709,637.25
Jul,23	980,669,422.41	1,081,498,489.78
Aug,23	980,669,422.41	1,998,800,764.86
Sep,23	980,669,422.41	1,286,790,990.43
Oct,23	980,669,422.41	2,185,693,240.40
Nov,23	980,669,422.41	1,619,569,862.13
Dec,23	980,669,422.41	1,065,463,881.14
Janu,24	980,669,422.41	1,332,730,286.92
Feb,24	980,669,422.41	778,598,610.20
Mar,24	980,669,422.41	788,725,223.96
April,24	980,669,422.41	999,885,393.10
May,24	980,669,422.41	-
June,24	980,669,422.41	-
July,24	980,669,422.41	-
Average	980,669,422.41	1,051,891,322.46

Source, own survey 2024



Source, own survey 2024

Figure 4.15: Monthly Forecasted Cost for Cinema Complex Project.

As shown from the graph above, in Jul 23, Aug23 Sep 23, Nov 2023, Dec2023, Jan 2024 and April,24 months, the project forecasting estimate was higher than the budgeted cost at completion suggesting that the project faced cost overruns. Nonetheless, in all other three months, the project's estimated costs were lower than anticipated. In these months, EAC was significantly lower than BAC, indicating that the project is expected to be completed well under budget. The maximum forecasted cost was ranked at the end of Oct, 23 to be 2,185,693,240.40 birrs, compared to the 980,669,422.41-birr projected cost. The total forecasted cost of this project within 11 months was 1,051,891,322.46 birr, while the budgeted amount was 980,669,422.41 birr, resulting in a 1 million variance.

In summary, the project's forecasted cost was well below budgeted cost in Jun 2023, Feb 2024, and Mar, 24 but experienced cost increases in the other months, likely due to different factors discussed in section 4.6. The project's cost performance fluctuated, but overall, it is expected to exceed its budget based on the average EAC.

4.6 Major factors which are causes of cost and time variations of a project

To look at the causes of schedule and cost variations in building construction projects and rank them according to how they affect project performance, a structured questionnaire survey approach

was selected. The purpose of the questionnaire was to ascertain owners', consultants', and contractors' opinions about the main reasons behind these variances. These questionnaires were distributed to seasoned engineers with a wealth of practical experience in the construction sector, such as project managers, site/office engineers, and project engineers, quantity surveyors, sanitary engineers, electrical engineers, safety engineers. They are the best candidates for the first stage of the study because of their extensive experience.

The major factors affecting selected public project performance and rankings from stakeholders' perspectives will be discussed based on the RII value.

Table 4.21 Client-related causes

No	Major causes for variations	Client		Contractor		Consultant	
		RII	Rank	RII	Rank	RII	Rank
1.1	Slow in decision-making	0.943	2	0.686	2	0.775	3
1.2	Underestimation of the time required for project completion.	0.914	1	0.686	3	0.800	2
1.3	Underestimation of project costs	0.971	3	0.829	1	0.85	1
1.4	Owner's delay in providing the site to the contractor.	0.743	5	0.486	7	0.625	6
1.5	Owner's tardiness in reviewing and approving design documents	0.743	5	0.543	6	0.750	4
1.6	Delay in approving drawings and samples by the owner	0.686	7	0.629	4	0.625	6
17	Delay in financial payments for completed work by the owner	0.800	4	0.6	5	0.700	5
1.8	Inadequate supervision	0.657	8	0.485	8	0.375	8

Client-related causes of project performance issues in public construction projects significantly impact the overall success of the project. Based on the provided Relative Importance Index (RII) and rankings in table 4.22, here's an analysis of these causes: Underestimation of project costs were ranked as the most critical issue across the two parties i.e. contractor, and consultant. This high ranking indicated that Underestimation of project costs led significant delays and cost overruns. The underestimation of the time required for project completion was a significant issue, especially from the client's perspective. This cause was ranked high because inaccurate time

estimations lead to unrealistic schedules, which can cause delays and disrupt the project timeline. Similar to time underestimation, slow in decision making was a critical issue and it was ranked as the second in client and contractor perspective. Inadequate supervision, while ranked lower along in all the three parties, was still a notable issue.

From the overall perspective, slow in decision making, underestimation of the time required for project completion, and Underestimation of project costs, were the top-ranked client-related issues.

Table 4.22 Contractor-related causes.

No	Major causes for variations	Client		Contractor		Consultant	
		RII	Rank	RII	Rank	RII	Rank
2.1	Financial problems	0.914	2	0.686	1	0.725	3
2.2	Sub-contractor delays	0.743	7	0.486	3	0.700	4
2.3	Contractor staff qualifications	0.829	4	0.514	2	0.800	2
2.4	Site management supervision	0.943	1	0.429	6	0.850	1
2.5	Rework due to errors	0.800	6	0.486	3	0.525	7
2.6	Ineffective planning/scheduling	0.829	4	0.486	3	0.625	6
2.7	Conflicts between contractor and other parties (consultant and owner)	0.886	3	0.400	7	0.650	5

Based on the provided Relative Importance Index (RII) and rankings, here's an analysis of these causes: Financial problems were a top concern across all parties. The contractor in Kolfe Keranyo General Hospital had faced these critical issues leads the project being delayed. Site management supervision was ranked as the first major problem in the client and consultant perception. The second major problem was contractor staff qualifications ranked as the second by both the contractor as well as consultant.

From the overall perspective, financial problems, contractor staff qualifications, and site management supervision were the top-ranked contractor-related issues.

Table 4.23 Consultant-related causes

No	Major causes for variations	Client		Contractor		Consultant	
		RII	Rank	RII	Rank	RII	Rank
3.1	design modification	0.943	2	0.829	1	0.750	1
3.2	Variations order cost	0.971	1	0.743	2	0.750	1
3.3	Consultant performance in terms of specifications and testing;	0.857	5	0.514	6	0.675	5
3.4	Poor Estimation of Project Costs	0.914	4	0.686	3	0.700	4
3.5	Inadequate and unclear detailing in drawings	0.857	5	0.629	5	0.550	7
3.6	Improper timing of the project	0.829	7	0.657	4	0.650	5
3.7	Monitoring and controlling the project	0.971	1	0.514	6	0.575	6

Consultant-related causes of project performance issues played a crucial role in the overall success of the selected public construction projects. Based on table 4.24 Relative Importance Index (RII) and rankings, here's an analysis of these causes: Design modifications were a major factor that affected the project which was ranked as the first, especially for contractors and consultants. These changes brought delays, additional costs, and disruptions in the construction schedule especially in the case of the Cinema complex building. Due to the client's numerous design modifications in this project, the consultant was unable to bring up the change issue as quickly as possible. It was the reason for the contractor's first problem as shown on the table. Variation orders were highly ranked by all parties, indicating their significant impact on the selected public building project's performance. Similarly, the performance of consultants in terms of specifications and testing is critical and ranked as the first major factor that influences the project from the first in contractors' perspective.

