ASSESSMENT OF FACTORS CAUSING DELAY IN WASTEWATER TREATMENT PLANT PROJECTS: A CASE OF ETHIOPIAN ENGINEERING CORPORATION

BY:

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A FINAL PROJECT WORK SUBMITTED TO ADDIS ABABA UNIVERSITY, SCHOOL OF COMMERCE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN PROJECT MANAGEMENT

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STATEMENT OF DECLARATION

I declare that the project work entitled "Assessment of Factors Causing Delay in Wastewater Treatment Plant Projects: A case of Ethiopian Engineering corporation (EEC)" is my original work and all sources of material used for the work have been duly acknowledged. ___________________________

HENOK GIRMA TSEGAYE

STATEMENT OF APPROVAL

This is to certify that, this project work "**Assessment of Factors Causing Delay in Wastewater Treatment Plant Projects: A case of Ethiopian Engineering corporation (EEC)**", undertaken by **HENOK GIRMA TSEGAYE** in partial fulfilment of the requirements for Master of Arts in Project Management at Addis Ababa University School of Commerce, is an original work and not submitted earlier for any Degree either at this university or any other university. **_______________________**

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STATEMENT OF CERTIFICATION

This is to certify that the project work prepared by Henok Girma entitled "Assessment of Factors Causing Delay in Wastewater Treatment Plant Projects: A case of Ethiopian Engineering corporation (EEC)" in Partial Fulfilment for the Requirements of the Master of Arts in Project Management complies with the regulation of the university and meets the accepted standards with regards to originality and quality

Approval of Examiners:

Advisor: ______________________________ Sig_____________ Date__________

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External Examiner: ______________________ Sig_____________ Date__________

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LIST OF ACRONYMS

AAWSA	Addis Ababa Water and Sewerage Authority
AC	Actual cost
CPI	Cost performance index
CV	Cost variance
EEA	Ethiopian Economic Association
EEC	Ethiopian engineering corporation
EV	Earned value
EVM	Earned value management
PMBOK	Project Management Body Of Knowledge
PV	Planned value
SPI	Schedule performance index
SPSS	Statistical Package for the Social Sciences
SV	Schedule variance
WWTP	Wastewater treatment plant

ABSTRACT

This study examines the causes of delays in wastewater treatment plant construction projects overseen by the Ethiopian Engineering Corporation. The research focuses on projects including Ziway Federal Prison WWTP, Dire Dawa Federal Prison WWTP, Bole Arabsa WWTP, and Ambo University WWTP. By distributing questionnaires to stakeholders such as clients, contractors, and consultants, an explanatory research approach was employed to establish the cause and effect relationship between variables like poor planning, price escalation, late delivery of construction material, inefficient machinery, and external factors. Utilizing SPSS 20 software for data analysis (including normality tests, correlation, and regression analysis), the study identified correlations between these factors and project delays. The findings emphasize the importance of proactive measures to ensure timely completion and project efficiency, recommending a comprehensive and proactive project management approach for successful outcomes in EEC-managed WWTP projects.

Key word: ***Project delay, delay factor, wastewater treatment plant, construction***

CHAPTER ONE

1 Introduction

The construction industry is a vital component of economic development, playing a significant role in driving a country's Gross Domestic Product (GDP) growth and creating employment opportunities across various sectors. It serves as a catalyst for economic growth by supporting industries such as transportation, manufacturing, trade, social services, and agriculture (EEA, 2008). One crucial aspect of the construction sector is the construction of wastewater treatment plants (WWTP), which holds paramount importance in the context of environmental sustainability and public health.

Wastewater treatment plants are essential infrastructure for maintaining a safe and healthy environment by treating wastewater before its discharge into rivers and water bodies. These plants play a crucial role in preventing water pollution, preserving water quality, and safeguarding public health (Metcalf & Eddy, 2003). Additionally, treated wastewater can be reused for various purposes, further enhancing water resource management and sustainability efforts.

In Ethiopia, the Ethiopian Engineering Corporation (EEC), a federal consulting firm, is actively involved in managing several WWTP construction projects. EEC undertakes responsibilities ranging from design review and approval to construction supervision and overseeing the operation of WWTP facilities. The corporation's role in ensuring the effective implementation of wastewater treatment projects underscores its commitment to environmental protection, public health, and sustainable development in Ethiopia.

This research project aims to assess factors contributing to delay of WWTP projects. The Ethiopian Engineering Corporation is engaged in managing in the design, construction and supervision of wastewater treatment plant with Design-Build and operate delivery mode.

1.1 Background of the study

In the context of environmental sustainability and public health, the construction of wastewater treatment plants (WWTP) holds paramount importance. WWTP infrastructure is essential for maintaining a safe and healthy environment for communities by treating wastewater before it is discharged into rivers and water bodies (Metcalf & Eddy, 2003). The WWTP play a crucial role in preventing water pollution, preserving water quality, and safeguarding public health. Treated wastewater can also be reused for various purposes, further enhancing water resource management and sustainability. Additionally, the construction and operation of WWTPs provide valuable employment opportunities and contribute to the overall well-being of society.

Within this framework, the Ethiopian Engineering Corporation (EEC), a federal consulting firm, is actively involved in managing several WWTP construction projects. As a key player in the sector, EEC undertakes responsibilities ranging from design review and approval to construction supervision and overseeing operation of WWTP facilities.

1.2 Statement of the problem

In recent times, the landscape of project management has evolved to encompass increasingly complex, large-scale endeavors that come with substantial costs and involve a number of stakeholders. These stakeholders typically include contractors, consultants, and the project owner, also known as the client. The interplay among these entities is characterized by a dynamic race to achieve the overarching goals and objectives set forth by the project. The complex nature of modern projects necessitates a high level of coordination and collaboration among all parties involved to ensure successful outcomes (Cicmil & Hodgson, 2006).

The construction industry in Ethiopia is a significant contributor to the country's economy, employing a large workforce and contributing to infrastructure development. The industry's contribution to Ethiopia's GDP is estimated to be around 5%. However, the sector faces various challenges, including a lack of skilled labor, inadequate infrastructure, and limited access to financing.

The construction industry, particularly in projects related to wastewater treatment plants, is inundated by challenges of delay in completion. The delay has significant implications on project success, stakeholder relationships, and overall project delivery. Factors such as poor planning, price escalation, late delivery of construction material, inefficient machinery, and external factors contribute to delay in WWTP construction projects (Aziz, 2012).

Wastewater treatment plant construction in Ethiopia is a crucial aspect of the country's efforts to improve sanitation and environmental sustainability. The construction of wastewater treatment plants in Ethiopia is still in its early stages, with a limited number of plants currently operational (MWIE, 2018).

The construction of wastewater treatment plants in Ethiopia is a critical component of the government's efforts to improve access to safe water and sanitation services. According to a report by the Water and Sanitation Program of the World Bank, only 13% of the population in Ethiopia has access to improved sanitation facilities, and only 8% of the wastewater generated in urban areas is treated (World Bank, 2021)

Understanding the root causes of WWTP project delay and their effects is crucial for project managers, policymakers, and stakeholders to mitigate risks and ensure successful project completion. Therefore, this project aims to investigate the factors contributing to delay in construction projects, specifically focusing on WWTP projects managed by EEC; Ziway Federal Prison WWTP, Dire Dawa Federal Prison WWTP, Bole Arabsa WWTP, and Ambo University WWTP.

1.3 Research Question

The following are the basic research questions:

- What is the impact of poor planning and scheduling in the delay of WWTP projects?
- What is the impact of price escalation in the delay of WWTP projects?
- What is the impact of late delivery of construction material in the delay of WWTP projects?
- What is the impact of inefficient construction machinery and equipment in the delay of WWTP projects?
- What is the impact of external factors in the delay of WWTP projects?

1.4 Objectives of the study

The general and specific objectives of this study is depicted as follows:

1.4.1 General Objective

The project aims to examine the critical factors influencing delay in WWTP construction projects and recommendation for mitigation.

1.4.2 Specific Objectives

- To identify the impact of poor planning and scheduling on WWTP projects delays
- To identify the impact of price escalation on WWTP projects delays
- To identify the impact of late delivery of construction material on WWTP projects delays
- To identify the impact of inefficient construction machinery and Equipment on WWTP projects delays
- To identify the impact of external factors on WWTP projects delays
- To propose recommendations for enhancing WWTP project efficiency.

1.5 Definition of terms

The definition of the following terms is defined taking in to consideration of contextual meaning of the term in this paper.

Project: A project is a temporary initiative carried out to develop a distinctive product, service, or outcome. Projects are executed to achieve specific goals by generating tangible results. They are implemented across all levels of an organization and can involve either an individual or a group. Furthermore, a project may encompass a single department within an organization or multiple units spanning various organizations (PMBOK® Guide, 2013)

Wastewater: The water supply that has been used for various purposes such as domestic, industrial, commercial, or agricultural activities and has become contaminated with pollutants, making it unsuitable for further use without treatment. This definition encompasses the broad spectrum of water that has been utilized and subsequently contaminated with various substances, requiring treatment before it can be safely discharged back into the environment. (Metcalf & Eddy, 2003)

Treatment plant: treatment plant, also known as a sewage treatment plant (STP), is a facility designed to receive and treat waste from various sources such as domestic, commercial, agricultural, and industrial activities. The primary goal of a treatment plant is to remove contaminants from the incoming waste to improve water quality and ensure public health and safety by producing environmentally safe effluent and sludge at the end of the treatment process (Aerni, 2004)

Consultant (Engineer): This person is designated by the Public Body to oversee the progress of the project and ensure that the contractor adheres to the terms of the agreement. They have the authority to inspect the worksite, examine materials used in the project, and test samples to assess their quality. Additionally, they are responsible for monitoring workmanship standards to ensure that they meet the specified requirements. Any authorized representative of this individual holds similar responsibilities (FFPPA, 2011)

Contractor: Entities contracted by governmental bodies to carry out the construction of wastewater treatment facilities. Individuals or legal entities engaged in an agreement with a Public Body to provide construction services (FFPPA, 2011)

Project owner (Client): In a construction project is the individual or organization that initiates and funds the project (FFPPA, 2011)

Stakeholder: Any one that has interest in the decision-making and activities of a project (PMBOK® Guide, 2013)

Commissioning: Checking the wastewater treatment plant for functionality after completion of the construction of it (FIDIC, 2008)

Plant operation: Actual operation of wastewater treatment plant. (FIDIC, 2008)

cost performance index (CPI): is a measure of the cost efficiency of budgeted resources, expressed as a ratio of earned value to actual cost (PMBOK® Guide, 2013)

Schedule performance index(SPI): is a measure of schedule efficiency expressed as the ratio of earned value to planned value. (PMBOK® Guide, 2013)

Planned value (PV): An authorized budget to be assigned foe a scheduled work (PMBOK® Guide, 2013)

Earned value (EV): is a measure of task accomplished, represented in terms of the budget authorized for that work (PMBOK® Guide, 2013)

1.6 Significance of the study

The research focusing on analyzing the critical factors influencing project delays in wastewater construction projects managed by EEC is significant for several reasons:

Efficient WWTP Construction Project Management: Understanding the key factors that contribute to project delays in WWTP construction projects is crucial for improving project management practices. By identifying these critical factors, stakeholders can implement strategies to enhance WWTP project efficiency and mitigate project delay.