From the overall perspective, variations in order cost, design modification, and poor estimation of project costs were the top-ranked consultant-related issues.

Table 4.24 Design-related causes

No	Major causes for variations	Client		Contractor		Consultant	
		RII	Rank	RII	Rank	RII	Rank
4.1	Complexity of project design	0.800	2	0.657	2	0.650	1
4.2	Unclear and inadequate details in drawings	0.829	1	0.743	1	0.600	2
4.3	Insufficient experience of the design team	0.771	4	0.657	2	0.550	3
4.4	Failure to use advanced engineering design software	0.800	2	0.543	4	0.400	4

Design-related causes of project performance issues had a profound impact on the success of public construction projects in Addis Ababa. Based on the Relative Importance Index (RII) and rankings in Table 4.25, here's an analysis of these causes: The complexity of the project design was a significant concern across all parties. Especially it was ranked as the first major factor for performance variation by the consultants. In all parties, unclear and inadequate details in drawings were also the highest-ranked design-related issue overall. There was insufficient experience in the design of cinema complex building projects. From the overall perspective, unclear and inadequate details in drawings and the complexity of project design were the top-ranked design-related issues.

Table 4.25 Material-related causes

No	Major causes for variations	Client		Contractor		Consultant	
		RII	Rank	RII	Rank	RII	Rank
5.1	Lack of available building materials in the market	0.971	2	0.857	1	0.675	3
5.2	Material delivery delays	0.943	3	0.714	2	0.75	2
5.3	Materials purchased beyond the deadline	0.943	3	0.629	3	0.675	3
5.4	Price escalation for materials	1	1	0.714	2	0.775	1

Material-related problems were crucial to public construction projects because they had an immediate impact on the work's availability, cost, and timeliness. There was an examination of these causes based on the suggested ranks and Relative Importance Index (RII): As can be seen in the table, price escalation for materials was the top concern for clients and consultants, reflecting the impact of fluctuating material costs on the selected project budget. The lack of available building materials in the market was a major concern, particularly for contractors, and ranked as the first and also ranked as the second and third major problem by clients and contractors respectively. Material delivery delays were also significant, affecting the project's timeline and cost in the three projects. It was especially the main problem that led the project to be delayed at Kolfe Keranyo Hospital. The client was always claimed on the contractor about the delay of the project. From the overall perspective, price escalation for materials and lack of available building materials in the market were the most significant material-related issues according to the three stakeholders.

Table 4.26 Labor and Equipment Delays

No	Major causes for variations	Client		contractor		consultant	
		RII	Rank	RII	Rank	RII	Rank
6.1	Insufficient workforce in the market	0.886	3	0.6	1	0.525	6
6.2	Laborers' productivity levels are below standard	0.771	6	0.514	3	0.600	3
6.3	Insufficient labor supply	0.886	3	0.486	6	0.575	4
6.4	Equipment operates with low productivity and efficiency	0.914	1	0.514	3	0.550	5
6.5	Issues with equipment availability and breakdowns	0.886	3	0.6	1	0.650	1
6.6	Limited availability of advanced mechanical equipment	0.914	1	0.514	3	0.625	2

Delays in labor and equipment are major problems that impact the timeliness and overall efficiency of public construction projects. As indicated by Table 4.27, the lack of available workforce was a significant problem that caused cost and time variation, especially for clients and contractors ranked first and third respectively. Equipment availability and breakdowns are significant concerns, particularly for contractors and consultants. On the other hand, the limited availability of advanced equipment delayed project progress and reduced efficiency. From the overall

perspective, issues with equipment availability and breakdowns and the limited availability of advanced mechanical equipment were the most significant labor and equipment-related issues.

Table 4.27 external delays

No	Major causes for variations	Client		Contractor		Consultant	
		RII	Rank	RII	Rank	RII	Rank
7.1	Impact of nderground Conditions	0.857	2	0.657	3	0.600	4
7.2	Lack of foreign currency	0.914	1	0.743	1	0.700	2
7.3	Weather-related impacts	0.800	3	0.657	3	0.600	4
7.4	Shifts in government rules and regulations	0.686	5	0.686	2	0.725	1
7.5	Lack of essential utilities on site (e.g., water, electricity, telephone)	0.771	4	0.657	3	0.525	6
7.6	Force majeure events like war.	0.600	6	0.571	6	0.625	3

External factors played a crucial role in causing variations in selected public construction projects. These factors were often beyond the control of the project team but significantly impacted project performance. Based on the above table, Relative Importance Index (RII), and rankings, here's an analysis of these external causes:

The lack of foreign currency was a critical issue, particularly in economies reliant on imported materials and equipment in all projects. Especially, it was the main challenge for the FHC mixed-building apartment. Since the contractor was an international contractor, they faced the problem of bringing the essential equipment and other materials from outside. Weather conditions caused significant delays, particularly in all projects in Addis Ababa according to all party's perceptions. From the overall perspective, the lack of foreign currency and the impact of underground conditions were the most significant external-related issues.

Table4.28 Combined Perspectives of Clients, Contractors, and Consultants

No	Major causes for variations	Overall		
		RII	Std	Rank
1	Client related causes			
1.1	Slow in decision-making	0.809	0.963	6

1.2	Underestimation of the time required for project completion.	0.8	1.02	7
1.3	Underestimation of project costs	0.818	0.921	4
1.4	Owner's delay in providing the site to the contractor.	0.618	1.342	38
1.5	Owner's tardiness in reviewing and approving design documents	0.682	1.186	23
1.6	Delay in approving drawings and samples by the owner	0.645	1.296	34
17	Delay in financial payments for completed work by the owner	0.7	1.184	21
1.8	Inadequate supervision	0.5	1.773	42
2	Contractor related causes	RII	Std	Rank
2.1	Financial problems	0.773	1.049	10
2.2	Sub-contractor delays	0.645	1.27	33
2.3	Contractor staff qualifications	0.718	1.098	14
2.4	Site management supervision	0.745	1.097	13
2.5	Rework due to errors	0.6	1.356	39
2.6	Ineffective planning/scheduling	0.645	1.269	32
2.7	Conflicts between contractor and other parties (consultant and owner)	0.645	1.307	36
3	Consultant related causes	RII	Std	Rank
3.1	Design modification	0.882	0.796	1
3.2	Variations order cost	0.818	0.959	5
3.3	Consultant performance in terms of specifications and testing;	0.709	1.113	16
3.4	Poor Estimation of Project Costs	0.764	1.066	11
3.5	Inadequate and unclear detailing in drawings	0.673	1.207	26
3.6	Improper timing of the project	0.709	1.141	17
3.7	Monitoring and controlling the project	0.682	1.193	24
4	Design related causes	RII	Std	Rank
4.1	Complexity of project design	0.7	1.185	22
4.2	Unclear and inadequate details in drawings	0.718	1.102	15
4.3	Insufficient experience of the design team	0.655	1.241	30
4.4	Failure to use advanced engineering design software	0.573	1.478	41
5	Material-related causes	RII	Std	Rank
5.1	Lack of available building materials in the market	0.836	0.816	3
5.2	Material delivery delays	0.8	1.024	8
5.3	Materials purchased beyond the deadline	0.745	1.09	12
5.4	Price escalation for materials	0.836	0.811	2

6	Labor and Equipment Delays	RII	Std	Rank
6.1	Insufficient workforce in the market	0.664	1.224	28
6.2	Laborers' productivity levels are below standard	0.627	1.308	37
6.3	Insufficient labor supply	0.645	1.241	31
6.4	Equipment operates with low productivity and efficiency	0.655	1.225	29
6.5	Issues with equipment availability and breakdowns	0.709	1.141	18
6.6	Limited availability of advanced mechanical equipment	0.682	1.202	25
7	External delays	RII	Std	Rank
7.1	Impact of underground Conditions	0.7	1.171	20
7.2	Lack of foreign currency	0.782	1.037	9
7.3	Weather-related impacts	0.682	1.221	27
7.4	Shifts in government rules and regulations	0.7	1.141	19
7.5	Lack of essential utilities on site (e.g., water, electricity, telephone)	0.645	1.296	35
7.6	Force majeure events like war.	0.6	1.42	40

Source, own survey 2024

As shown in the above table 4.28, the combined perception of the clients, contractors, and consultants was ranked via SPSS 26 and RII ranking methods. With an RII of 0.882, design modifications were highlighted as a key factor influencing project cost and time performance. Especially the design changes in the Kolfe Keranyo General Hospital Building Project were the concrete grade and slab thickness changes from c-30 to c-40 and from 15 cm to 30 cm respectively. Due to this concrete volume and rebar construction highly increased. In the case of FHC Mixed Apartment Building Projects, there were design modifications in room units. Before the modification, there were 5 units (3 bedrooms, 2 bedrooms, and 1 bedroom) on a floor. However, design modification was made to change from 5 units (houses) to 8 units (houses) on a floor. In addition, a design change was made to increase the number of floors from 3B+G+21 to 3B+G+23. In the case of Cinema complex public building projects there was a design modification of RC beams to pretensioned beam structure and was modification in all sanitary, electrical, and architectural works. These impact both time and cost.

The second main reason why project costs and schedules varied was because of delays in Price escalation for materials with a relative importance index 0. 836 and Std of 0. 811. This factor affected all three projects. The FHC Mixed Apartment Building Project was stopped on Jan-23, Feb-23, and Mar-23 due to this factor. Similarly, Market Fluctuations such as in ready-mix,

cement, rebar & fuel were the main factors for cost and time variations in the Kolfe Keranyo General Hospital Building Project.

According to the table, the Lack of available building materials in the market was the main responsible root cause for major variations. This factor ranked as the third highest factor with an RII and 0.836 and Std of 0.816 respectively, indicating its critical role in project delays and cost overruns. Material shortages led to project halts, rework, and increased costs due to expedited shipping or alternative sourcing and this affects both the time and cost. There was a shortage of materials in all three projects especially, the Kolfe Keranyo General Hospital Building Project faced a shortage of materials at the stage of reinforcement bar work and fuel.

The fourth place with a 0.818 RII and Std of 0.921 value was occupied by Underestimation of project costs, and inaccurate & realistic cost estimation and cost control. This significant factor was evident in all three projects. Especially this problem was a big challenge in the FHC Mixed Apartment Building Project due to, Scope Changes, and unforeseen conditions when the basement was excavated leading to cost and schedule deviations. Aluminum window door quantity is very much underestimation in the case of the Kolfe Kerano General Hospital project.

The Variations order cost of the project's fifth major cause for cost variation with RII of 0.818 and Std of 0.959. Especially on the Cinema complex project when the RC beam changed to a pre-tensioned beam the cost of the project was affected and when LTZ for windows and door frames changed to aluminum frames. For the FHC Mixed Apartment Building Project, cost variation when the number of units (rooms) per floor increased from 5 to 8. Additional retaining structure (concrete retaining wall) was the main variation order due to the depth of the excavation height being highly increased for Kolfe Keranyo General Hospital. In addition to this, stretcher lifts and fire exit stairs were added to the project scope, The ward floor finish was changed from epoxy flooring to linoleum mat flooring, Skylight (newly added), contextra paint was also added and angle iron corner protection was also newly added. All three projects had cost variations due to design or material changes, and variation orders.

Slow decision-making of the projects also ranked as the sixth major factor that affected the project cost and time performance with an RII of 0.809 and a standard deviation of 0.963. Slow decision-making by the client caused significant delays in all three project timelines. It was the main problem especially at Kolfe Keranyo General Hospital when the design modification was made. Due to this, the project was extended to 42 calendar days. Similarly, it was a big challenge in FHC mixed apartment, when a room modification was made.

On the other hand, underestimation of the time required for project completion with a relative important index of 0.800 was ranked as the seventh major factor for the project performance variation. All three projects encountered these challenges. The questionnaire and discussion showed that initial schedules were based on optimistic assumptions and lacked detailed task breakdowns.

Time and cost variances were mostly caused by Material delivery delays. The results of the questionnaire, desk research, and discussion made it evident that the Kolfe Keranyo General Hospital project is more impacted than the other programs. Poor delivery of coarse aggregate and sand reduced the daily production of concrete work on the Kolfe Keranyo General Hospital project. Due to inadequate material delivery, the Cinema Complex project also had block shortages. Delivery delays of materials were ranked eighth in the questionnaire results, with an RII of 0.791. Similar to material delivery delays, the Lack of foreign currency with an RII score of 0.782, was the ninth primary cause of alterations because of the conflict in the country. The construction projects have been affected by our country's conflict in several ways, including the lack of young laborers and issues with transportation.