Stakeholder Engagement: The study's focus on key stakeholders who are major actors of construction of WWTP, including contractors, project owners (clients), and consultants (EEC), highlights the importance of involving all relevant parties in addressing project challenges. Effective communication and collaboration among stakeholders are essential for successful project delivery.

Mitigation Strategies: The research aims to propose strategies for effectively mitigating project delays in WWTP projects. These mitigation strategies can help prevent future delays, minimize financial losses, and ensure the timely completion of wastewater construction projects.

Knowledge Advancement: By investigating into the specific challenges faced by concerned stakeholders in managing WWTP projects, this research contributes to advancing knowledge in the area of wastewater infrastructure development. The study's findings may also serve as a basis for further research on optimizing project performance in similar contexts.

Overall, this project holds significance not only for key stakeholders and an ongoing WWTP projects, even for the wider construction industry involved in wastewater treatment infrastructure development do have significance.

1.7 Scope of the study

The study will focus solely on delay in wastewater treatment plant (WWTP) projects managed by EEC. Specifically, the study will concentrate on WWTP projects overseen by the corporation. The key stakeholders targeted for this study include contractors, project owners (clients), and the consultant (EEC) actively involved in the construction of WWTP projects. The content of the study is limited to analyzing critical factors (poor planning, price escalation, late delivery of construction material, inefficient machinery, and external factors) that influence delay of wastewater treatment plant construction projects.

1.8 Organization of the study

The paper is structured into five main chapters, beginning with the introduction in chapter one, followed by a review of related literature in chapter two. Chapter three outlines the research design and methodology employed in the study, while chapter four contains data analysis and interpretation. The fifth and final chapter summarizes the findings of the research, drawing conclusions based on these findings and providing recommendations.

1.9 Limitations of the Study

The research for this study primarily focused on delay of wastewater treatment plant projects, where all electro-mechanical components were supplied by foreign suppliers. While it was essential to gather information about these suppliers as they play a significant role in the project, accessing them were challenging. Consequently, the study could have been more comprehensive if the researcher had been granted the opportunity to communicate these suppliers.

CHAPTER TWO

2 Review of Related Literature

In this chapter, an extensive review of previously conducted research papers, books, and articles related to the topic of this study will be presented. By referring the existing literature, the review aims to provide a comprehensive understanding of the knowledge, ideas, and insights shared by other researchers in the field.

2.1 Theoretical Literature Review

The construction industry holds a significant role in the economic growth of countries, as highlighted in a report by the Ethiopian Economic Association (EEA, 2008) in 2008. The report projects a growth rate of 8% per annum in the construction sector from 2023 to 2026. Notably, one crucial aspect of infrastructure development is the establishment of sewage systems, including the construction of wastewater treatment plants.

The construction of wastewater treatment plants is essential for effectively treating wastewater before its discharge into water bodies, as emphasized by (Metcalf & Eddy, 2003). However, a persistent challenge in construction projects, particularly in developing countries, is the difficulty in completing projects on time. (Othman, 2013) categorizes the challenges hindering construction projects in developing nations into four groups: Engineering Challenges, Human Development Challenges, Managerial and Political Challenges, and Sustainability Challenges. The research suggests that addressing these challenges requires the construction of infrastructure facilities to enhance capacity building efforts and mitigate key issues.

Achieving timely and cost-effective completion of projects, such as wastewater treatment plant constructions, remains a difficult task, mirroring the challenges faced by other construction endeavors (Aziz, 2012).

2.1.1 Project Time Management

According to (PMBOK® Guide, 2013) project time management is defined as insuring project completion within the specified completion period. It further elaborates that project time management encompasses the following process to assure timely completion of projects.

Plan Schedule Management: to plan, develop, manage, execute, and control project schedule, framing policies, procedures, and documentation is necessary. The overall process of this is termed as Plan Schedule Management

Define Activities: for production of deliverables of the project, specific actions have to be executed. This process; identifying and recording of the specific action is termed as define Activities.

Sequence Activities: identifying relation among activities and sequencing accordingly.

Estimate Activity Resources: needed resource quantification for performing activities of a given project

Estimate Activity Durations: this is estimating the period required for activities to be completed with the estimated resources.

Develop Schedule: sequencing activities on the basis of dependability, required period and estimated resource.

Control Schedule: the process of updating project progress and entertaining changes through monitoring of project activity status.

2.1.1.1 Project Delay

As (Sweis, 2013) explained time overrun or schedule delay as; the extra time, extending the period beyond the contract duration, to execute remaining tasks stated in the contract document. Time overrun in public construction projects can have significant implications on various aspects of the project, stakeholders involved, and the overall economy of a country. The paper by (Sweis, 2013) focuses on factors affecting time overruns in public construction projects, specifically in the context of Jordan. Understanding the effects of time overrun is crucial for project managers, policymakers, and other stakeholders to mitigate risks and ensure successful project delivery.

2.1.1.2 Causes of Project Delay

(Nega, 2008) has shown the major reasons of time overrun in the construction sector; specifically, in public buildings Causes and Effects of time Overrun on Public Building Construction Projects in Ethiopia, sixty-seven out of seventy of completed public building construction projects were examined and found confronted to time overrun. The study concluded that material price inflation, fluctuation in currency exchange rate, change orders and, slow decision making.

(Habte, 2021) has depicted factors contributing to time overruns in the construction of condominium house project 6 in Addis Ababa. The study aimed to identify the factors contributing to time delays in the construction of condominium house Project 6 in Addis Ababa. The findings of the study highlighted various factors contributing to construction delays in condominium projects, including poor planning and scheduling, inadequate inspection, improper time estimation, insufficient monitoring and evaluation, scarcity of utilities, inefficiencies in equipment and material management were identified as key contributors to time overruns.

2.1.1.3 Effects of Project Delay

Delayed projects might end up in compromising quality, loss of economic justification for a project, legal disputes between different stakeholders involved (including employers, contractors, and consultants), reduced productivity and ultimately termination of the project (Alavifar, 2014).

In conclusion, time overrun in public construction projects has multifaceted effects that go beyond mere delays in project completion. It is essential for stakeholders to address the root causes of time overruns proactively to minimize these adverse impacts and ensure successful project outcomes (Sweis, 2013).

2.1.2 **Project Cost Management**

Project cost management is a critical aspect of construction projects, encompassing a series of intricate processes aimed at effectively allocating resources to ensure the successful completion of a project within the predefined budgetary constraints. As articulated in the (PMBOK® Guide, 2013) project cost management involves a comprehensive approach that includes planning, estimating, budgeting, financing, funding, managing, and controlling costs throughout the project lifecycle.

Planning: The initial phase of project cost management involves meticulous planning to outline the financial framework of the project. This includes developing a detailed cost management plan that delineates how costs will be estimated, budgeted, and controlled throughout the project.

Estimating: Accurate cost estimation is crucial for setting realistic budgetary targets and ensuring financial feasibility. This process involves assessing the costs associated with various project components, activities, resources, and potential risks to develop a comprehensive budget.

Budgeting: Once cost estimates are determined, the next step is to establish a project budget that allocates financial resources to different project tasks and activities. Budgeting helps in tracking expenditures, monitoring financial performance, and ensuring that the project remains within the approved financial limits.

Financing and Funding: Securing adequate financing and funding sources is essential for the successful execution of a construction project. Project managers must identify and secure the necessary financial resources to support project activities, procure materials, hire labor, and meet other financial obligations.

Managing Costs: Effective cost management involves ongoing monitoring and control of project expenditures to prevent cost overruns and ensure that financial resources are utilized efficiently. Project managers must implement cost control measures, track expenses, and address any deviations from the budget in a timely manner.

Controlling Costs: The final stage of project cost management involves controlling costs through regular monitoring, analysis, and adjustment of financial resources. This process includes comparing actual costs against budgeted amounts, identifying variances, investigating the reasons for discrepancies, and implementing corrective actions to realign project finances.

In conclusion, project cost management is a multifaceted process that plays a pivotal role in the successful delivery of construction projects. By implementing robust cost management practices, project stakeholders can enhance financial transparency, mitigate risks of cost overruns, and ensure the efficient utilization of resources to achieve project objectives within the specified budget constraints.

2.1.2.1 Cost Overrun

Cost overrun in construction projects, including those related to wastewater infrastructure, can originate from various sources such as inaccurate cost estimation, scope changes, delays, unforeseen site conditions, inflation, poor project planning, inadequate risk management, and ineffective communication among stakeholders. By analyzing these factors, it is crucial to develop and employed to mitigate them (Aziz, 2012)

When the cost performance index (CPI) value, that is going to be calculated by dividing the earned value to that of the actual cost (EV/AC), is less than 1.0, it indicates cost overrun, as stipulated in (PMBOK® Guide, 2013).

2.1.2.2 Causes of Cost Overrun

(Ghadge, 2016) has shown the major factors for cost overruns. The study identified the major factors contributing for cost overrun in construction projects. The key factors are as follows: poor site management, problem on scheduling, poor stakeholder management, weather condition, not well defined scope of work and knowledge gap.

(Habte, 2021) has depicted factors contributing cost overruns in the construction of condominium house project 6 in Addis Ababa. The study aimed to identify the factors contributing to cost overruns in the construction of condominium house Project 6 in Addis Ababa. The findings of the study highlighted various factors contributing to construction cost overruns in condominium projects, including fluctuation of material prices, inadequate inspection, lack of government control, insufficient monitoring and evaluation, scarcity of utilities, inefficiencies in equipment and material management were identified as key contributors to cost overruns.

2.1.2.3 Effects of Cost Overrun

According (Aziz, 2012) Cost overrun is a common issue in construction projects and can have significant implications on project success and financial viability. the effect of cost overrun as discussed (Aziz, 2012) paper likely emphasizes the importance of cost-relevance analysis in implementing effective strategies for overrun control within project management practices.

2.1.3 Project Stakeholder Management

Project Stakeholder Management involves the essential processes necessary to identify individuals, groups, or organizations that have the potential to influence or be influenced by a project. It encompasses analyzing stakeholder expectations and understanding how these expectations can impact the project. Moreover, it entails developing effective management strategies to engage stakeholders in project decisions and activities (PMBOK® Guide, 2013).

- **Identification of Stakeholders**: The initial step in stakeholder management is identifying all parties that may have an interest in the project. This includes internal and external stakeholders such as team members, sponsors, customers, suppliers, regulatory bodies, and the community (PMBOK® Guide, 2013).
- **Analysis of Stakeholder Expectations**: Once stakeholders are identified, it is crucial to analyze their expectations, needs, concerns, and potential impact on the project. Understanding these factors helps in creating strategies to manage stakeholder relationships effectively (PMBOK® Guide, 2013).
- **Development of Management Strategies**: Based on the analysis of stakeholder expectations and influence, appropriate management strategies are formulated. These strategies aim to engage stakeholders proactively throughout the project lifecycle (PMBOK® Guide, 2013).
- **Continuous Communication**: Effective communication is vital in stakeholder management. Maintaining open lines of communication with stakeholders helps in understanding their evolving needs and expectations, addressing issues promptly, managing conflicts of interest, and fostering active engagement in project decisions (PMBOK® Guide, 2013).
- **Stakeholder Satisfaction as a Key Objective**: Ensuring stakeholder satisfaction is a fundamental objective of project stakeholder management. By meeting stakeholder needs and expectations, projects are more likely to achieve success and gain support from key stakeholders (PMBOK® Guide, 2013).

2.2 Empirical Literature Review

Construction projects in general and specifically Wastewater treatment plant construction projects get delayed due to a number of factors; however, the critical factors that leads delay of WWTP projects are related with key stakeholders of construction of wastewater treatment plant. These stakeholders are; Projects owner, consultant, contractor, construction material, Equipment and machinery, Labor and contract management related factors.

2.2.1 Project Owner (Client) Related Factors

Project owners (Clients) do contribute for project delay due to level of client experience, how the client defines the scope, how the client communicates with other stakeholders, Clients attitude towards variations and Budget constraints as stated by , (Belay et al, 2021) for construction projects in Ethiopia . Further the main factors contributing to project delay from client side are; following a list bidder procurement to select contractors and consultant for a specific WWTP projects, offering additional work once the project is commenced that leads to price escalation; cost overrun. Bureaucracy in bidding/tendering method that hinders competent contractors and consultant to stay away from the bidding and shortening of contract period for political or other purpose as stated by (Aziz, 2012), for WWTP project in Egypt.

2.2.2 Engineer/Consultant Related Factors

The engineer/Consultant related factors for project delay are as follows as identified by (Aziz, 2012). Delay due to Poor planning and scheduling, lack of integration of stakeholders and not using up-to-date cost of materials are identified as major factors contributing for project delay.

Poor planning and scheduling, poor design drawing preparation, not maintaining quality as per the specification, slowness in doing inspection and not timely undertaking test do have great impact in leading to project delay as explained by (Odeh & Battaineh, 2002) are identified as factors related to the engineer or consultant

2.2.3 Contractor and Sub-Contractor Related Factors

According to (Aziz, 2012) late delivery of construction material, Inefficient construction machinery and equipment, shortage of skilled labor specifically for WWTP construction and Lack of coordination between general contractors and subcontractors are identified as major factor contributing to WWTP project delays.

2.2.4 Construction Material Related Factors

Base on the research done by (Belay et al, 2021) Scarcity of construction materials, material prices increase, late delivery of material on-site, use of substandard material due to scarcity and unable to import from abroad the genuine one are the major factors contributing to both cost and time overrun.

the quality of construction materials plays a pivotal role in determining project delays, as emphasized by (Odeh & Battaineh, 2002). Substandard materials can trigger rework, impede construction progress, and ultimately disrupt project timelines and budgets. Moreover, shortages of materials pose a significant threat to construction schedules by causing delays in project completion. Factors such as procurement delays, transportation challenges, and unexpected shortages all contribute to the hindrance of project progress. The local availability of construction materials also influences project delays, with limited options for essential items like cement, steel, and asphalt leading to procurement delays and construction disruptions. Importing construction materials introduces further risks of delays due to extended procurement times, customs clearance issues, and transportation complexities, all of which can impact project schedules negatively.

To address material-related delays effectively, implementing mitigation strategies is crucial. Actions such as maintaining buffer stocks, diversifying suppliers, and conducting regular quality checks can help mitigate the adverse effects of material issues on project schedules. By proactively managing material quality and availability, construction firms can enhance project efficiency, minimize delays, and ultimately improve overall project performance’s

2.2.5 Construction machinery and Equipment related factor

Machinery and equipment-related factors are significant contributors to construction project delays and performance issues. Studies have highlighted the importance of effective management and utilization of machinery and equipment in construction projects. Issues such as equipment availability, reliability, maintenance, and failure can have a direct impact on project timelines and costs. Furthermore, (Odeh & Battaineh, 2002) emphasized the significance of labor productivity as a top-ranked factor for contractors, highlighting the crucial role of machinery and equipment in enhancing workforce efficiency. Proper planning and coordination of equipment usage, timely maintenance, and ensuring the availability of necessary machinery on-site are essential for preventing delays and optimizing construction operations. The effective management of machinery and equipment-related factors is essential for improving project performance, reducing downtime, and enhancing overall productivity in construction projects. By addressing equipment availability, maintenance, and reliability proactively, construction firms can mitigate risks of delays and cost overruns, ultimately leading to successful project outcomes.

2.2.6 External factor

Land acquisition challenges significantly contribute to delays in the construction of wastewater treatment plants, adverse weather conditions also play a substantial role in causing project delays, while delays in regulatory approvals and permits further disturb project timelines. Additionally, alterations in project scope driven by stakeholder demands, such as nearby residents of the project site, frequently result in delays that impact project outcomes and schedules. (Odeh & Battaineh, 2002) conducted a study on construction delays, highlighting the influence of external factors on project performance, emphasizing the critical importance of external factors in meeting project deadlines and ensuring the smooth execution of construction activities.

2.3 Conceptual framework of the Study

In this section a conceptual framework is depicted to show what has been drawn from both theoretical and empirical literature review. For ease of explanation it is depicted in figure 2.3 1 as follows. Therefore, the researcher used a correlation design to investigate the relationship among the five (poor planning, price escalation, late delivery of construction material, inefficient machinery, and external factors) factors and WWTP project delays in order to test the following hypotheses:

Alternative Hypothesis (H1): Poor planning and scheduling do affect WWTP project delays significantly.

Alternative Hypothesis (H2): Price Escalation do affect WWTP project delays significantly.

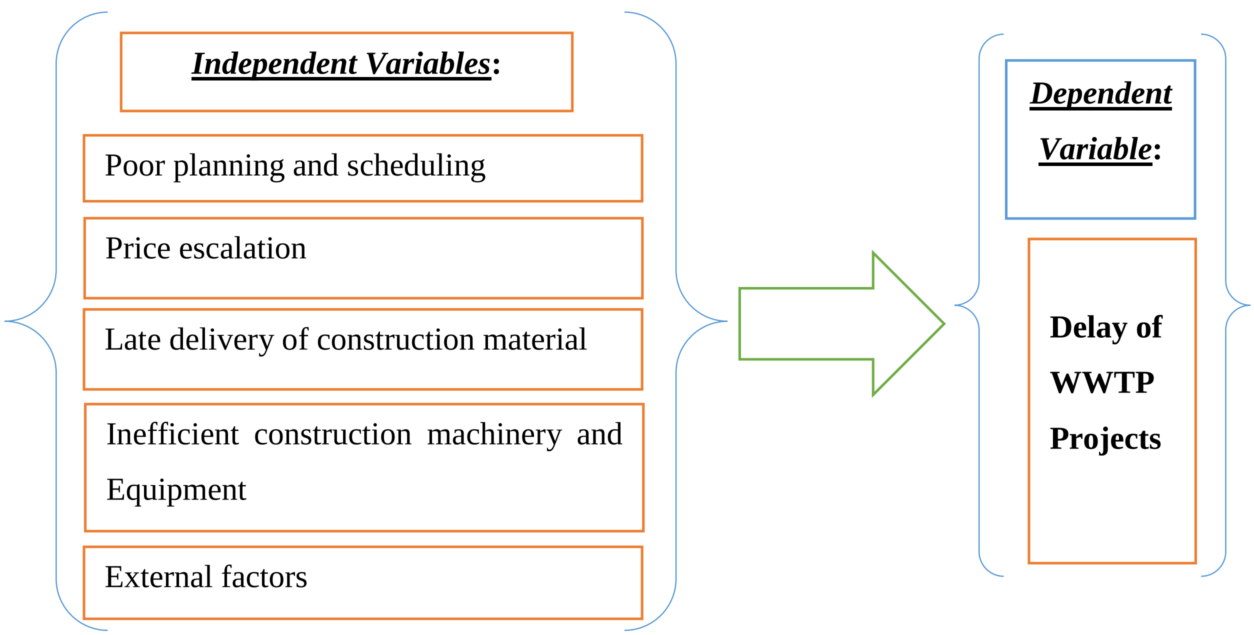
Alternative Hypothesis (H3): Price Escalation do affect WWTP project delays significantly.

Alternative Hypothesis (H4): inefficient construction machinery and equipment do affect WWTP project delays significantly.

Alternative Hypothesis (H5): External factors do affect WWTP project delays significantly.

The hypotheses were formulated to investigate the potential relationships between causal factors and their impact, whether significant or non-significant, on the delays in completing WWTP projects. These hypotheses draw support from various studies in the literature that have explored delays in construction projects. Furthermore, the researcher derived these hypotheses from the research questions, which were developed based on the problem statement and empirical findings (Worku, 2016) and many similar authors

Figure 2.3-1- Conceptual frame work



Source: conceptual model developed by a researcher to explain project delay based on study objectives and existing empirical literature

2.4 Summary of the Literature Review and Research Gap

The referred literatures discuss the challenges of project delay in construction projects. It highlights the significant implications of project delay on project success, stakeholder relationships, and overall project delivery. The literatures emphasize the importance of understanding the causes of project delay, such as material price inflation, currency exchange rate fluctuations, change orders, and poor planning.

Overall, the literature review section emphasizes the importance of proactive measures to mitigate project delay in construction projects to ensure successful project outcomes and stakeholder satisfaction. However, it wasn't discussed much about factors that cause for project delay of wastewater treatment plant projects, managed by EEC.

CHAPTER THREE

3 Research methodology

3.1 Introduction

This chapter discusses the research methodology employed in the study. It depicts the analytical approach and how analysis will be carried out in line with the study goal. It covers the research design, population sample size and sampling technique, data collection instruments and methods of data analysis.