In all three projects, the contractor's financial problems primarily affected the time performance of all three projects. The contractor for the Cinema complex project was unable to complete the project by the deadline (July 15/2024). There was a failure to pay payments on time for Subcontractors working with the contractor. The contractor was for example, despite financial difficulties, the contractor was unable to assign sufficient labor and deliver construction materials on time to complete the project on time. As a result, the contractor's financial stability is unquestioned. Survey results and interviews revealed that, albeit not as much as for the third project, the contractor's inadequate financial standing also affected the Kolfe Keranyo General Hospital project and FHC Mixed Apartment Building projects' timeline performance. As per the questionnaire results, the contractor's financial capacity is positioned in tenth place with an RII value of 0.773.

As per the questionnaire results, the participants contended that the eleventh primary reason for the variation between the actual construction time and the planned cost was Poor Estimation of Project Costs. The relative relevance index for the poor project cost estimation has a value of 0.764 according to the questionnaire study. Materials purchased beyond the deadline with an RII of 0.745 and a Std of 1.090 also ranked as the twelfth major factor for time and cost variation according to the questionnaires. This indicated that the issue of materials being purchased beyond the deadline

had a moderate impact on the three-project performance, with relative importance that places it in a significant position among other causes.

According to the questionnaire analysis, one of the main reasons for the schedule and cost discrepancies in the projects was poor Site management/supervision. There is a direct correlation between the order of activities and insufficient site monitoring. With RII of 0.745 and Std of 1.097, poor site monitoring systems ranked thirteenth. Because the tasks were not completed in the order specified by the schedule, a subpar site management system was the primary factor contributing to all three project's time and expense variations. This resulted in the project being inefficient in terms of both time and money.

The contractor's staff qualifications with the Relative Importance Index (RII) for the qualification of contractor staff is 0.718 and Std of 1.098, and it is ranked fourteenth among the contractor-related causes of variations in public construction projects. This was the root cause, especially in the Kolfe Keranyo General Hospital project and cinema complex public projects. Similarly, the Limited availability of advanced mechanical equipment" has an RII value of 0.682. Even though there has been better mechanical equipment in the FHC Mixed Apartment Building projects, the other two projects steel used outdated or less efficient equipment and this necessitated more manual labor, increasing overall labor costs and potentially leading to labor shortages.

In design-related causes, unclear and inadequate details in drawings were ranked as a main factor for cost and time variation in fifteenth place with an RII value of 0.718 and Std of 1.102. Ambiguities or missing details in drawings were the main challenges in all three projects, leading to misunderstandings and incorrect execution, causing delays as issues were identified and clarified. This issue was particularly problematic in cinema complex public projects, resulting in additional costs due to rework, change orders, and delays.

The complexity of project design and Consultant performance in terms of specifications and testing was ranked sixteenth with RII 0.700. Even though Consultants are responsible for providing precise and comprehensive specifications that detail the materials, workmanship, and standards required for the project, there were gaps in training for consultants to ensure they are up-to-date with the latest standards, testing methods, and technologies in all three projects. In the case of cinema complex public projects, the design complex some typically require more detailed planning, advanced materials, and specialized labor, leading to higher costs. Efficiently managing resources such as labor, materials, and equipment was challenging in cinema complex public projects.

Delay in financial payments for completed work by the owner was ranked as the twenty-first major factor for cost and time variance with RII 0.700 with a Std of 1.184. The problem occurred in all projects, especially in the Kolfe Keranyo General Hospital project the client failed to pay payments to the contractor for completed work items. Due to this, the contractor slowed down or halted work, leading to project delays. This has created a domino effect, delayed subsequent activities, and impacted the overall project timeline.

As the FHC Mixed Apartment Building projects started primarily in the summer, Weather-related impacts with RII 0.682 and Std of 1.221 ranked as twenty-seventh, specifically the amount of rain, was a significant obstacle to finishing the work on time. For example, the client allowed an additional 30 days for this project because of a delay caused by the wet season. Rain was a crucial factor in the project schedule for the FHC Mixed Apartment Building projects, which start in June. The analysis of the questionnaires completed throughout the collection process revealed that the site's climate was the three major sources of the temporal variance of cost and time.

Insufficient labor supply with RII 0.645 ranked 30^{1st} with a Std of 1.241, similar to workforce insufficiency. Insufficient labor supply was a major cause of time and expense variation in the cinema complex and Kolfe Kenanyo General Hospital projects, particularly in the initial phase. There was also insufficient labor supply on Dec-22, Jan-23, and Feb-23 at the FHC Mixed Apartment Building project. Similarly, Equipment operates with, low productivity and efficiency Ranked 29th, equipment inefficiencies cause delays, especially in the cinema complex and Kolfe Keranyo General Hospital projects.

According to the table in your document, ineffective planning and scheduling have a Relative Importance Index (RII) of 0.645 and a standard deviation of 1.269, ranking thirty second among various major factors affecting time and cost of project performance. This cause of variation brought in Delays and Cost Overruns for all three projects

Sub-contractor delays with RII of 0.645 and Std of 1.270 ranked thirty-second, were the major cost and schedule variance that caused significant delays in all projects. Due to these challenges, the project's performance was affected by, Schedule Delays, Cost Overruns in Kolfe Keranyo Hospital, and cinema complex public projects. Similar to this, the Lack of essential utilities on site (e.g., water, electricity, telephone), with RII 0.646 was also ranked as 32nd and it was the main problem in the FHC Mixed Apartment Building project and all other two projects.

Laborers' productivity levels are below standard, was ranked thirty-seventh with RII of 0.627 and Std of 1.308. This is the factor in all three projects that occurred. In all three projects, there were inadequate Skills or Training, Poor Management, and Poor Work Environment.

Delay resulting from the Owner's delay in providing the site to the contractor was the thirty-eighth major source of cost and time differences for the projects, with a relative relevance index value of 0.618. Site possession was established and work/legal permits were integrated into the Addis Ababa city administration and other stakeholders before the start of the project. In the case of Kolfe Keranyo General Hospital, a contract agreement was made before infrastructural facilities, container shops, and toilets houses were demolished. Due to that, there was 60 additional time.

Force majeure events like war were ranked at fortieth with RII 0.600 and Std 1.420. It impacted all three selected projects in Addis Ababa and disrupted the supply chain, making it difficult to procure the necessary materials and equipment for the projects. In the FHC mixed apartment project, the contractor was unable to bring necessary materials like sand, gravel, and other construction materials out of the city. It was also a big challenge to the other two contractors.