3.2 Research design

Explanatory or casual research approach is used with the objective of establishing the cause and effect relationship between variables (dependent and independent) which are depicted in Figure 2.3 1- Conceptual frame work.

An explanatory study is utilized to establish a causal relationship between variables. In this research design, questionnaires are employed for data collection, focusing on quantitative approaches. The aim of this approach is to comprehensively understand the key factors contributing to delays in WWTP construction projects. Explanatory research examines into causes and reasons, by uncovering and measuring causal relations among dependent and independent variables (Mitchell, 2007) that led to delay in WWTP projects.

3.3 Target Population

The populations considered for this research are the technical staff members of the major stakeholders involved in the construction of Wastewater Treatment Plant (WWTP) projects managed by EEC. These stakeholders include clients, consultants, and contractors working on projects such as Ziway Prison WWTP, Diredawa Prison WWTP, Ambo University WWTP, and Bole Arabsa WWTP.

3.4 Sampling Technique

Considering the different positions of the staff members of the major stakeholders; Contractor, consultant and Client, they are stratified accordingly. To ensure that all staff members in both the managerial and technical position categories have an equal chance of being chosen for the sample, a simple random sampling technique is utilized.

3.5 Sample Size

Sample size is going to be determined by proportionating the population; staff members of the major stakeholders. For the sake of formula simplicity and being the population finite the formula, depicted in equation 3.5-1, developed by Yamane (1973) is considered.

$n = N/(1 + Ne^2)$ ....*Equation 3.5-1*

A 95% confidence level, and e = ±5% are assumed for the Equation

Where:

n-is the sample size

N-is the population size

e-is the level of precision

Projects Considered

In this study, a comprehensive analysis was conducted on four distinct projects. These projects include; Diredawa prison center WWTP project, Ziway prison center WWTP project, Bole Arabsa WWTP project, and the Ambo University WWTP project.

a) **Diredawa Prison Center WWTP Project:**
   - **Client:** Federal Prison Administration
   - **Contractor:** TNT Construction and Trading
   - **Consultant:** EEC

b) **Ziway Prison Center WWTP Project:**
   - **Client:** Federal Prison Administration
   - **Contractor:** FE Construction PLC
   - **Consultant:** EEC

c) **Bole Arabsa WWTP Project:**
   - **Client:** Addis Ababa Water and Sewerage Authority

- **Contractor:** CGCOC Group, Chinese construction company
- **Consultant:** EEC

d) **Ambo University WWTP Project:**

- **Client:** Ambo University
- **Contractor:** TNT Construction and Trading
- **Consultant:** EEC

Sample size calculation: Using Equation 3.5-1

$$\mathbf{n = N/(1 + Ne^2) = 156/(1 + 156\ (0.05^2)) = 112}$$

Thus, 112 questionnaires were distributed to respondents and the detail of how proportion is made is depicted in the table 3.5 1 as follows.

Table 3.5-1 Summary of sample size computation

No	Key stakeholders involved	Total no of employees related with the selected projects	Simple random sampling
1	Project owners (Client)	54	37
2	Contractors	70	37
3	Consultants	32	38
	Total	**156**	**112**

3.6 Data collection instrument

To fulfill the purpose of the study, the researcher used primary data sources. The primary data is collected through questionnaire. The questionnaire method as instrument of data collection is used because it provides wider coverage to the sample and also facilitates collection of a large amount of data.

For this study, close-ended questionnaires are utilized and distributed to clients, consultants, and contractors of the following four projects: Diredawa Prison Center WWTP project, Ziway Prison Center WWTP project, Bole Arabsa WWTP project, and the Ambo University WWTP project via google form and hard copy questioner.

3.7 Methods of Data Analysis

The collected quantitative data, through closed ended questionnaire, is tabulated, arranged and coded, organized using Microsoft excel office software. After the data is organized in Excel, the data is analyzed using a statistical software named SPSS 20; The data analysis techniques employed for analyzing the primary data includes reliability test, correlation test and Regression analysis**.**

3.7.1 Reliability Test

According to (Saunders, 2009) reliability in data analysis refers to the consistency and dependability of the results obtained through data collection techniques or analysis procedures. It indicates the extent to which these methods yield consistent findings when applied repeatedly under the same conditions. For this study a reliability test is done by using Cronbach's Alpha (α) Coefficient. this coefficient, is a statistical method used to assess the internal consistency and reliability of scales or questionnaires. It evaluates how closely related a set of items are as a group, indicating the extent to which the items in the scale measure the same underlying construct. When a Cronbach's alpha coefficient is zero, it indicates that variability is due to measurement error. On the contrary, when a Cronbach's alpha coefficient becomes one, it indicates true score variability (Mouton, 2001).

The value of Cronbach's alpha coefficient serves as a measure of reliability in statistical analysis. When the alpha coefficient is equal to or greater than 0.9, it indicates very high reliability in the data being analyzed. If the alpha coefficient falls below 0.9 but is still equal to or greater than 0.7, the reliability is considered high. Similarly, when the alpha coefficient is less than 0.7 but equal to or greater than 0.5, the reliability is categorized as moderate. However, if the alpha coefficient drops below 0.3, it signifies little to no reliability in the data under examination

The calculation of Cronbach's alpha coefficient involves using Equation 3.7-1, as illustrated below.

$$\propto = \frac{k}{(k-1)}\left(1 - \frac{\sum_{i=1}^{k}\sigma_i^2}{\sigma_t^2}\right) \text{..} \textit{Equation 3.7-1}$$

Where:

k- the number of items in a scale

σ_i^2 – the variance of i^th item

σ_t^2 –the variance of the scale (total) scores

For reliability test 20 questioners were distributed and the reliability test result is tabulate in the table under

Table 3.7-1 Reliability Statistics

Reliability Statistics	
Description	Cronbach's Alpha
Project delay	0.917
Poor planning and scheduling	0.742
Price Escalation	0.831
Late delivery of construction materials	0.624
Inefficient construction machinery and equipment	0.441
External Factor	0.816

Source: The Reliability Statistics were obtained from the results of this study conducted at the selected institution, EEC.

The results presented in Table 3.7-1 indicate the reliability of the data collected through the five-point Likert scale survey. To assess the reliability of the data, Cronbach's Alpha test was conducted. This statistical method measures the internal consistency of a questionnaire or scale by calculating the correlation between items. In this study, the result of Cronbach's Alpha test is good. This value signifies an acceptable level of reliability on the five-point Likert scale, where responses range from 1 (strongly disagree) to 5 (strongly agree).

3.7.2 Regression model

Regression analysis model is a statistical technique employed to establish the relationship amongst a dependent variable and one or more independent variables. It provides a means to estimate dependent variable value based on independent variables values (Kothari, 2004).

$$PD = \beta_0 + X_1\,\beta_1 + X_2\,\beta_2 + X_3\,\beta_3 + X_4\,\beta_4 + X_5\,\beta_5 + e \text{ ......Equation 3.7-2}$$

Where

PD-project delay

$\boldsymbol{\beta_0}$ – slope

$\boldsymbol{\beta_1}$ – coefficient of independent variable, poor planning and scheduling

$\boldsymbol{\beta_2}$ – coefficient of independent variable, price escalation

$\boldsymbol{\beta_3}$ – coefficient of independent variable, late delivery of construction material

$\boldsymbol{\beta_4}$ – coefficient of independent variable, inefficient equipment and machinery

$\boldsymbol{\beta_5}$ – coefficient of independent variable, external variable

e- error term

3.7.3 Correlation Test (Pearson correlation coefficient (r_s))

For statistical measurement of the strength of a monotonic relationship between paired data. It is represented by (rs) and its value ranges between -1 and 1. i.e. $-1 \leq r_s \leq 1$. When the value is close to 1 and -1, it indicates strong monotonic relationship.

It is used to determine how well the relationship between two variables can be described using a monotonic relationship. The test helps in determining the strength and direction of the relationship between two variables. A value close to +1 indicates a perfect positive monotonic relationship, while a value close to -1 indicates a perfect negative monotonic relationship. The formula by Charles Spearman, 1904 for calculating the Spearman rank correlation coefficient is as follows:

$$r_s = 1 - \frac{6\sum d_i{}^2}{n(n^2-1)} \quad \text{..........} \quad \textit{Equation 3.7-3}$$

Where

r_s –Pearson correlation coefficient

d_i –Difference between the ranks of corresponding pairs of variables

n -Number of observations

3.7.4 Variable Measurements

For this study a 5-point Likert scale is considered. It is commonly used in research to measure attitudes, opinions, or behaviors. It consists of five response options that makes respondents to choose either their level of agreement or disagreement. The options typically range from strongly disagree to strongly agree, with a neutral option in the middle.

Table 3.7-2 variable measurement using Likert's scale

Item	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Scale	5	4	3	2	1

3.8 Research Ethical Consideration

In this study, Ethical consideration is made to ensure participants right, wellbeing and off course for the validation of findings. To conduct an impactful research in a responsible way research guidelines must be followed. Some of critical consideration to be made while interacting with the participants are as follows; voluntary participation, informed consent, anonymity, confidentiality and potential for harm.

CHAPTER FOUR

4 RESULTS AND DISCUSSIONS

4.1 Results of the Study

The analysis involves a thorough review of the data collected and recorded together with the identified problem statements. This process is crucial for understanding the underlying issues that contribute to project delays within Ethiopian Engineering corporation on wastewater treatment plant projects.

4.1.1 Respondents Characteristics

Based on the careful preparation and distribution of one hundred twelve (112) questionnaires to the identified target respondents, a 100% response rate was achieved. The completed questionnaires were subsequently subjected to data analysis utilizing excel and SPSS 20.

4.1.2 Demographic Characteristics

This section provides insights into the demographic characteristics of respondents involved in wastewater treatment plant construction projects. The study includes participants with varying educational qualifications, such as certificate, diploma, bachelor's degree (BSc), and master's degree (MSc). The positions within organizations related to the projects range from Project Managers to foreman, reflecting a diverse range of roles. Additionally, the study considers the years of relevant work experience in wastewater treatment plant construction projects, categorizing participants based on their experience levels. All of these characteristics are summarized and depicted in table 4.1-1-The Demographic Characteristics of respondent.

Table 4.1-1 Demographic Characteristics of respondent

No	Attributes	Frequency	Percentage of frequency (%)
1	**Gender**		
	• Male	96	85.7
	• Female	16	14.3
	Total	**112**	**100**
2	**Qualification**		
	• Certificate	0	0
	• Diploma	12	10.7
	• Bachelor's Degree (B.Sc.)	52	46.4
	• Master's Degree (M.Sc.)	48	42.9
	Total	112	100
3	**Position**		
	• Project Manage	18	16.1
	• Site Engineer	44	39.3
	• Office Engineer	38	33.9
	• Forman	12	10.7
	Total	112	100
4	**Work Experience**		
	• <4	33	29.5
	• 4-8	50	44.6
	• 9-12	8	7.1
	• >12	21	18.8
	Total	112	100

Source: The demographic characteristics of respondents were obtained from the results of this study conducted at the selected institution, EEC.