With an RII value of 0.573, last but not least Failure to use advanced engineering design software was ranked forty-first. In all three public construction projects, there was a failure to use advanced engineering software and this had several negative impacts on productivity, efficiency, and overall project success. With an RII value of 0.573, the final but equally significant factor, the failure to utilize advanced engineering design software, was ranked as forty-first. Across all three public construction projects, there was a gap in utilizing advanced engineering software which had numerous adverse effects on productivity, efficiency, and the overall success of the three projects.

4.7 Correlation analyses between several responders

Correlation describes the strength of association between variables. According to Brooks (2008), correlation analysis measures the degree of linear association between dependent and independent variable. The value of correlation coefficient ranges from -1 to 1. A correlation coefficient of 1 indicates that there is perfect positive relationship between two variables; while -1 indicates that there is perfect negative relationship between two variables. On the other hand, a correlation coefficient of zero indicates no relationship between variables. According to McDaniel and gates (2006), a value of correlation coefficient between 0.1 and 0.29 indicates the association among the items is poor. A correlation coefficient between 0.3 and 0.49 implies there is moderate relationship correlation coefficient greater than 0.5 implies strong relationship between two variables.

According to section 4.8, the primary causes can be divided into seven categories: client-related causes contractor contractor-related causes, consultant-related causes, design-related causes, labor and equipment delays, and, lastly, external factors. Spearman's rank correlation coefficient is used to perform correlation for each responder. According to Kothari (1990), Charles Spearman's coefficient of correlation, also known as rank correlation, is to ascertain the degree of similarity or dissimilarity between the two sets of rankings in the case of ordinal data where ranks are assigned to the different values of the variables.

Table 4.29 Correlation among the respondents in client-related causes

Spearman's rank correlation coefficient					
Respondents			Clients	Contractors	Consultants
	Clients	Correlation Coefficient	1	.775	.882
	Contractors	Correlation Coefficient	.775	1	.775
	Consultants	Correlation Coefficient	.882	.775	1

Table 4.30 Correlation among the respondents in contractor-related causes

Spearman's rank correlation coefficient					
Respondents			Clients	Contractor	Consultants
	Clients	Correlation Coefficient	1	-.150	.577
	Contractor	Correlation Coefficient	-.150	1	.548
	Consultants	Correlation Coefficient	.577	.548	1

Table 4.31 Correlation among the respondents in consultant-related causes

Spearman's rank correlation coefficient					
Respondents			Clients	Contractors	Consultants
	Clients	Correlation Coefficient	1	.557	.483
	Contractors	Correlation Coefficient	.557	1	.682
	Consultants	Correlation Coefficient	.483	.682	1

Table 4.32 Correlation among the respondents in design-related causes

Spearman's rank correlation coefficient					
Respondents			Clients	Contractors	Consultants
	Clients	Correlation Coefficient	1	.500	.316
	Contractors	Correlation Coefficient	.500	1	.632
	Consultants	Correlation Coefficient	.316	.632	1

Table 4.33 Correlation among the respondents in material-related causes

Spearman's rank correlation coefficient					
Respondents			Clients	Contractors	Consultants
	Clients	Correlation Coefficient	1	.500	.500
	Contractors	Correlation Coefficient	.500	1	.000
	Consultants	Correlation Coefficient	.500	.000	1

Table 4.34 Correlation among the respondents in labor & equipment related causes

Spearman's rank correlation coefficient					
Respondents			Clients	Contractors	Consultants
	Clients	Correlation Coefficient	1	-.100	-.062
	Contractors	Correlation Coefficient	-.100	1	.361
	Consultants	Correlation Coefficient	-.062	.361	1

Table 4.35 Correlation among the respondents in external related causes

Spearman's rank correlation coefficient					
Respondents			Clients	Contractors	Consultants
	Clients	Correlation Coefficient	1	.577	-.116
	Contractors	Correlation Coefficient	.577	1	.524
	Consultants	Correlation Coefficient	-.116	.524	1

From Table 4.29, the Spearman rank correlation coefficient clearly shows the respondent's relationships and strengths among themselves. From the table, the client-contractor correlation coefficient was 0.775. This indicated a strong positive relationship between the rankings provided by clients and contractors. Between the clients and consultants, the correlation coefficient was 0.882. It suggested an even stronger positive relationship between the rankings provided by clients and consultants. At the same time, between contractors and consultants, the correlation coefficient was 0.775. This indicates a strong positive relationship between the rankings provided by contractors and consultants.

From Table 4.30, between Clients and Contractors, the correlation coefficient is -0.150 . The correlation coefficient is -0.150 , which suggests a weak negative relationship. As the rank of client's increases, the rank of contractors tends to slightly decrease. Clients and Consultants had a correlation coefficient is 0.577. This suggested a moderately positive relationship between the rankings provided by clients and consultants. Contractors and consultants also had a correlation coefficient of .548. This indicates a strong positive relationship between the rankings provided by contractors and consultants.

From Table 4.33, Clients and Contractors as well as Clients and Consultants had a correlation coefficient is 0.500. This showed a moderate positive relationship between the rankings provided by clients and contractors. There was also a correlation coefficient of 0.000 between Contractors and Consultants: This 0.000 indicated that no correlation between the rankings provided by contractors and consultants, meaning there was no relationship between how these two groups ranked the factors.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The application of EVA in assessing the performance of public construction projects in Addis Ababa revealed critical insights into the cost and time management of these projects. The findings underscored the importance of effective project planning, stakeholder communication, and timely decision-making in mitigating delays and cost overruns. The progress of three selected public building projects was assessed using Earned Value Analysis (EVA). The findings indicating that, for each project, the total cumulated planned project cost exceeded the cumulative earned value. It indicates that the projects were not completed on schedule. The total actual cost exceeded the total earned value in the Cinema Complex Building Project whereas the total actual cost was under the total earned value in the case of Kolfe Keranyo General Hospital and FHC Mixed Apartment building Projects, indicating that the projects' cost performance was also good in the two projects. The following detailed conclusions about the three projects were made in light of the assessment and outcomes of the performed research.

- Except the Cinema Complex Building Project, all projects' cost variances were positive, meaning that their total costs were under their allocated budgets. There was a minimum cost variance of 133,814,316.19 birrs for the Cinema Complex Building Project and a maximum cost variance of 368,096,099.82 birrs for the FHC Mixed Apartment Building Project. The cost variation of the Cinema Complex Building Project was numerically negative, meaning that it was over budget.
- Specifically, the Kolfe Keranyo General Hospital and Cinema Complex projects were behind schedule by 34% and 22%, respectively. In terms of cost variance, the FHC Mixed Apartment Building Project was 32% under budget, while the Cinema Complex Project was 21% over budget.
- For the Kolfe Keranyo General Hospital public project, the average cost performance index was 1.98, and the FHC Mixed Apartment building project had an average cost performance index of 2.47. Both of the projects had greater than 1 indicating that, the projects were accomplishing more work for less money than initially planned. Especially, in the case of the FHC Mixed Apartment building project, there was no activity for about three months i.e. Dec-22, Jan-23, and Feb-23. Due to this, the CPI for the Mixed Apartment

building project was maximum from others. In other words, the two projects were under budget.

- For Kolfe Keranyo General Hospital public project scored the maximum schedule variation as quantitatively negative by 943,225,950.16-birr variance. On the other hand, the Cinema Complex Building Project assessed the minimum schedule variance as numerically negative by 218,816,363.37 Birr. The schedule variance for all three of the active projects was numerically negative, meaning that each project was running later than expected.
- The FHC Mixed Apartment building Project scored a minimum average schedule performance index from the three projects i.e. 0.67 less than the actual cost incurred, whereas the Kolfe Keranyo General Hospital Public project scored a maximum schedule performance index of 0.91. Every single one of the three projects had an average schedule performance index that was numerically less than 1, meaning that each project was running behind schedule.
- The Future forecasts have been thoroughly examined in this research. The estimation at completion forecast was computed for all three projects, and it was based on the projects to date completion. The estimated completion costs for the public cinema complex project revealed a 1,051,891,322.46-birr forecasted cost above the original budget indicating that the project's cost increased at completion, while the Kolfe Keranyo General Hospital public projects indicated a numerical 1,634,594,981.86-birr average forecasted cost less than from its budgeted cost, it suggested that the project will be expected to be completed under budget. Similarly, a 753,996,848.68-birr average forecasted cost was found for the FHC Mixed Apartment building Project and it was less than the planned cost at completion i.e. 1,863,141,858.49 birr within 14 phases (42 months).
- The study utilized a structured questionnaire survey approach to gather insights from project owners, consultants, and contractors. The combined perspectives of these stakeholders were analyzed using the Relative Importance Index (RII) and ranked to determine the most significant causes of project variations. Lastly, with RII scores of 0.882, 0.836, 0.836, 0.818, and 0.818, respectively, the top five major responsible causes for time and cost variations were, design modification, Price escalation for materials with a Std of 0.811, Lack of available building materials in the market with a Std of 0.816, Underestimation of project costs, and Variations order cost. The bottom five rankings, with RIIs of 0.618, 0.600, 0.600, 0.573, and 0.550 respectively were, owner's delay in providing the site to the contractor, Rework due to errors, Force majeure events like war, Failure to

use advanced engineering design software and Inadequate supervision. Suresh and Ramasamy (2015) contended that variation between executed and planned activity quantities is the primary cause of variation in costs, schedules, and resource utilization issues.

The researcher concluded that, above all other variables and discussions, schedule variation and schedule performance were the primary factors influencing the performance of building construction projects.

5.2 Recommendations

This research primarily assessed selected public building project schedules and cost performance practices in the building construction projects in Addis Ababa city. The result of the research helps to draw the following recommendations for the projects:

- Before beginning building construction projects, the public building project owners and consultants at Addis Ababa city should take into account the following factors: design modification, Price escalation for materials, Lack of available building materials in the market, Underestimation of project costs, and Variations order cost. These were the main reasons for variances in time and cost. It should be an effective collaboration between designers, engineers, and stakeholders to minimize design modifications and their associated delays and costs.
- It is advised that contractors should have an appropriate accounting and cost recording system that is project-based. Because the cost incurred for each work activity was not precisely known, this tendency made it nearly impossible to determine the actual cost of work performed for each project.
- It is recommended for all stakeholders to make EVA their work culture in their projects to assess the project's time and schedule performance. In addition, should implement regular training sessions for project managers and key stakeholders on the principles and applications of EVA. This would help to keep the projects on track without any delay or cost overrun. This would ensure that all parties involved have a solid understanding of how to effectively use EVA for monitoring project performance. In addition, it is recommended to establish monthly performance review meetings to discuss EVA reports. These meetings should involve project managers, contractors, and consultants to ensure a collaborative approach to addressing performance issues promptly. Use integrated project management software that should support EVA to streamline data collection, analysis, and reporting

processes. This integration should help in maintaining accurate and up-to-date project performance data.

- The researcher recommended EVA as a crucial tool for cost control in construction projects, despite its limited adoption in Addis Ababa public building construction projects. The technique should offer significant benefits and require minimal training for project utilization, making it a cost-effective solution.
- Future research should likely incorporate new metrics in EVA methodology to address risk analysis, quality, and technical performance issues for efficient project control, aiming to reduce extra work and integration of planning, scheduling, budgeting, and work authorization processes.

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APPENDIX:

A. Tables for Earned Value Analysis

Table A.1: Kolfe- Keranyo General Hospital Building Construction Project.

Phase s	Planned Value (PV) (birr)	Comm. PV (birr)	Comm. Percentag e (%)	Actual Cost (AC) (birr)	Comm. AC (Birr).	Earned value (EV)	Comm. EV (birr)
1	106,277,639.19	106,277,639.19	2.0%	50,836,896.20	50,836,896.20	64,759,763.14	64,759,763.14
2	110,369,250.69	216,646,889.88	4.5%	53,867,843.00	104,704,739.20	80,949,703.93	145,709,467.07
3	120,690,260.60	337,337,150.48	7.4%	64,563,789.66	169,268,528.86	93,901,656.56	239,611,123.63
4	115,623,580.66	452,960,731.14	13.0%	58,367,895.60	227,636,424.46	181,327,336.80	420,938,460.43
5	105,698,365.20	558,659,096.34	18.1%	48,976,236.90	276,612,661.36	165,137,396.01	586,075,856.44
6	79,006,738.66	637,665,835.00	24.5%	50,258,690.33	326,871,351.69	207,231,242.06	793,307,098.49
7	650,080,580.53	1,287,746,415.53	31.7%	101,618,752.36	428,490,104.05	233,135,147.31	1,026,442,245.81
8	690,404,354.87	,978,150,770.40	41.3%	26,352,980.26	554,843,084.31	310,846,863.08	1,337,289,108.89
9	611,690,150.36	,589,840,920.76	53.3%	50,560,263.97	1,005,403,348.2	387,587,182.41	1,724,876,291.30
10	648,147,236.36	,237,988,157.12	66.3%	10,236,980.40	1,515,640,328.6	420,938,460.43	2,145,814,751.72
11			70.9%	287,698,652.30	1,803,338,980.9	148,947,455.23	2,294,762,206.95
12			-	-	-	-	-

Source, own survey 2024

Table A.2: FHC Mixed Apartment Building Project.