The demographic characteristics of the study results reveals the 112 respondents' profiles. Firstly, the gender distribution indicates a male majority, accounting for 85.7 % of the sample compared to 14.3 % females. Secondly, the educational qualifications of the respondents show a well-educated group, with a significant proportion holding either a

Bachelor's Degree (46.4%) or a Master's Degree (42.9%). This high level of educational attainment implies a knowledgeable and skilled group of individuals contributing to the study.

Moving on to the positions held by the respondents, the data highlights a diverse range of roles within the wastewater treatment plant industry. Site engineer appeared as the most common position at 39.3 %, followed closely by office Engineers at 33.9%. The rest project manager (16.1%) and Forman (10.7%) are following the small percentage. This distribution suggests a blend of various technical expertise among the respondents, reflecting the hierarchical structure and functional diversity within the industry. Lastly, the distribution of work experience levels among the respondents indicates a mix of experienced professionals and those in the early stages of their careers. The majority fell within the 4-8 years of experience group (44.6%), with notable representation in the less than 4 years of experience (29.5%) years, between 9-12 years of experience 7.1% and finally with greater than 12 years (18.8%).

In summary, the demographic characteristics of the study results depicts of a predominantly male, highly educated group of professionals occupying various roles within the industry. The blend of managerial and technical positions, coupled with a range of experience levels, enriches the diversity and expertise brought to the study. Understanding these demographic profiles is crucial for contextualizing the study findings, identifying trends, and drawing meaningful insights that can inform decision-making and future research directions

4.1.3 **Descriptive Statistics of the Participants**

Table 4.1-2 descriptive statistics of participants in construction projects reveal valuable insights into the factors contributing to delays. The mean delay values ranging from 4.158 to 4.195 indicate that delays due to poor planning and scheduling, late delivery of construction material, and inefficient construction machinery and equipment are relatively close in magnitude, while delays related to external factors have a slightly higher mean delay. The standard deviations varying from 0.345 to 0.485 suggest that delays due to poor planning and scheduling have the least variability, while delays related to external factors exhibit the highest variability, indicating a wider range of delay experiences among participants. This variability underscores the diverse nature of external factors impacting project timelines, potentially leading to more unpredictable delays compared to other factors.

Table 4.1-2 Descriptive statics of participants

	N	Minimum	Maximum	Mean	Std. Deviation
Delay related to External factors	112	3.00	5.00	4.178	0.485
Delay due to price escalation	112	3.00	5.00	4.176	0.381
Delay due to Inefficient construction machinery and equipment	112	3.00	5.00	4.158	0.366
Delay due to late delivery of construction material	112	3.00	5.00	4.195	0.355
Delay due to Poor planning and scheduling	112	3.00	5.00	4.172	0.345

Source: The Descriptive statics of participants were obtained from the results of this study conducted at the selected institution, EEC.

4.1.4 **Correlation Analysis**

The Pearson correlation analysis, that is conducted in this study depicts the relationships between project delays and the five independent variables; poor planning, price escalation, late delivery of construction material, inefficient machinery and equipment and external factors in the context of wastewater treatment plant construction projects at Ethiopian engineering corporation.

The results reveal significant correlations between project delays and factors: poor planning, price escalation, late delivery of construction material, inefficient machinery and equipment, and external factors.

Poor Planning and Scheduling: The positive correlation coefficient of (**r_s=0.900, p=0.000**) between poor planning and project delays suggests that inadequate planning and scheduling practices are associated with delays in project completion. This relationship underscores the importance of comprehensive and efficient project planning to minimize delays and ensure project success.

Price Escalation: The strong correlation coefficient of (**r_s=0.881, p=0.00**) between price escalation and project delays indicates a significant relationship between increasing project costs and delays in project. This finding emphasizes the critical role of cost management strategies in controlling project delays.

Late Delivery of Construction Material: The positive correlation coefficient of (**rs=876 p=0.000**) between late delivery of construction material and project delays highlights the impact of delays in material procurement and delivery on project timelines. Timely and reliable material delivery is crucial for preventing disruptions and avoiding delays in wastewater treatment plant construction projects.

Inefficient Construction Machinery and Equipment: The high correlation coefficient of (**rs=0.671, p=0.000**) between inefficient machinery and project delays underscores the considerable impact of machinery performance on project delay. utilizing efficient and well-maintained machinery is essential for minimizing project delays due to inefficient construction machinery and equipment.

External Factors: The significant correlation coefficient of **(rs=0.875, p=0.000)** between external factors and project delays indicates that external influences, such as land acquisition, adverse weather conditions, delay in approval of permit from regulatory or unforeseen events, play a crucial role in project delays. Managing and mitigating external risks are essential for minimizing delays.

Overall, the relationships between the independent variables and project delays reveal the relationship of factors that contribute to delays in construction projects. Addressing issues related to poor planning, price escalation, material delivery delays, machinery inefficiencies, and external risks is dominant for effective wastewater treatment plant project management and successful project outcomes.

Table 4.1-3 Pearson Correlation Analysis

		PPS	PE	LDCM	ICME	EF	PD
PPS	CC	1	.853	.938	.578	.840	.900
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	112	112	112	112	112	112
PE	CC	.853	1	.829	.603	.878	.881
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	112	112	112	112	112	112
LDCM	CC	.938	.829	1	.535	.794	.876
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	112	112	112	112	112	112
ICME	CC	.578	.603	.535	1	.609	.671
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	112	112	112	112	112	112
EF	CC	.840	.878	.794	.609	1	.875
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	112	112	112	112	112	112
PD	CC	.900	.881	.876	.671	.875	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	112	112	112	112	112	112

CC-Pearson Correlation

** Correlation is significant at the 0.01 level (2-tailed).

Source: The Pearson Correlation Analysis were obtained from the results of this study conducted at the selected institution, EEC.

4.1.5 **Regression Analysis**

4.1.5.1 Tests of Normality

Testing of data; to measure the deviation of the data from the mean/ central tendency of the data normality test is done via SPSS-20 numerically. The result is depicted in table 4.1 4 Tests of Normality.

Table 4.1-4 Tests of Normality

Tests of Normality

	Kolmogorov-Smirnov[a]			***Shapiro-Wilk***		
	Statistic	df	Sig.	**Statistic**	**df**	**Sig.**
Project Delay	.173	112	.000	**.928**	**112**	**.350**

a. Lilliefors Significance Correction

Source: Tests of Normality were obtained from the results of this study conducted at the selected institution, EEC.

The normality tests were conducted using the Shapiro-Wilk tests for the Project Delay data. The results indicated that the data do follow a normal distribution, as evidenced by the significant p-values for both tests (p = 0.350). Based on the results of the normality tests, it is recommended to consider parametric statistical methods. For this study as depicted in Table 4.1.3 a Pearson Correlation Analysis is done and result of it also depicted in the same table.

4.1.6 **Regression Results**

4.1.6.1 The ANOVA table

The analysis of variance (ANOVA) table, depicted in the table under Table 4.1 5, The ANOVA table of the regression analysis, for the regression model on project delays depicts significant findings. The F-statistic which is equal to 171.427 is highly significant with p value of 0.000 indicating that the regression model is a good fit.

Furthermore, the model result depicts that it is statistically significant, supporting the alternative hypothesis that all of the predictors has a significant effect on project delays. Therefore, we reject the null hypothesis of no relationship between the predictors and project delays. Thus all null hypotheses are rejected.

To sum up, based on the ANOVA results, we can confidently accept the alternative hypotheses that the predictors included in the regression model have a significant influence on project delays in construction projects of wastewater treatment plants.

Table 4.1-5 The ANOVA table of the regression analysis

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19.944	5	3.989	171.427	.000[b]
	Residual	2.466	106	.023		
	Total	22.410	111			

a. Dependent Variable: Project Delay

b. Predictors: (Constant), External Factors, Inefficient Construction Machinery and Equipment, Late Delivery of Construction Material, Price Escalation, Poor Planning and Scheduling

Source: The ANOVA table were obtained from the results of this study conducted at the selected institution, EEC.

4.1.6.2 Model summery

The model summary depicted under table 4.1 6 Model Summary, indicates that the regression model for project delays is statistically significant and provides valuable understandings into the factors influencing project delay.

Table 4.1-6 Model Summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.943[a]	.890	.885	.15254	2.008

a. Predictors: (Constant), External Factors, Inefficient Construction Machinery and Equipment, Late Delivery of Construction Material, Price Escalation, Poor Planning and Scheduling.

b. Dependent Variable: Project Delay

Source: model summery were obtained from the results of this study conducted at the selected institution, EEC.

The R-squared value of 0.890 shows that approximately 89% of the variance in project delays can be explained by the predictors. This high R-squared value indicates a strong relationship between the independent variables (External Factors, Inefficient Construction Machinery and Equipment, Late Delivery of Construction Material, Price Escalation, Poor Planning and Scheduling) and the dependent variable (Project Delay).

Furthermore, the Adjusted R-squared value of 0.885 adjusts the R-squared value for the number of predictors in the model, providing a more accurate representation of the model's goodness of fit. The standard error of the estimate (0.15254) reflects the accuracy of the model in predicting project delays based on the selected predictors.

The Durbin-Watson statistic of 2.008 is close to the ideal value of 2, indicating that there is no significant autocorrelation present in the model. This suggests that the residuals are independent and do not exhibit a systematic pattern and this reinforce the reliability of the regression analysis results.

In conclusion, the model summary highlights the effectiveness of the regression model in explaining and predicting project delays based on the identified factors.

4.1.6.3 The Coefficients of the Regression Analysis

The coefficient table, depicted under table 4.1 7 Coefficients of the Regression Analysis, presents a detailed examination of the relationship between the five predictors and project delays. Each predictor, namely poor planning and scheduling, price escalation, late delivery of construction material, inefficient machinery and equipment, and external factors, demonstrates a statistically significant coefficient (p less than 0.05), indicating their individual impact on project delays.

$$\boldsymbol{PD = \beta_0 + X_1\,\beta_1 + X_2\,\beta_2 + X_3\,\beta_3 + X_4\,\beta_4 + X_5\,\beta_5 + e}$$

Where:

PD-project delay

$\boldsymbol{\beta_0}$ – slope

$\boldsymbol{\beta_1}$ – coefficient of independent variable, poor planning and scheduling

$\boldsymbol{\beta_2}$ – coefficient of independent variable, price escalation

$\boldsymbol{\beta_3}$ – coefficient of independent variable, late delivery of construction material

$\boldsymbol{\beta_4}$ – coefficient of independent variable, inefficient equipment and machinery

$\boldsymbol{\beta_5}$ – coefficient of independent variable, external variable

e- error term

Table 4.1-7 Coefficients of the Regression Analysis

		Coefficients[a]				
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.013	.207		-4.883	.000
	Poor Planning and Scheduling	.322	.138	.247	2.336	.021
	Price Escalation	.233	.091	.198	2.571	.012
	Late Delivery of Construction Material	.275	.120	.218	2.301	.023
	Inefficient Construction Machinery and Equipment	.189	.051	.154	3.702	.000
	External Factors	.210	.068	.227	3.100	.002

a. Dependent Variable: Project Delay

Source: Coefficients of the Regression Analysis were obtained from the results of this study conducted at the selected institution, EEC.

The coefficient for poor planning and scheduling is .322 ($p = .021$), suggesting that for every unit increase in poor planning, project delays are expected to increase by .322 units. Similarly, price escalation exhibits a coefficient of .233 ($p = .012$), late delivery of construction material shows a coefficient of .275 ($p = .023$), inefficient machinery and equipment display a coefficient of .189 ($p = .000$), and external factors present a coefficient of .210 ($p = .002$).

4.2 Discussions

4.2.1 Discussions of the Hypothesis Testing

Hypothesis testing is used to evaluate the results of a hypothesis that has been tested on a sample data set from the entire population. The outcome of the test helps to determine whether the alternative hypothesis is true or not

Based on the regression analysis result discussed under section 4.1, the results can be interpreted. The process typically involves two hypotheses - the null hypothesis (H0) and the alternative hypothesis (Ha). The null hypothesis typically states that there is no significant relationship between the independent variable and the dependent variable, while the alternative hypothesis suggests that there is a significant relationship.

Restrictions for the Hypothesis: A low p-value suggests rejecting the null hypothesis at a significance level of $p<0.05$. A predictor with a low p-value is likely to significantly contribute to changes in the response variables within the model.

For this study's results, the primary limitations imposed on the hypotheses are as follows: If the p-value is less than α (0.05), **reject the null hypothesis; otherwise, accept it**.

i. Discussions of the first Hypothesis result (Poor Planning and Scheduling):

The coefficient analysis showed that poor planning and scheduling significantly impact wastewater treatment plant project delays, with a statistically significant coefficient ($p = 0.021$), leading to the rejection of the null hypothesis.

Null Hypothesis (H0): Poor planning and scheduling do not have a significant influence on project delays.

Alternative Hypothesis (Ha): Poor planning and scheduling do affect project delays significantly.

Interpretation: Poor planning and scheduling significantly impact project delays, as the coefficient is statistically significant ($p = 0.021$), refer Table 4.1.7 Coefficients of the Regression Analysis

Decision: Reject the null hypothesis (H0).

Effective planning and scheduling practices are critical components in ensuring the success of any project. When projects are well-planned and scheduled, they are more likely to be completed with no delay at all. This finding highlights the significance of careful planning and scheduling in mitigating delays.

The coefficient analysis showed that late delivery of construction material significantly impacts wastewater treatment plant project delays. As depicted by a statistically significant coefficient ($p = 0.023$) that necessitated the rejection of the null hypothesis. This finding emphasizes the critical relationship of timely and reliable material delivery and wastewater treatment plant projects delay

ii. Discussions of the second Hypothesis result (Price Escalation):

The coefficient analysis showed that ` significantly impacts wastewater treatment plant project delays, with a statistically significant coefficient ($p = 0.012$) that led to the rejection of the null hypothesis. This outcome emphasizes the importance of implementing effective cost management strategies to control wastewater treatment plant project delays and follow to budget constraints

Null Hypothesis (H0): Price Escalation do not have a significant influence on project delays.

Alternative Hypothesis (Ha): Price Escalation do affect project delays significantly.

Interpretation: Price Escalation significantly impact project delays, as the coefficient is statistically significant ($p = 0.012$), refer Table 4.1 7 Coefficients of the Regression Analysis.

Decision: Reject the null hypothesis (H0).

The implication of this outcome is that organizations undertaking projects need to pay close attention to cost management practices. By implementing strong strategies to monitor and control costs effectively, project managers can better navigate potential delays caused by price escalations. This proactive approach not only helps in adhering to budgetary constraints but also ensures smoother project execution and delivery within specified timelines.

In conclusion, the examination of price escalation's impact on wastewater treatment plant project delays emphasizes the critical role of cost management in project success. By recognizing and addressing the challenges posed by price fluctuations early on, organizations can enhance their ability to deliver projects efficiently and within budget

iii. Discussions of the third Hypothesis result (Late Delivery of Construction Material):

The coefficient analysis showed that late delivery of construction material significantly impacts wastewater treatment plant project delays.

Null Hypothesis (H0): Late Delivery of Construction Material do not have a significant influence on project delays.

Alternative Hypothesis (Ha): Price Escalation do affect project delays significantly.

Interpretation: Late Delivery of Construction Material significantly impact project delays, as the coefficient is statistically significant (p = 0.023), refer Table 4.1 7 Coefficients of the Regression Analysis.

Decision: Reject the null hypothesis (H0).

As depicted by a statistically significant coefficient that necessitated the rejection of the null hypothesis. This finding emphasizes the critical relationship of timely and reliable material delivery and wastewater treatment plant projects delay.

iv. Discussions of the fourth Hypothesis result (Inefficient Construction Machinery and Equipment):

The coefficient analysis showed that inefficient construction machinery and equipment on wastewater treatment plant project delays.

Null Hypothesis (H0): inefficient construction machinery and equipment do not have a significant influence on project delays.

Alternative Hypothesis (Ha): inefficient construction machinery and equipment do affect project delays significantly.

Interpretation: inefficient construction machinery and equipment significantly impact project delays, as the coefficient is statistically significant (p = 0.000), refer Table 4.1 7 Coefficients of the Regression Analysis.

Decision: Reject the null hypothesis (H0).

As depicted by a statistically significant coefficient (p = 0.000) that necessitated the rejection of the null hypothesis. This emphasizes the vitality of leveraging efficient and well-maintained machinery to minimize delays attributed to machinery inefficiencies.

v. Discussions of the fifth Hypothesis result (External factors):

The coefficient analysis showed that external factors on wastewater treatment plant project delays delay

Null Hypothesis (H0): External factors do not have a significant influence on project delays.

Alternative Hypothesis (Ha): External factors do affect project delays significantly.

Interpretation: External factors significantly impact project delays, as the coefficient is statistically significant (p = 0.002), refer Table 4.1 7 Coefficients of the Regression Analysis.

Decision: Reject the null hypothesis (H0).

As depicted by a statistically significant coefficient that necessitated the rejection of the null hypothesis. This emphasizes the crucial role played by external influences such as land acquisition challenges, adverse weather conditions and delays in permit approvals.

CHAPTER FIVE

5 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Major Findings

The research study conducted within the Ethiopian Engineering Corporation focused on investigating the predictors influencing project delays in wastewater treatment plant projects. The construction industry, known for its competitiveness and complexity, faces challenges in executing such projects due to uncertainties that can lead to delays. The analysis highlighted the significant impact of external factors, inefficient construction machinery and equipment, late delivery of construction material, price escalation, and poor planning and scheduling on project delays. These predictors were found to explain approximately 89% of the variance in project delays, emphasizing the critical role of addressing these factors to enhance project success.

The findings underscore the importance of effective management of external factors, such as land acquisition challenges, adverse weather conditions, and delays in permit approvals, to minimize project delays. Additionally, the study emphasized the significance of utilizing efficient and well-maintained machinery to reduce delays attributed to machinery inefficiencies. Timely and reliable delivery of construction material, along with implementing cost management strategies to control price escalation, were identified as crucial factors in mitigating project delays. Furthermore, the research highlighted the essential role of effective planning and scheduling practices in ensuring project success and timely delivery.

The findings of this paper align (Liu, 2018) emphasized the critical role of effective project management in addressing delays in wastewater treatment plant projects. The research highlighted the significance of proactive planning, stakeholder involvement, and efficient resource management in ensuring project success. In a research article, (Wang, 2019) the authors discussed the impact of external factors such as regulatory approvals, weather conditions, and material availability on project delays in construction projects. The study underscored the need for proactive measures to mitigate the influence of these external factors and enhance project efficiency

5.2 CONCLUSION

After conducting a research on project delays in wastewater treatment plant projects managed by Ethiopian Engineering Corporation (EEC) by considering wastewater treatment plants located at Ziway Federal Prison, Dire Dawa Federal Prison, Ambo University, and Bole Arabsa Condominium housing site, several key understandings have emerged. The study, which involved a thorough literature review and analysis of factors impacting project delays, indicates the complexities and challenges occurring in managing construction projects within the wastewater treatment sector.

In this study, a detailed investigation was conducted into critical factors that results project delay in wastewater treatment plant projects. These factors included factors; such as poor planning and scheduling, price escalation, late delivery of construction material, inefficient construction machinery and equipment, and external factors, the study revealed significant correlations between these variables and project delays. Through this comprehensive examination, the study uncovered substantial correlations between these variables and the occurrence of project delays. This correlation highlights the interconnected nature of these factors and their direct influence on the timely completion of wastewater treatment plant projects.

The findings of the study emphasized the vital importance of proactively addressing these identified factors to effectively mitigate delays in project execution. By recognizing the significant impact of poor planning and scheduling, price escalation, late delivery of construction material, inefficient construction machinery and equipment, and external factors on project delays. Thus proactive approach is essential for ensuring the successful and timely completion of wastewater treatment plant projects, ultimately contributing to the overall efficiency and effectiveness of project management practices.

The research result serve as an indication for project stakeholders to prioritize the early identification and mitigation of these critical factors to enhance project outcomes. By acknowledging the interconnectedness of poor planning, price escalations, material delays, machinery inefficiencies, and external factors with project delays.

Project teams can develop tailored solutions and contingency plans to address these challenges effectively. This proactive stand not only mitigates the risk of delays but also care for a stronger and adaptive project management approach that can navigate unforeseen obstacles and ensure project success.

In conclusion, the study depicts the significant correlations between key project factors and delays in wastewater treatment plant projects emphasize the need for a holistic and proactive project management approach. By addressing these factors early on, project teams can enhance wastewater treatment plant project efficiency, minimize delays and deliver within specified timelines.

The involvement of key stakeholders including contractors, consultants, and clients in the selected wastewater treatment plant projects played a fundamental role in shaping project outcomes. The interactions and collaborations among these stakeholders influenced decision-making processes, project timelines, and ultimately, the success of the projects. Understanding the dynamics between stakeholders and their impact on project delays is essential for effective project management and delivery.