Phases	Planned Value (birr)	Comm. PV (birr)	Comm. Percentag e (%)	Actual Cost (AC) (birr)	Comm. AC (Birr).	Earned value (EV)	Comm. EV (birr)
1	110,360,780.20	110,360,780.20	2.10%	13,005,688.47	13,005,688.47	39,125,979.03	39,125,979.03
2	89,762,340.69	200,123,120.89	4.16%	21,317,287.94	34,322,976.41	38,380,722.28	77,506,701.31
3	130,780,236.78	330,903,357.67	6.64%	29,689,160.33	64,012,136.74	46,205,918.09	123,712,619.40
4	132,671,494.78	463,574,852.45	13.84%	33,645,826.85	97,657,963.59	134,101,615.53	257,814,234.94
5	112,369,360.12	575,944,212.57	24.60%	107,522,564.21	205,180,527.80	200,474,063.97	458,288,298.91
6	171,455,682.58	747,399,895.16	30.20%	46,129,733.89	251,310,261.69	9,601,518.22	467,889,817.13
7	151,836,171.70	899,236,066.86	37.40%	11,044,903.58	262,355,165.27	134,146,213.81	602,036,030.95
8	112,178,869.67	1,011,414,936.52	37.40%	-	262,355,165.27	-	602,036,030.95
9	136,962,360.36	1,148,377,296.88	44.20%	33,650,493.88	296,005,659.15	126,693,646.38	728,729,677.32
10	100,369,362.21	1,248,746,659.09	49.01%	155,620,109.20	451,625,768.35	89,642,959.69	818,372,637.02
11	120,690,361.36	1,369,437,020.45	53.26%	138,560,884.48	590,186,652.82	79,183,528.99	897,556,166.00
12	153,142,782.13	1,522,579,802.58	59.48%	87,632,135.33	677,818,788.15	115,891,368.37	1,013,447,534.37
13	210,321,690.60	1,732,901,493.18	66.68%	101,678,860.21	779,497,648.36	134,146,213.81	1,147,593,748.18
14	130,240,365.31	1,863,141,858.49					

Source, own survey 2024

Table A.3 FHC Mixed Apartment Building Project.

Months	Planned Value (birr)	Cumulative. PV (birr)	Cumu. Complete (%)	Actual Cost (birr)	Cumulative. AC (birr).	Earned value(EV) (birr)	Comm. EV (birr)
Jun,23	31,252,978.74	31,252,978.74	5.1%	26,301,191.50	26,301,191.50	50,014,140.54	50,014,140.54
Jul,23	62,520,899.68	93,773,878.42	11.4%	68,134,404.86	94,435,596.36	61,782,173.61	111,796,314.15
Aug,23	154,158,938.00	247,932,816.42	15.1%	73,955,628.30	168,391,224.66	36,284,768.63	148,081,082.78
Sep,23	110,980,963.90	358,913,780.32	19.7%	59,192,385.56	227,583,610.22	45,110,793.43	193,191,876.21
oct,23	147,751,794.92	506,665,575.24	25.2%	120,213,128.22	347,796,738.44	53,936,818.23	247,128,694.45
Nov,23	114,179,683.23	620,845,258.47	34.3%	147,380,857.45	495,177,595.89	89,240,917.44	336,369,611.89
Dec,23	54,035,112.00	674,880,370.47	37.8%	37,291,235.84	532,468,831.73	34,323,429.78	370,693,041.67
Janu,24	27,924,000.00	702,804,370.47	40.4%	34,650,987.46	567,119,819.19	25,497,404.98	396,190,446.65
Feb,24	43,837,773.00	746,642,143.47	50.2%	76,302,663.80	643,422,482.99	96,105,603.40	492,296,050.05
Mar,24	68,837,773.00	815,479,916.47	59.8%	75,717,621.50	719,140,104.49	94,144,264.55	586,440,314.60
April,24	46,655,588.00	862,135,504.47	65.6%	57,993,352.80	777,133,457.29	56,878,826.50	643,319,141.10
May,24	40,617,754.68	902,753,259.15					
June,24	38,319,745.75	941,073,004.90					
July,24	39,596,417.51	980,669,422.41					

Source, own survey 2024

B. Questionnaire raw data

No	Major causes for variations	Points				
		ΣW	A	N	RII	Rank
1	Client related causes					
1.1.	Slow in decision making	190	5	47	0.809	6
1.2.	underestimation of the time required for project completion	188	5	47	0.800	7
1.3.	Underestimation of project costs	192	5	47	0.818	4
1.4.	Owner's delay in providing the site to the contractor	145	5	47	0.618	38
1.5.	Owner's tardiness in reviewing and approving design documents	160	5	47	0.682	23
1.6.	Delay in approving drawings and samples by the owner	152	5	47	0.645	34
1.7.	Delay in financial payments for completed work by the owner	165	5	47	0.700	21
1.8.	Inadequate supervision	118	5	47	0.550	42
2	Contractor related causes	ΣW	A	N	RII	Rank
2.1	Financial problems	182	5	47	0.773	10
2.2	Sub-contractor delays	152	5	47	0.645	33
2.3	Contractor staff qualifications	169	5	47	0.718	14
2.4	Site management/supervision	175	5	47	0.745	13
2.5	Rework due to errors	141	5	47	0.600	39
2.6	Ineffective planning/scheduling	152	5	47	0.645	32
2.7	Conflicts between contractor and other parties (consultant and owner)	152	5	47	0.645	36
3	Consultant related causes	ΣW	A	N	RII	Rank
3.1	design modification	207	5	47	0.882	1
3.2	Variations order cost	192	5	47	0.818	5
3.3	Consultant performance in terms of specifications and testing;	167	5	47	0.709	16
3.4	Poor Estimation of Project Costs	179	5	47	0.764	11
3.5	Inadequate and unclear detailing in drawings	158	5	47	0.673	26
3.6	Improper timing of the project	167	5	47	0.709	17