5.3 RECOMMENDATIONS

In order to optimize project management practices and reduce delays in wastewater treatment plant projects, a comprehensive set of recommendations has been devised. These recommendations encompass enhancing planning and scheduling practices, implementing cost management strategies, modernizing material procurement processes, optimizing machinery and equipment efficiency, and mitigating external risks.

The recommendations involve establishing strong planning and scheduling mechanisms, developing strict cost management strategies, modernizing procurement processes, investing in machinery efficiency, and creating risk management strategies to address external factors.

These recommendations should be put into action from the project's initiation and continuously monitored throughout its lifecycle to ensure timely completion and successful outcomes. It is imperative for project managers, contractors, consultants, clients, and all project stakeholders to collaborate closely in implementing and upholding these recommendations effectively.

In the short term, these recommendations will simplify project execution, enhance communication, and enable prompt resolution of potential delays. Over the long term, they will establish a sustainable foundation for project management practices, leading to increased efficiency, minimized delays, and successful project completions in the wastewater treatment plant construction sector.

5.3.1 Need for Further Research

While the existing recommendations provide valuable insights into enhancing project management practices and minimizing delays in wastewater treatment plant projects, there remains a need for further research in this domain. Future studies could focus on the following areas.

Further research in wastewater treatment plant projects is essential to investigate the key areas that can enhance project management practices and minimize delays. The research could focus on investigating the challenges faced during the implementation of existing recommendations, exploring the integration of advanced technologies like AI and studying the impact of sustainable practices on project timelines.

Additionally, research could examine the role of stakeholder engagement strategies in fostering collaboration and reducing delays, as well as developing frameworks for measuring the performance of project management practices and their direct influence on project success.

By addressing these research areas, future studies can contribute to the continual improvement of project management practices in wastewater treatment plant projects, leading to more efficient project outcomes and successful completions.

5.3.2 Implications for the Industry

The insights collected from this study have broader implications for the wastewater treatment plant construction industry in Ethiopia. By addressing the identified factors contributing to project delays and fostering collaboration among stakeholders, the industry can enhance project efficiency, sustainability, and overall success.

In conclusion, the study on project delays in wastewater treatment plant projects managed by Ethiopian Engineering Corporation provides valuable insights into the multi-layered nature of construction project management within the sector. By understanding and addressing the key factors influencing wastewater treatment plant project delays, stakeholders can work towards improving project outcomes, meeting timelines, and delivering high-quality wastewater treatment infrastructure essential for public health and environmental sustainability.

Furthermore, the study did not look into whether the government or other external parties were involved in the projects managed by EEC and how their participation might affect project delays. It also did not examine how natural disasters could impact project delays in the projects. Additionally, the study did not investigate how the quality of project execution could influence project completion and how to assess issues related to project performance quality. These gaps in knowledge highlight the need for future research to explore these aspects further in the specific context of wastewater treatment plant construction projects at the Ethiopian Engineering Corporation.

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ANNEX-I

DATA COLLECTION INSTRUMENTS

Questioners

My name is Henok Girma, and I am currently pursuing a Master's degree in Project Management at Addis Ababa University College of Business and Economics, School of Commerce.

I am Conducting a study on the ***Assessment of Factors Causing Delay in Wastewater Treatment Plant Projects: A case of Ethiopian Engineering corporation (EEC)*** as part of the requirements for a Master's Degree in Project Management.

I invite you to participate in this research study by completing the attached questionnaire. Please omit your name for confidentiality. Your honest responses are appreciated, and I kindly ask for a few minutes of your time to fill it out. Please return the completed questionnaire at your earliest convenience. If you need clarification, feel free to contact me via the following address.

henihydro7@gmail.com

+251911830724.

Assessment of Factors Causing Delay in Wastewater Treatment Plant Projects: A case of Ethiopian Engineering corporation (EEC)

Part One: **Demographic Information**

1	Please specify your role in the wastewater treatment plant construction project:.							
	Client	☐	contractor	☐	consultant	☐		
2	Gender.							
	Male	☐	Female	☐				
3	What is your highest educational qualification?							
	Certificate	☐	Diploma	☐	Bachelor's Degree (BSc)	☐	Master's Degree (MSc)	☐
4	What is your position within the organization/company related to the wastewater treatment plant construction project?							
	Project manager	☐	site engineer	☐	Office Engineer	☐	Forman	☐
5	How many years of relevant work experience do you have in wastewater treatment plant construction projects?							
	<4	☐	4-8	☐	9-12	☐	12	☐

Part Two: Factors Influencing Project Delay

Please rate the significance of the following factors in contributing to Project Delay in wastewater treatment plant construction projects based on the following rank order

Level of agreement on factors that leads to project delay					
	Strongly Disagree (SD)	Disagree (D)	Neutral (N)	Agree (A)	Strongly Agree (SA)
Rank level	1	2	3	4	5

I. Causes of project delay related to Consultant

No	Factors for project delay	S.A (5	A (4)	N (3)	D (2)	S.D (1)
Delay due to Poor planning and scheduling						
1	Inadequate initial project scoping leading to poor planning.					
2	Unrealistic project planning and scheduling.					
3	Insufficient knowledge about the project to advise on the activity scheduling of the contractors.					
4	Inadequate technical expertise to plan and schedule.					
5	Delayed decision-making and approvals by consultants affecting project timeline.					
6	Inaccurate project documentation and specifications by consultants impacting project schedule.					
7	Lack of control of progress of project and rescheduling accordingly.					
8	Some stages of the construction processes are reworked due to technical error					
9	Unrealistic project planning and scheduling.					

II. Causes of project delay related to Project owner (Client)

No	Factors for project delay	S.A (5	A (4)	N (3)	D (2)	S.D (1)
Delay due to price escalation						
1	Inadequate budget planning by the project owner leading to delays caused by price escalation.					
2	Delayed approvals from the client for budget revisions/amendments due to price escalation.					

No	Factors for project delay	S.A (5	A (4)	N (3)	D (2)	S.D (1)
3	Failure of the client to monitor and control cost fluctuations effectively.					
4	Lack of contingency planning by the client to address price escalation issues promptly.					
5	Client's failure to engage in proactive cost management practices to mitigate price escalation delays.					
6	Insufficient financial risk assessment and mitigation strategies by the project owner.					
7	Client's reluctance to allocate additional funds to address price escalation challenges promptly.					
8	Inadequate collaboration between the project owner and project management team in addressing price escalation issues.					

III. Causes of project delay related to Contractors

No	Factors for project delay	S.A (5	A (4)	N (3)	D (2)	S.D (1)
Delay due to late delivery of construction material						
1	Lack of coordination with suppliers leading to delays in material shipments.					
2	Inaccurate estimation of material lead times causing project timeline disruptions.					
3	Failure to order materials with full specifications resulting in rework and delays.					
4	Damage to construction materials during transportation leading to replacement delays.					
5	Financial constraints hindering timely importation of critical construction materials.					

No	Factors for project delay	S.A (5	A (4)	N (3)	D (2)	S.D (1)
6	Lack of knowledge of requirements for material shipment from abroad leading to unrealistic planning.					
7	Delay in customs clearance procedures for imported construction materials causing project delays.					
	Delay due to Inefficient construction machinery and equipment					
1	Frequent breakdowns of critical machinery.					
2	Inadequate maintenance schedules for essential equipment.					
3	Lack of spare parts inventory for quick repairs of malfunctioning machinery.					
4	Failure to conduct regular inspections and preventive maintenance on key equipment.					
5	Lack of contingency plans for equipment failures causing project timeline disruptions.					

IV. Causes of project delay related to External factors

1	land acquisition issues contribute substantially to project delays in wastewater treatment plant construction					
2	Adverse weather conditions significantly contribute to project delays					
3	Delay in approvals and permits from Regulatory causes project delays					
4	Changes in project scope due to stakeholder demands (nearby resident of project site) often lead to project delays					

V. The project delay

1	Project deliverables are not delivered to the client on time					
2	Projects are subject to repeated extension of time					
3	Projects cost are overrunning					
4	Termination of project					
5	Wastewater treatment plant projects implemented by EEC are delayed					

ANNEX-II

DETAILED DESCRIPTIVE ANALYSIS

Project Delay

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	5	4.5	4.5	4.5
	3.20	3	2.7	2.7	7.1
	3.40	3	2.7	2.7	9.8
	3.60	7	6.3	6.3	16.1
	3.80	11	9.8	9.8	25.9
	Agree	15	13.4	13.4	39.3
	4.20	25	22.3	22.3	61.6
	4.40	19	17.0	17.0	78.6
	4.60	21	18.8	18.8	97.3
	Strongly Agree	3	2.7	2.7	100.0
	Total	112	100.0	100.0	

External Factors

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	.9	.9	.9
	2.50	2	1.8	1.8	2.7
	Neutral	2	1.8	1.8	4.5
	3.25	1	.9	.9	5.4
	3.50	4	3.6	3.6	8.9
	3.75	6	5.4	5.4	14.3
	Agree	27	24.1	24.1	38.4
	4.25	30	26.8	26.8	65.2
	4.50	25	22.3	22.3	87.5
	4.75	11	9.8	9.8	97.3
	Strongly Agree	3	2.7	2.7	100.0
	Total	112	100.0	100.0	

Inefficient Construction Machinery and Equipment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.80	1	.9	.9	.9
	Neutral	1	.9	.9	1.8
	3.20	2	1.8	1.8	3.6
	3.40	2	1.8	1.8	5.4
	3.60	5	4.5	4.5	9.8
	3.80	7	6.3	6.3	16.1
	Agree	19	17.0	17.0	33.0
	4.20	41	36.6	36.6	69.6
	4.40	19	17.0	17.0	86.6
	4.60	10	8.9	8.9	95.5
	4.80	3	2.7	2.7	98.2
	Strongly Agree	2	1.8	1.8	100.0
	Total	112	100.0	100.0	

Price Escalation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.88	1	.9	.9	.9
	Neutral	1	.9	.9	1.8
	3.25	1	.9	.9	2.7
	3.50	5	4.5	4.5	7.1
	3.75	7	6.3	6.3	13.4
	3.88	12	10.7	10.7	24.1
	Agree	15	13.4	13.4	37.5
	4.13	7	6.3	6.3	43.8
	4.25	28	25.0	25.0	68.8
	4.38	3	2.7	2.7	71.4
	4.50	21	18.8	18.8	90.2
	4.63	1	.9	.9	91.1
	4.75	7	6.3	6.3	97.3
	Strongly Agree	3	2.7	2.7	100.0
	Total	112	100.0	100.0	