3.7	Monitoring and controlling of the project	160	5	47	0.682	24
4	Design related causes	ΣW	A	N	RII	Rank
4.1	Complexity of project design	165	5	47	0.7	22
4.2	Unclear and inadequate details in drawings	169	5	47	0.718	15
4.3	Insufficient experience of the design team	154	5	47	0.655	30
4.4	Failure to use advanced engineering design software	135	5	47	0.573	41
5	Material delays	ΣW	A	N	RII	Rank
5.1	Lack of available building materials in the market	197	5	47	0.836	3
5.2	Material delivery delays	188	5	47	0.8	8
5.3	Materials purchased beyond the deadline	175	5	47	0.745	12
5.4	Price escalation for materials	197	5	47	0.836	2
6	Labor and equipment delays	ΣW	A	N	RII	Rank
6.1	Insufficient workforce in the market	156	5	47	0.664	28
6.2	Laborers' productivity levels are below standard	147	5	47	0.627	37
6.3	Insufficient labor supply	152	5	47	0.645	31
6.4	Equipment operates with low productivity and efficiency	154	5	47	0.655	29
6.5	Issues with equipment availability and breakdowns	167	5	47	0.709	18
6.6	Limited availability of advanced mechanical equipment	160	5	47	0.682	25
7	External delays	ΣW	A	N	RII	Rank
7.1	Impact of underground conditions	165	5	47	0.700	20
7.2	Lack of foreign currency	184	5	47	0.782	9
7.3	Weather-related impacts	160	5	47	0.682	27
7.4	Shifts in government rules and regulations	165	5	47	0.700	19
7.5	Lack of essential utilities on site (e.g., water, electricity, telephone)	152	5	47	0.645	35
7.6	Force majeure events like war.	141	5	47	0.600	40

Source, own survey 2024

C.QUESTIONNAIRE FOR THESIS WORK

Dear /Sir

Please complete this questionnaire in order to participate in and support the research being done as a partial fulfilment of the MSc requirement in construction technology and management on " Assessment of Building Construction Project Performance Using Earned Value Analysis (EVA): A Case of Selected Public Buildings in Addis Ababa.". I would be very grateful for any assistance you could provide. This questionnaire's main objective is to pinpoint the main factors that affect time and cost variances in order to produce a concrete conclusion and formulate targeted recommendations in light of the findings. There are two parts to the questionnaire. General organizational information is covered in part one. The main reasons why Debre Markos University public building development projects differ are covered in part two. The second part outlines the main reasons why selected public building development projects in Addis Ababa city vary.

In this sense, your input is really significant and helps the research's conclusion. All comments will be treated with the utmost confidentiality and used exclusively for this academic project.

Thank you,

Yetsedaw Mekonnen

Candidate for Master of Science in Construction Technology and Management.

Addis College, Construction and Technology Management Post Graduate Program.

Tel: 0912 249464 —Email: yetsedawm@gmail.com.

Addis Ababa, Ethiopia.

QUESTIONNAIRE FOR PARTICIPANTS

PART 1: General information regarding the organization

This questionnaire is intended for completion by respondents, including contractors, clients, and consultants involved in selected public building projects. It aims to explore the main reasons for time and cost discrepancies in chosen public building projects in Addis Ababa.

1. Please specify the type of organization/company representing the respondent.

Client _____ Contractor _____ Consultant _____

2. Respondent's designation:

Project Coordinator _____ Project manager _____ Safety Engineer _____

Office engineer _____ Resident engineer _____ Site supervisor _____

Site Engineer _____ External Consultant _____ Architect _____

Quantity surveyor _____ contact administrator _____ Construction Engineer _____

Structural Engineer _____ Sanitary Engineer _____ Mechanical Engineer _____

Others _____

PART 2: Factors that influence variations in the cost and schedule performance of selected public building projects in Addis Ababa.

Please mark the importance of each cause by ticking the corresponding boxes. Include any comments regarding each factor in the last column, such as reasons, critical causes, or solutions.

E.S. = extremely significant (5);

V.S. = Very significant (4);

M.S. = moderately significant (3);

S.S. = slightly significant (2);

N.S. = Not significant (1).

No.	major causes for variations	Scales					Additional comment (If any)
		E.S (5)	V.S (4)	M.S (3)	S.S (2)	N.S (1)	
1	Client related causes						
1.1	Modifications requested by the owner during construction						
1.2	underestimation of the time required for project completion						
1.3	Underestimation of project costs						
1.4	Owner's delay in providing the site to the contractor						
1.5	Owner's tardiness in reviewing and approving design documents						
1.6	Delay in approving drawings and samples by the owner						
1.7	Delay in financial payments for completed work by the owner						
1.8	Inadequate supervision						
2	Contractor related causes						
2.1	Financial problems						
2.2	Sub-contractor delays						
2.3	Contractor staff qualifications						
2.4	Site management/supervision						
2.5	Rework due to errors						
2.6	Ineffective planning/scheduling						
2.7	Conflicts between contractor and other parties (consultant and owner)						
3	Consultant related causes						
3.1	design modification						
3.2	Variations order cost						
3.3	Consultant performance in terms of specifications and testing;						
3.4	Poor Estimation of Project Costs						
3.5	Inadequate and unclear detailing in drawings						
3.6	Improper timing of the project						
3.7	Monitoring and controlling of the project						
4	Design related causes						

4.1	Complexity of project design						
4.2	Unclear and inadequate details in drawings						
4.3	Insufficient experience of the design team						
4.4	Failure to use advanced engineering design software						
5	Material delays	E.S (5)	V.S (4)	M.S (3)	S.S (2)	N.S (1)	
5.1	Lack of available building materials in the market						
5.2	Material delivery delays						
5.3	Materials purchased beyond the deadline						
5.4	Price escalation for materials						
6	Labor and equipment delays	E.S (5)	V.S (4)	M.S (3)	S.S (2)	N.S (1)	
6.1	Insufficient workforce in the market						
6.2	Laborers' productivity levels are below standard						
6.3	Insufficient labor supply						
6.4	Equipment operates with low productivity and efficiency						
6.5	Issues with equipment availability and breakdowns						
6.6	Limited availability of advanced mechanical equipment						
7	External delays	E.S (5)	V.S (4)	M.S (3)	S.S (2)	N.S (1)	
7.1	Impact of underground conditions						
7.2	Lack of foreign currency						
7.3	Weather-related impacts						
7.4	Shifts in government rules and regulations						
7.5	Lack of essential utilities on site (e.g., water, electricity, telephone)						
7.6	Force majeure events like war.						