Late Delivery of Construction Material

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	1	.9	.9	.9
	3.29	1	.9	.9	1.8
	3.43	3	2.7	2.7	4.5
	3.57	4	3.6	3.6	8.0
	3.71	3	2.7	2.7	10.7
	3.86	7	6.3	6.3	17.0
	Agree	21	18.8	18.8	35.7
	4.14	15	13.4	13.4	49.1
	4.29	20	17.9	17.9	67.0
	4.43	13	11.6	11.6	78.6
	4.57	17	15.2	15.2	93.8
	4.71	4	3.6	3.6	97.3
	4.86	1	.9	.9	98.2
	Strongly Agree	2	1.8	1.8	100.0
	Total	112	100.0	100.0	

Poor Planning and Scheduling

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	1	.9	.9	.9
	3.11	1	.9	.9	1.8
	3.44	3	2.7	2.7	4.5
	3.56	5	4.5	4.5	8.9
	3.67	1	.9	.9	9.8
	3.78	4	3.6	3.6	13.4
	3.89	8	7.1	7.1	20.5
	Agree	9	8.0	8.0	28.6
	4.11	15	13.4	13.4	42.0
	4.22	23	20.5	20.5	62.5
	4.33	14	12.5	12.5	75.0
	4.44	14	12.5	12.5	87.5
	4.56	8	7.1	7.1	94.6
	4.67	2	1.8	1.8	96.4
	4.78	1	.9	.9	97.3
	4.89	1	.9	.9	98.2
	Strongly Agree	2	1.8	1.8	100.0
	Total	112	100.0	100.0	

ANNEX-III

Raw data for reliability test: Demographic information

Respondent no	Demographic_Information				
	Please specify your role in the wastewater treatment plant construction project	Gender	What is your highest educational qualification?	What is your position within the organization/company related to the wastewater treatment plant construction project?	How many years of relevant work experience do you have in wastewater treatment plant construction projects?
1	Client	Female	Bachelor's Degree (BSc)	Office Engineer	4-8
2	Client	Male	Master's Degree (MSc)	Project manager	> 12
3	Client	Male	Master's Degree (MSc)	Site engineer	4-8
4	Client	Male	Bachelor's Degree (BSc)	Site engineer	4-8
5	Client	Male	Bachelor's Degree (BSc)	Office Engineer	< 4
6	Client	Male	Bachelor's Degree (BSc)	Site engineer	4-8
7	Client	Female	Bachelor's Degree (BSc)	Office Engineer	4-8
8	Client	Male	Bachelor's Degree (BSc)	Site engineer	< 4
9	Client	Female	Bachelor's Degree (BSc)	Office Engineer	4-8
10	Client	Male	Master's Degree (MSc)	Site engineer	< 4
11	Client	Male	Bachelor's Degree (BSc)	Site engineer	4-8
12	Client	Female	Bachelor's Degree (BSc)	Office Engineer	4-8
13	Client	Male	Master's Degree (MSc)	Project manager	> 12
14	Client	Male	Master's Degree (MSc)	Site engineer	4-8
15	Client	Female	Bachelor's Degree (BSc)	Office Engineer	< 4
16	Client	Male	Master's Degree (MSc)	Site engineer	4-8
17	Client	Male	Bachelor's Degree (BSc)	Site engineer	< 4
18	Client	Male	Master's Degree (MSc)	Site engineer	< 4
19	Client	Male	Master's Degree (MSc)	Site engineer	4-8
20	Client	Male	Master's Degree (MSc)	Project manager	> 12

Raw data for reliability test: Poor Planning and Scheduling

For the following five tables, (under Annex-III) the rank level is as depicted below:

Level of agreement on factors that leads to project delay					
	Strongly Disagree (SD)	Disagree (D)	Neutral (N)	Agree (A)	Strongly Agree (SA)
Rank level	1	2	3	4	5

Respondent no	Poor_Planning_and_Scheduling								
	Inadequate initial project scoping leading to poor planning.	Unrealistic project planning and scheduling.	Insufficient knowledge about the project to advise on the activity scheduling of the contractors.	Inadequate technical expertise to plan and schedule.	Delayed decision-making and approvals by consultants affecting project timeline	Inaccurate project documentation and specifications by consultants, impacting project schedule.	Lack of control of progress of project and rescheduling accordingly.	Some stages of the construction processes are reworked due to technical error	Unrealistic project planning and scheduling.
1	4	4	4	5	5	4	4	5	3
2	1	3	3	3	5	3	3	3	3
3	4	5	5	4	5	5	4	5	4
4	5	4	4	4	5	4	4	4	5
5	5	4	4	3	5	4	5	5	5
6	5	4	4	4	5	4	4	4	4
7	5	5	5	4	4	3	4	4	4
8	5	5	5	5	5	5	5	5	5
9	5	4	4	4	4	4	4	4	4
10	4	4	4	4	4	4	4	4	4
11	5	4	4	5	5	4	4	4	5
12	4	4	4	4	4	4	5	4	4
13	4	4	4	4	4	4	5	4	4
14	4	5	5	4	4	5	5	4	4
15	2	4	4	5	4	4	5	4	4
16	4	4	4	5	4	4	4	4	4
17	4	4	4	5	4	4	5	5	4
18	4	4	4	5	4	4	2	5	3
19	5	4	4	4	4	4	4	5	5
20	4	4	4	5	5	4	4	4	4

Raw data for reliability test: Price Escalation

Respondent no	Price_Escalation							
	Inadequate budget planning by the project owner, leading to delays caused by price escalation.	Delayed approvals from the client for budget revisions/amendments due to price escalation.	Failure of the client to monitor and control cost fluctuations effectively.	Lack of contingency planning by the client to address price escalation issues promptly.	Client's failure to engage in proactive cost management practices to mitigate price escalation delays.	Insufficient financial risk assessment and mitigation strategies by the project owner.	Client's reluctance to allocate additional funds to address price escalation challenges promptly.	Inadequate collaboration between the project owner and project management team in addressing price escalation issues.
1	4	4	5	4	4	4	5	4
2	4	4	4	2	2	2	3	2
3	4	4	5	5	4	4	5	5
4	5	4	4	4	5	4	4	4
5	5	5	5	4	5	5	5	4
6	4	4	4	4	4	4	4	4
7	4	4	4	5	4	4	4	5
8	5	5	5	5	5	5	5	5
9	4	4	4	3	4	4	4	4
10	4	4	4	4	3	4	4	4
11	5	4	4	4	5	4	4	4
12	4	5	4	4	4	5	4	4
13	4	5	4	4	4	5	4	4
14	4	5	4	5	4	5	4	5
15	4	5	4	4	4	5	4	4
16	4	4	4	4	4	4	4	4
17	4	5	5	4	4	5	5	4
18	3	2	5	4	3	2	5	4
19	5	4	5	4	5	4	5	4
20	4	4	4	4	4	4	4	4

Raw data for reliability test: Late Delivery of Construction Material

Respondent no	Late_Delivery_of_Construction_Material						
	Lack of coordination with suppliers leading to delays in material shipments.	Inaccurate estimation of material lead times, causing project timeline disruptions.	Failure to order materials with full specifications resulting in rework and delays.	Damage to construction materials during transportation, leading to replacement delays.	Financial constraints hindering timely importation of critical construction materials.	Lack of knowledge of requirements for material shipment from abroad leading to unrealistic planning.	Delay in customs clearance procedures for imported construction materials causing project delays.
1	4	5	5	4	4	5	3
2	3	3	5	3	3	3	3
3	5	4	5	5	4	5	4
4	4	4	5	4	4	4	5
5	4	3	5	4	5	5	5
6	4	4	5	4	4	4	4
7	5	4	4	3	4	4	4
8	5	5	5	5	5	5	5
9	4	4	4	4	4	4	4
10	4	4	4	4	4	4	4
11	4	5	5	4	4	4	5
12	4	4	4	4	5	4	4
13	4	4	4	4	5	4	4
14	5	4	4	5	5	4	4
15	4	5	4	4	5	4	4
16	4	5	4	4	4	4	4
17	4	5	4	4	5	5	4
18	4	5	4	4	2	5	3
19	4	4	4	4	4	5	5
20	4	5	5	4	4	4	4

Raw data for reliability test: Construction Machinery and Equipment and External factor

Respondent no	Inefficient_Construction_Machinery_and_Equipment					External_Factors			
	Frequent breakdowns of critical machinery.	Inadequate maintenance schedules for essential equipment.	Lack of spare parts inventory for quick repairs of malfunctioning machinery.	Failure to conduct regular inspections and preventive maintenance on key equipment.	Lack of contingency plans for equipment failures causing project timeline disruptions.	Land acquisition issues contribute substantially to project delays in wastewater treatment plant construction	Adverse weather conditions significantly contribute to project delays	Delay in approvals and permits from Regulatory causes project delays	Changes in project scope due to stakeholder demands (nearby resident of project site) often lead to project delays
1	3	3	5	4	5	4	4	5	4
2	5	4	4	4	3	2	2	2	2
3	4	2	4	2	4	4	4	5	5
4	4	4	4	4	4	5	4	4	4
5	4	4	5	5	3	5	5	5	4
6	5	4	4	5	4	4	4	4	4
7	4	4	4	5	4	4	4	4	5
8	5	4	4	4	5	5	5	5	5
9	4	4	4	4	4	4	4	4	3
10	4	5	4	4	4	4	4	4	4
11	3	3	3	4	5	5	4	4	4
12	4	5	4	4	4	4	5	4	4
13	4	4	5	4	4	4	5	4	4
14	5	5	5	5	4	4	5	4	5
15	4	4	4	4	5	4	5	4	4
16	4	4	4	4	5	4	4	4	4
17	5	5	5	4	5	4	5	5	4
18	4	4	4	4	5	3	2	5	4
19	4	4	4	4	4	5	4	5	4
20	4	4	5	4	5	4	4	4	4

Raw data for reliability test: Project delay

Respondent no	Project_Delay				
	Project deliverables are not delivered to the client on time	Projects are subject to repeated extension of time	Projects cost are overrunning	Termination of project	Wastewater treatment plant projects implemented by EEC are delayed
1	4	4	5	4	5
2	3	3	3	3	3
3	4	4	5	5	4
4	5	4	4	4	4
5	5	5	5	4	3
6	4	4	4	4	4
7	4	4	4	5	4
8	5	5	5	5	5
9	4	4	4	4	4
10	3	4	4	4	4
11	5	4	4	4	5
12	4	5	4	4	4
13	4	5	4	4	4
14	4	5	4	5	4
15	4	5	4	4	5
16	4	4	4	4	5
17	4	5	5	4	5
18	3	2	5	4	5
19	5	4	5	4	4
20	4	4	4	4	5